



Sporad na Mara Offshore Wind Farm

Offshore Project

Environmental Impact Assessment Report

Chapter 12: Fish Ecology, Volume 2a

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12 FISH ECOLOGY

12.1 INTRODUCTION

12.1.1 OVERVIEW

12.1.1.1 This chapter of the Environmental Impact Assessment Report (EIAR) presents the results of the assessment of the likely significant effects of the proposed Sporad na Mara Offshore Wind Farm (hereafter referred to as 'the Offshore Project') with respect to Fish Ecology, including demersal, pelagic, elasmobranch (sharks, skates and rays) and diadromous (Atlantic salmon, sea-trout and European eel) fish species.

12.1.1.2 This chapter should be read in conjunction with the project description provided in **Chapter 3: Project Description, Volume 1a** and the relevant parts of the following chapters and appendices:

- **Chapter 9: Physical and Coastal Processes, Volume 2a:** Changes to marine geology, oceanography and physical processes have the potential to directly or indirectly impact fish features due to the reliance on physical processes during certain stages of their lifecycle;
- **Chapter 10: Marine Sediment and Water Quality, Volume 2a:** Changes in marine water and sediment quality have the potential to result in adverse effects on fish fauna through toxicity and other mechanisms;
- **Chapter 11: Benthic and Intertidal Ecology, Volume 2a:** Changes to the benthic environment has the potential to impact fish receptors that rely on benthic species as prey items or utilise benthic habitats;
- **Chapter 13: Marine Mammals, Volume 2a:** Marine mammals considered within the Environmental Impact Assessment (EIA) will include some species that rely on fish species as part of their diet and therefore impacts to fish could potentially indirectly impact marine mammals;
- **Chapter 14: Marine and Nearshore Ornithology, Volume 2a:** Fish form a part of the diet of several seabirds. A potential change in fish abundance or distribution may result in adverse effects on seabirds that are sensitive to changes to prey resource;
- **Chapter 21: Commercial Fisheries, Volume 2a:** The commercial fisheries chapter includes commercially important species and fisheries data and there is an overlap between these sections. Information and data from this assessment will be used to inform the Fish Ecology assessment as commercial fisheries has the potential to directly and indirectly impact Fish Ecology.

12.1.1.3 This technical chapter describes the following:

- Legislation, planning policy and other documentation that has informed the assessment (Section 12.2: Summary of policy and legislative context and **Chapter 2: Policy and Legislative Context, Volume 1a**);
- Outcome of consultation and engagement that has been undertaken to date, including how matters relating to Fish Ecology have been addressed (Section 12.3: Scoping and consultation);
- Scope of the assessment for Fish Ecology (Section 12.4: Scope of the assessment);
- The methods of assessment used for baseline data gathering and impact assessment (Section 12.5: Methodology for baseline data gathering and impact assessment);
- Overall baseline (Section 12.6: Baseline conditions);
- Embedded environmental measures relevant to Fish Ecology and the relevant maximum design scenario (Section 12.7: Basis for Environmental Impact Assessment);
- Assessment of Fish Ecology likely significant effects and further mitigation (Section 12.12-12.10: Assessment of effects)
- Assessment of Fish Ecology Combined effects (Section 12.11: Assessment of Combined Effects);
- Assessment of Fish Ecology Whole Project effects (Section 12.12: Whole Project Effects Assessment);
- Assessment of Fish Ecology Cumulative effects (Section 12.13: Assessment of Cumulative Effects);
- Assessment of Transboundary effects (Section 12.14: Transboundary Effects)
- A summary of residual effects for Fish Ecology (Section 12.15: Summary of Residual Effects);
- Glossary and abbreviations used in the Fish Ecology assessment (Section: 12.16 Glossary of terms and abbreviations);
- Information sources and documentation referred to in this chapter (Section 12.17: References).

12.1.1.4 The chapter is supported by the following appendices and figures:

- **Appendix 3.1: Percussive Piling Installation Approach, Volume 1c;**
- **Appendix 11.1: Subtidal Environmental Baseline Survey Technical Report, Volume 2c;**
- **Figure 12-1: Fish Ecology Study Area, Volume 2b;**
- **Figure 12-2: Underwater noise representative percussive piling locations, Volume 2b;**
- **Figure 12-3: Impact ranges for mortality (210dB), recoverable injury (203dB) and TTS (186dB) based on a stationary receptor for pile locations 2, 3, 4 and 5; Volume 2b;**
- **Figure 12-4: Impact ranges for mortality (210dB), recoverable injury (203dB) and TTS (186dB) based on a stationary receptor for pile locations 1 and 4; Volume 2b;**
- **Figure 12-5: Other Developments Considered as part of the Fish Ecology CEA; Volume 2b;**
- **Appendix 12.1: Fish Ecology Baseline, Volume 2c; and its annexes:**
 - **Annex 12.1.1: Species List, Volume 2c;**
 - **Annex 12.1.2: eDNA Report, Volume 2c;**
 - **Annex 12.1.3: Fish Tracking Study, Volume 2c;**

- **Appendix 12.2: Consultation on Atlantic salmon underwater noise assessment and associated data analysis, Volume 2c;**
- **Appendix 12.3: Overview of Percussive Piling Fish Ecology Mitigation, Volume 2c;**
- **Appendix 13.3: Underwater Noise Modelling, Volume 2c.**

12.2 SUMMARY OF POLICY AND LEGISLATIVE CONTEXT

12.2.1.1 This section outlines the legislation, policy and guidance that is relevant to the assessment of likely significant effects on Fish Ecology associated with the construction, operation, maintenance and decommissioning of the Offshore Project. In addition, other national, regional, and local policies are considered within this assessment where they are judged to be relevant. Further information on policies relevant to the EIA is provided in **Chapter 2, Volume 1a**.

12.2.1.2 A summary of the legislation, policy and guidance relevant to Fish Ecology is provided in **Table 12-1** which examined their relevance to the assessment.

Table 12-1 Legislation and Policy in relation to Fish Ecology

Title	Relevance to Fish Ecology
International Legislation	
The Convention on the Conservation of Migratory Species of Wild Animals (CMS) (the 'Bonn Convention')	The Bonn Convention aims to protect endangered migratory species and their habitats. This covers several species of migratory fish found within Scottish waters.
The Convention on the Conservation of European Wildlife and Natural Habitats (the 'Bern Convention')	The Bern Convention aims to conserve and protect wild flora and fauna and their habitats. Some fish species listed under Annex II – Strictly protected fauna species, and Annex III – Protected fauna species are known from the Study Area.
National Legislation / Policy	
Conservation (Natural Habitats, &c.) Regulations 1994 (as amended) (Habitat Regulations) Conservation of Offshore Marine Habitats and Species Regulations 2017 Conservation of Habitats and Species Regulations 2017 (as amended)	Together these pieces of legislation transpose the requirements of the EC Directive (92/43/EEC) on the Conservation of Natural Habitats and wild Fauna and Flora (Habitats Directive) into UK legislation, with the Offshore Regulations applying outside UK territorial waters, i.e. the area greater than 12 nautical miles from the landward baseline of the territorial sea. The legislation aims to conserve natural habitats and wild flora and fauna by protecting sites that are internationally important for threatened habitats and species (European sites) and provides a legal framework for species requiring strict protection, known as European protected species ² .

² Sturgeon, *Acipenser sturio* is the only fish EPS known from Scottish waters.

Title	Relevance to Fish Ecology
Conservation of Habitats and Species (Amendment) (Scotland) (EU Exit) Regulations 2019 ¹	
Marine (Scotland) Act 2010	<p>The Marine (Scotland) Act 2010 establishes a framework for managing Scotland/<i>Alba</i>'s marine environment, focusing on sustainable development and conservation.</p> <p>It also provides for the designation of marine protected areas (MPAs). For mobile species, such as fish, the Act requires that potential impacts on these species are considered during impact assessments, even for projects that fall outside the extent of an MPA. MPAs with mobile fish species listed as protected features are located in proximity to the Offshore Project, including the West of Scotland MPA.</p>
Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003 (as amended)	<p>The Act consolidates the vast majority of Scottish salmon and freshwater fisheries law into a single Act.</p> <p>The Act includes provisions pertinent to the marine environment through its protection of migratory salmon and sea trout. It mandates that the safe passage of these species between freshwater and marine environments is maintained and includes measures to prevent obstructions and adverse impacts on their migration routes.</p>
Wildlife & Countryside Act 1981 (as amended by the Wildlife and Natural Environment (Scotland) Act 2012 & Nature Conservation (Scotland) Act 2004)	<p>These acts collectively provide protection for wildlife, countryside, and natural habitats and address specific conservation needs and priorities in Scotland/<i>Alba</i>.</p> <p>These acts make it an offence to intentionally or recklessly kill, injure or take, possess or sell or intentionally or recklessly disturb or harass species listed under Schedule 5 of the Wildlife & Countryside Act 1981. Some fish species protected under Schedule 5 of the Act³ are known from the Study Area.</p>
Technical Guidance	
Chartered Institute for Ecology and Environmental Management (CIEEM), Guidelines for Ecological Impact Assessment in the UK and	CIEEM methodology for Ecological Impact Assessments have been used to inform the method adopted in this chapter, amongst other criteria.

¹ The Conservation of Habitats and Species Regulations 2017 (as amended) and The Conservation of Offshore Marine Habitats and Species Regulations 2017 (as amended) transpose the EU Habitats Directive (Council Directive 92/43/EEC) and certain elements of the Wild Birds Directive (Directive 2009/147/EC) (known together as the Nature Directives) into UK law. Most functions of these Regulations have now been transferred from the European Commission (EC) to the appropriate authorities in Scotland under the Conservation of Habitats and Species (Amendment) (Scotland) (EU Exit) Regulations 2019.

³Basking sharks, *Cetorhinus maximus*, vendace, *Coregonus albula* and powan, *Coregonus lavaretus*. Allis shad, *A. alosa* and twaite shad, *A. fallax* receive partial protection under Schedule 5, which regulates how they can be killed or taken.

Title	Relevance to Fish Ecology
Ireland Terrestrial, Freshwater, Coastal and Marine (CIEEM, 2019)	
NatureScot advice on Marine non-native species (NatureScot, 2022)	This advice provides guidance on identification of non-native species and preventing introduction, including Marine Biosecurity Planning guidance. This guidance will be incorporated into the technical assessment and embedded environmental measures.
The Marine Life Information Network (MarLIN), Marine Evidence-based Sensitivity Assessment (MarESA)	The MarLIN 'evidence base' remains the largest review yet undertaken on the effects of human activities and natural events on marine species and habitats. The MarESA is a sensitivity assessment based on a detailed review of available evidence (the 'evidence base') on the effects of pressures on marine species or habitats, and a subsequent scoring of sensitivity against a standard list of pressures, and their benchmark levels of effect.
Feature Activity Sensitivity Tool (FeAST) (Marine Directorate, 2022)	FeAST provides information regarding the sensitivity of marine features in Scotland/ <i>Alba's</i> seas, to pressures arising from human activities.
Marine Scotland Consenting and Licensing Guidance: offshore renewable energy projects (Marine Scotland (2025)	Guidance for offshore renewable energy projects on marine licensing and consenting requirements that are administered by the Marine Directorate – Licensing Operations Team (MD-LOT). This guidance will be incorporated into the technical assessment and embedded environmental measures.
Impacts from Piling on Fish at Offshore Wind Sites: Collating Population Information, Gap Analysis and Appraisal of Mitigation Options (Boyle and New, 2018)	A literature review identifying current knowledge and data gaps associated with percussive piling impacts, associated with offshore wind developments, on Atlantic herring spawning populations.
A Review of Assessment Methodologies for Offshore Wind Farms (Collaborative Offshore Wind Research into The Environment (COWRIE) METH-08-08) (Maclean <i>et al.</i> , 2009)	A comprehensive review of existing methods and guidelines for assessing the environmental impacts of offshore wind farms. This guidance will be incorporated into the technical assessment and embedded environmental measures.
British Standards Institute (BSI), Environmental Impact Assessment for Offshore Renewable Energy Projects (BSI, 2015)	This guidance provides a framework for assessing the environmental effects of offshore renewable energy (ORE) projects, incorporating input from key industry organizations and driven by the UK's national goals for climate change mitigation and economic development in the offshore wind sector. This guidance will be incorporated into the technical assessment and embedded environmental measures.

12.3 SCOPING AND CONSULTATION

12.3.1 OVERVIEW

- 12.3.1.1 This section describes the stakeholder engagement undertaken for the Offshore Project. This consists of early engagement, the outcome of, and response to, the Scoping Opinion in relation to the Fish Ecology assessment, informal consultation and consultation undertaken through the Pre-Application Consultation (PAC) process (hereafter referred to as the 'formal consultation'). An overview of engagement undertaken for the Project as a whole can be found in **Chapter 5: Approach to EIA, Volume 1a** and **Appendix 5.4: Stakeholder Consultation and Engagement, Volume 1c**.
- 12.3.1.2 Consultation is a key feature of the EIA process and continues throughout the lifecycle of the Offshore Project, from the initial stages through to consent and post consent.
- 12.3.1.3 Consultation captures all consultation and engagement and has been ongoing with a number of prescribed and non-prescribed consultation bodies and local authorities in relation Fish Ecology. All consultation to date has been undertaken in line with the process described in **Chapter 5, Volume 1a** and **Appendix 5.4, Volume 1c**. Feedback received during this process has been incorporated into the EIAR wherever possible as appropriate.

12.3.2 EARLY ENGAGEMENT

- 12.3.2.1 Early engagement was undertaken with a number of consultation bodies in relation to Fish Ecology. This engagement was undertaken to introduce the Offshore Project and the proposed approach to scoping the EIA. In accordance with MD-LOT guidance (Marine Scotland, 2024), the Applicant held formal scoping workshops with the Marine Directorate, NatureScot, and the Outer Hebrides Fisheries Trust (OHFT) in May 2023 to inform the Scoping Report. Further details of the consultation undertaken and the post-workshop feedback can be found in Section 5.3 and Table 5.3-1 of the Scoping Report.

Marine Directorate

- 12.3.2.2 The Marine Directorate – Science, Evidence, Data and Digital (MD-SEDD) team indicated that work relating to the coastal movements of salmon smolts on the west coast of Scotland/*Alba* is yet to be published from a number of studies including the West Coast Tracking Project, COMPASS and SEAMonitor. They recommended that these organisations be approached, specifically researchers at the University of Glasgow and the Atlantic Salmon Trust. The Licensing Operations Team (MD-LOT) did not raise any specific concerns relating to Fish Ecology.

NatureScot

- 12.3.2.3 NatureScot noted clarification was needed as to whether direct effects from noise cause disturbance and/or auditory injury. Clarity was provided within the relevant scoping chapter on

whether direct noise effects cause disturbance or injury. NatureScot also advised they were due to provide advice on diadromous fish related to the Langavat Special Area of Conservation (SAC) and North Harris SAC, and how they should be considered within the (Habitat Regulations Appraisal (HRA) and EIAR. As specific advice from NatureScot was not available at the time of writing the scoping report, diadromous fish, relating to the Langavat SAC and North Harris SAC, were included within the Fish Ecology chapter of the scoping report. NatureScot noted that ghost fishing had been scoped into the Fish Ecology assessment yet scoped out of marine mammals. This was corrected and ghost fishing was scoped out of both Fish Ecology and marine mammals assessments within the Scoping Report (Spiorad na Mara Ltd, 2023).

Outer Hebrides Fisheries Trust

- 12.3.2.4 OHFT noted that the spawning of Atlantic Salmon is November/December time. Scoping report correctly identified the November/December spawning period of Salmon in Langavat SAC.

Scoping Opinion

- 12.3.2.5 Spiorad na Mara Limited (hereafter referred to as 'the Applicant') submitted a Scoping Report (Spiorad na Mara Limited, 2023) and request for a Scoping Opinion to the MD-LOT in September 2023. A Scoping Opinion was received in May 2024. The Scoping Report sets out the proposed Fish Ecology assessment methodologies, outline of the baseline data collected to date and proposed, and the scope of the assessment. The comments received in the Scoping Opinion and how these have been addressed in this EIAR is provided in **Appendix 5.2: Response to Scoping Opinion, Volume 1c**.
- 12.3.2.6 A summary of those responses relevant to Fish Ecology is shown in **Table 12-2**. Regard has also been given to other stakeholder comments that were received in relation to the Scoping Report.

Table 12-2 Scoping Opinion responses – Fish Ecology

Consultee	Date / Document	Comment	Response/where this is addressed in the EIAR
MD-LOT / NatureScot	Licensing Operations Team Scoping Opinion, May 2024	The Scottish Ministers are broadly content with the impact pathways proposed to be scoped into and out of the EIA Report as detailed in table 6.2-1 of the Scoping Report however advise that "effect of seabed vibration" also be scoped in for assessment of migratory fish. This is a view supported NatureScot in its representation. (Paragraph 5.2.2.2 of scoping opinion – MD-LOT)	While vibration from percussive piling into the seabed will occur during construction, there is no practical methodology available to calculate or assess this potential mechanical impact in isolation. MD-LOT and NatureScot agreed that this impact pathway for benthic and demersal species can be scoped out in the Scoping Opinion, but it was

Consultee	Date / Document	Comment	Response/where this is addressed in the EIAR
		<p>Table 6.2-1 summarises the impacts to be scoped into the underwater noise assessment. We support the proposed approach and impacts that have been scoped in/ out, and note that assessments will be presented in the relevant receptor chapters of the EIA Report. We note that "effect of seabed vibration on benthic and demersal species" is the only impact that has been scoped out, and this applies to all stages of the development. Noting that we advise it should remain scoped in for consideration of migratory fish. (Appendix E – Underwater Noise, Page no: 34 of scoping opinion appendix I - NatureScot)</p>	<p>requested that the effects of seabed vibration on migratory species be included.</p> <p>The migratory species scoped-in for assessment for the Offshore Project are Atlantic salmon, sea trout and European eel. Because they are present in the water column they do not directly detect mechanical seabed vibration. These species detect seabed vibration transmitted into the water column as particle motion through their auditory apparatus. Vibration as a contributory source of noise within the water column is assessed as part of the underwater noise and vibration assessment for all fish receptors (refer Section 12.8.4 and 12.9.4).</p>
MD-LOT	Licensing Operations Team Scoping Opinion, May 2024	Furthermore, in relation to assessing the effects of underwater noise on fish, the Scottish Ministers support the use of Popper <i>et al.</i> 2014. This is in line with the NatureScot representation	Assessment of the effects of underwater noise on fish was carried out using the Popper et al. (2014) guidelines. See sections 12.8.4, 12.8.5 and 12.9.4
MD-LOT	Licensing Operations Team Scoping Opinion, May 2024	The Scottish Ministers advise that the study area for fish and shellfish ecology should be reviewed to ensure it encompasses the modelled distances for suspended sediment concentration change and underwater noise/vibration. (Paragraph 5.2.5.2 of scoping opinion)	The study area has been expanded to reflect sediment and noise modelling outputs. See Section 12.4.2.
MD-LOT	Licensing Operations Team Scoping Opinion, May 2024	The Scottish Ministers advise that mitigation measures for migratory fish should include timing of construction periods, consideration of underwater noise effects during both construction	Mitigation measures for migratory fish are detailed in Appendix 12.3, Volume 2c.

Consultee	Date / Document	Comment	Response/where this is addressed in the EIAR
		and operation, and consideration of lighting and barrier effects/attraction of predators. (Paragraph 5.2.5.15 of scoping opinion)	These mitigation measures are incorporated into the embedded mitigation strategy. See Section 12.7 and 12.8.4.
MD-LOT	Licensing Operations Team Scoping Opinion, May 2024	The Scottish Ministers advise that the generic approach to assessment is expected but highlight the absence of any attempt to address key evidence gaps regarding potential impact pathways, particularly the overlap between the development area and migratory fish at local and regional scale. (Paragraph 5.2.5.13 of scoping opinion)	Migratory fish pathways and regional connectivity are addressed through the definition of the Diadromous Fish Study Area and precautionary assessment of impact pathways. See Sections 12.4.2 and 12.5.
MD-LOT	Licensing Operations Team Scoping Opinion, May 2024	The Scottish Ministers advise that transboundary impacts on most fish receptor groups can be scoped out from further assessment. However, transboundary impacts on migratory fish should be scoped into the EIAR.	Potential transboundary impacts on migratory fish have been considered within the Fish Ecology assessment, see Section 12.14.
Western Isles District Salmon Fishery Board (WIDSFB)	Licensing Operations Team Scoping Opinion, May 2024	Desk-based assessments are not appropriate for some of the potential likely significant effects, e.g. disturbance to migration pathways. Telemetry studies should be used. (Q: 3 of scoping opinion)	Telemetry data from the Loch Roag Sea Trout Study and other tracking sources have been incorporated to assess migratory pathways and exposure. See 12.6.1.18 and Appendix 12.1, Volume 2c (Annex C: Fish Tracking Study) .
WIDSFB	Licensing Operations Team Scoping Opinion, May 2024	Infrastructure may be adopted by predators to increase exploitation of migratory fish. Permanent disturbance to migration pathways is also a concern (Q: 2 of scoping opinion).	These concerns are addressed in the assessment of predator-prey dynamics and migratory fish vulnerability. See Section 12.9.6.
WIDSFB	Licensing Operations Team Scoping Opinion, May 2024	The report does not clearly explain what mitigation measures are being adopted for wild fish receptors (Atlantic Salmon). Therefore, WIDSFB would like to ask what mitigation is being proposed to ensure smolts emanating from the Langavat SAC will not be harmed or impeded in their migration. What consideration in	Mitigation measures for migratory fish (including Atlantic salmon) are detailed in Appendix 12.3, Volume 2c . These mitigation measures are incorporated into the embedded mitigation strategy. See Section 12.7 and 12.8.4.

Consultee	Date / Document	Comment	Response/where this is addressed in the EIAR
		terms of best practice has been given to the timings and duration of the works in relation to the sensitive period when wild salmon smolts will be migrating out of Loch Roag. (Q: 4 of scoping opinion).	
NatureScot	Licensing Operations Team Scoping Opinion, May 2024	Atlantic salmon, European eel, and sea trout should be scoped in due to conservation status and proximity to SACs. (Appendix D – Fish and shellfish Ecology, Page no: 25 and 26 of scoping opinion appendix i)	These species are scoped in and assessed as diadromous receptors with consideration of conservation status and SAC proximity. See Sections 12.7 and 12.9.
NatureScot	Licensing Operations Team Scoping Opinion, May 2024	EMF, underwater noise, lighting, and predator attraction should be assessed as potential impact pathways. (Paragraph 5.2.5.15 and 5.2.5.4 of scoping opinion)	These pathways are assessed in Sections 12.8.4 (underwater noise), 12.9.5 (EMF), and 12.9.6 (predator attraction). Lighting has been scoped out from requiring further assessment see Table 12-6 .
NatureScot	Licensing Operations Team Scoping Opinion, May 2024	The list of data sources is insufficient. Additional sources such as Fisheries Sensitivity Maps (Gonzalez-Irusta, 2014), Langton <i>et al.</i> (2021) sandeel models, and ScotMER habitat maps should be included.	These sources have been incorporated into the baseline characterisation. See Section 12.5 and 12.6.
Comhairle nan Eilean Siar (CnES)	Licensing Operations Team Scoping Opinion, May 2024	Invasive Non-Native Species (INNS) should not be scoped out; there is a high risk of introduction and spread even with mitigation. (Paragraph 5.2.5.7 of scoping opinion)	INNS is scoped out of the Fish Ecology chapter but addressed under Chapter 11, Volume 2a . Risk management is covered via the Invasive Non-Native Species Management Plan, Volume 3 . See Section 12.4.6 and justification in Table 12-6 .
CnES	Licensing Operations Team Scoping Opinion, May 2024	Permanent seabed habitat loss lacks embedded mitigation. (Paragraph 5.2.5.14 of scoping opinion)	Embedded mitigation has been added to minimise permanent habitat loss by prioritising infrastructure placement on existing hard substrate and micro-siting to avoid sensitive areas. See mitigation measure M001 in Table 12-22 and assessment in Section 12.8.

Consultee	Date / Document	Comment	Response/where this is addressed in the EIAR
CnES	Licensing Operations Team Scoping Opinion, May 2024	Clarification requested: brown trout and sea trout are not the same species. (Section 6.5, Q4 of scoping opinion)	Sea trout are assessed as a diadromous species throughout this chapter. While brown trout are not assessed, the ecological distinction is reflected in the treatment of sea trout as a migratory receptor. See Section 12.6.1.
Carloway Estate Trust	Appendix I - Consultation representations. pdf	Migratory salmon and sea trout from the Carloway River likely pass through the development area. (Paragraph 6.9.3.5 of scoping opinion)	Migratory pathways and potential exposure of Carloway/Càrlabhadh River salmonids are assessed in relation to underwater noise and predator effects. See Sections 12.8.4 and 12.9.4.
Barvas Estate Trust	Appendix I - Consultation representations. pdf	Concerns about impacts on Barvas and Arnol River spawning grounds. (Paragraph 6.9.3.5 of scoping opinion)	Potential spawning grounds within the ensonified zone are assessed for species such as herring and sprat. See Appendix 12.1, Volume 2c ; Section 12.6.1.
Anderson MacArthur (on behalf of Lewis Island Crofters Ltd)	Appendix I - Consultation representations. pdf	Concerns about salmon spawning grounds in the Carloway River. (Paragraph 6.9.3.5 of scoping opinion)	Potential impacts on salmon from rivers draining the west of the Isle of Lewis/Eilean Leòdhais, including the Carloway/Càrlabhadh, are assessed in relation to underwater noise and predator effects. See Sections 12.8.4 and 12.9.4.
CnES	Licensing Operations Team Scoping Opinion, May 2024	Suggests restocking or enhancement programs to mitigate fishery impacts. (Paragraph 5.2.9.7 of scoping opinion)	Restocking is considered under commercial fisheries mitigation. See Chapter 21, Volume 2a .
CnES	Licensing Operations Team Scoping Opinion, May 2024	Recommends consultation with local fishery groups (e.g. Outer Hebrides Inshore Fisheries Group (OHIFG), Western Isles Fisherman's Association (WIFA)). (Section 6.9.5 of scoping opinion)	No direct consultation with OHIFG or WIFA is recorded. However, related concerns may have been represented through engagement with WIDSFB and CnES. See Section 12.3.2 and Appendix 5.4, Volume 1c .

Consultee	Date / Document	Comment	Response/where this is addressed in the EIAR
CnES	Licensing Operations Team Scoping Opinion, May 2024	Recommends bundling cables and limiting crossings to reduce impact on fishing grounds. (Section 6.9.5 of scoping opinion)	Cable bundling with no crossings has been considered in the design envelope. A cluster of 12 Array Cables was modelled for electric and magnetic fields in parallel to simulate bundling at junctions, and cable routing strategies aim to reduce seabed footprint. Potential impact on fishing grounds has been considered in Chapter 21, Volume 2a . See Section 12.9.5 and EMF modelling assumptions in Appendix 12.2, Volume 2c .

12.3.3 POST SCOPING CONSULTATION

12.3.3.1 Following the receipt of the Scoping Opinion, further consultation relating to Fish Ecology has been held with a number of stakeholders. A summary of this consultation is provided in **Table 12-3** and further detail is provided in **Appendix 12.2, Volume 2c**.

Table 12-3 Summary of post scoping consultation - Fish Ecology

Consultee	Date / Document	Comment	Response/where this is addressed in the EIAR
NatureScot, MD-LOT and MD-SEDD	Engagement meeting (July 2025)	Atlantic salmon baseline to cover all life stages and FWPM	Detail in Appendix 12.1, Volume 2c . Summary in Section 12.6.
		Approach to underwater noise modelling including thresholds for Atlantic salmon smolt, post-smolts and adults swim speeds.	Underwater noise report (Appendix 13.3, Volume 2c) and summarised in Section 12.8.4. Outputs from modelling summarised in paragraphs 12.8.4.32 to 12.8.4.53.
		Approach to assigning sensitivity and value to fish receptors particularly those that are qualifying features of SACs.	Approach to valuation covered in Section 12.5. Sensitivity of individual IEFs covered for each impact pathway in Sections 12.8, 12.9, and 12.10.
		Seasonal migration windows for smolts and adult salmon	Literature used to support migration windows for smolts presented in Appendix 12.1, Volume 2c . Approach to

Consultee	Date / Document	Comment	Response/where this is addressed in the EIAR
			assessing timing of returning adult salmon summarised in paragraphs 12.6.
		Spatial considerations of salmon migration routes	Covered in assessment of impact of underwater noise impacts on Atlantic salmon in Section 12.8.4.
NatureScot, MD-LOT and MD-SEDD	Engagement meeting (October 2025)	Does altering the TTS noise contour away from the coast by 1.5 km sufficiently allow for migrating fish.	The assumption of a 1.5 km migratory corridor was removed following this consultation. A precautionary approach was adopted with respect to impacts from threshold shift (TTS) on adult Atlantic salmon migrating from the north along the coastline of the Hebrides/ <i>Innse Gall</i> . Outputs from modelling and assessment of underwater noise is provided in Section 12.8.4.
		Is there value in the designated percussive piling zones for secondary mitigation targeting areas that require lower hammer energy during peak migration periods.	The Applicant has updated the secondary mitigation to incorporate restrictions on percussive piling in during the summer period and quiet periods into the programme to minimise impacts for further details see Section 12.8.4 and Appendix 12.3, Volume 2c).
		Queried whether a shorter, higher-energy percussive piling event might be preferable to a longer, lower-energy one.	Choice of hammer energy and percussive piling duration is influenced by site-specific ground conditions, which will be determined by detailed geophysical surveys. The Applicant acknowledges that this trade-off is important and will further explore installation options as more geotechnical data becomes available and detailed design is undertaken.
		Quiet periods could be made adaptive.	The proposed spatial and temporal mitigation described in Appendix 12.3, Volume 2c is considered to be a more practical and robust approach to minimising impacts on migrating salmon.
		Do longer quiet periods during peak migration periods offer more effective mitigation.	The current construction plan includes quiet periods built into the construction sequencing (see Appendix 12.3, Volume 2c). Acknowledged that the longer the quiet period, the better for fish migration, but this must be balanced with construction needs.

Consultee	Date / Document	Comment	Response/where this is addressed in the EIAR
		<p>It would be beneficial to maximise quiet time provision during peak smolt migration period (April – May).</p>	<p>The secondary mitigation strategy includes a restriction on percussive piling during the peak migration during April and May (see Appendix 12.3, Volume 2c).</p> <p>The Applicant may choose to undertake a dedicated study (prior to construction commencing) to understand if the Percussive Piling Programme could be extended into April/May. The purpose of this study would be to provide further information on the timing of smolt emigration through Loch Roag/Loch Ròg. Further details of this study are provided in Section 3.4.2 of Appendix 12.3, Volume 2c.</p>
		<p>Could phasing of percussive piling activities based on ground conditions further reduce risks to migrating salmon.</p>	<p>Choice of hammer energy and percussive piling duration is influenced by site-specific ground conditions, which will be determined by detailed geophysical surveys. Phasing will be optimised as more site data becomes available and detailed design is undertaken.</p>

12.4 SCOPE OF THE ASSESSMENT

12.4.1 OVERVIEW

12.4.1.1 This section sets out the scope of the EIA assessment for Fish Ecology. This scope has been developed as the Offshore Project design has evolved and responds to feedback received to date as set out in Section 12.3.

12.4.2 SPATIAL SCOPE AND STUDY AREA

12.4.2.1 The spatial scope of the Fish Ecology assessment encompasses both the Offshore Project Boundary and the Zone of Influence (Zol), the area where the project-related impacts may occur. This combined area forms the basis of the study area described in this section. Following guidance from the Scottish Ministers and NatureScot provided in the Scoping Opinion, the original fish study area defined at scoping has been extended to account for modelled changes in suspended sediment concentration and underwater noise. Of these, underwater noise – particularly from percussive

piling during turbine installation – was predicted to have the widest spatial extent. Accordingly, the Marine Fish Study Area has been defined using the extent of underwater noise propagation from percussive piling. Additionally, it was advised by NatureScot as part of the Scoping Opinion that a separate migratory (diadromous) fish study area be included in the EIAR.

12.4.2.2 In response to these recommendations, the Fish Ecology study areas have been revised. Ocean sunfish *Mola mola* and basking sharks *Cetorhinus maximus*, which were originally included in the Marine Mammal and Other Megafauna chapter at scoping, are now incorporated within the Fish Ecology chapter. As a result, a third study area is included here, reflecting the area originally defined at scoping for these species. All study areas are shown **Figure 12.1, Volume 2b**. Collectively these study areas are referred to as the Fish Ecology Study Area.

Marine Fish Study Area

12.4.2.3 The Marine Fish Study Area is determined by the extent of modelled impacts from suspended sediment mobilisation and underwater noise. A review of sediment and noise modelling indicates that noise impacts extend further than sediment mobilisation, making noise propagation the greatest Zol. This study area applies to all marine fish species, excluding diadromous species, basking sharks, and ocean sunfish.

12.4.2.4 For the purposes of defining the Marine Fish Study Area, the spatial extent of underwater noise propagation was determined using modelling based on an unmitigated, single-strike sound pressure level of 150 dB re 1 μ Pa (RMS), as used by the United States National Marine Fisheries Service (NMFS). This sound pressure level was selected solely because it provides a numerically defined, spatially mappable extent of potential behavioural disturbance, enabling a clear and reproducible study area boundary.

12.4.2.5 The 150 dB re 1 μ Pa RMS threshold is considered a conservative indicator of where behavioural responses may begin in some species (Popper *et al.*, 2014). Thus, although appropriate for defining a broad spatial study area, it is not appropriate for the assessment of behavioural effects on fish. Behavioural criteria appropriate for the assessment of behavioural effects on fish (i.e., Popper *et al.*, 2014) use qualitative distance categories (e.g. near, intermediate, far), which cannot be translated into a mapped spatial extent and therefore cannot be used to define a study area. For this reason, the 150 dB contour is used only to define the Marine Fish Study Area, while assessment of behavioural effects on fish uses the Popper *et al.* (2014) criteria agreed at scoping (**Table 12-2**). These guidelines are described in detail in **Table 12-33** and Section 12.8.4.

12.4.2.6 The Marine Fish Study Area is shown on **Figure 12.1, Volume 2b**.

Diadromous Fish Study Area

12.4.2.7 Given the extensive open ocean and near shore migrations undertaken by diadromous species, there is the potential for activities associated with the Offshore Project to cause potential significant effects to stocks with implications for recruitment within natal waters at a substantial

distance from the Offshore Project. A wider regional context has therefore been considered for diadromous fish species.

- 12.4.2.8 On this basis, the Diadromous Fish Study Area has been defined as encompassing coastal and offshore waters extending along the west coast of Scotland, from the southern extent of the Outer Hebrides/*Na h-Eileanan Siar* to the mainland coast, as shown in **Figure 12.1, Volume 2b**. This area is informed by published literature on the known or likely migratory pathways of the species relevant to the assessment. Due to the limited availability of detailed empirical data on migration routes and spatial ranges for some diadromous species, the defined area is relatively large, potentially exceeding the area of direct relevance. This precautionary approach has been adopted to ensure a robust and comprehensive assessment. Where species-specific data are available, a more refined analysis of potential interactions with the Offshore Project is presented in subsequent sections of this report (Section 12.6).

Basking Sharks and Ocean Sunfish Study Area

- 12.4.2.9 Ocean sunfish and basking sharks are highly mobile species with regular though very scarce seasonal presence in the region. To account for the highly mobile nature of these species, the Basking Shark and Ocean Sunfish Study Area is defined as a 100 km around the Offshore Project Boundary, as shown in **Figure 12.1, Volume 2b** in order to adequately capture records of these normally oceanic species.

12.4.3 TEMPORAL SCOPE

- 12.4.3.1 The temporal scope of the assessment of Fish Ecology is the entire lifetime of the Offshore Project, which therefore covers the construction, operation and maintenance (O&M), and decommissioning phases. The construction phase is anticipated to be between 2028 and 2033, with works being undertaken between April and October. The operational lifetime of the Offshore Project is up to 35 years.

12.4.4 POTENTIAL RECEPTORS

- 12.4.4.1 The spatial and temporal scope of the assessment enables the identification of receptors which may experience a change as a result of the Offshore Project. For the purposes of this assessment, fish have been grouped into 2 broad ecological receptor group categories, as defined in **Table 12-4**.
- 12.4.4.2 It is recognised that within the broad receptor groups defined in **Table 12-4**, different fish species may share ecological, behavioural or life-history traits that influence how they respond to a given impact pathway. For this reason, receptors are often assessed within ecologically meaningful groups (e.g., species with nursery grounds, species with spawning grounds), as these shared characteristics result in similar pathways of effect.

12.4.4.3 In addition, where an individual species exhibits specific sensitivities, or holds particular ecological, conservation or commercial importance, or where its response is not adequately represented by the wider group, that species may be assessed in isolation. In such cases, the value and sensitivity of the species are considered separately, and, where appropriate, a species-specific significance conclusion provided. Important ecological features (IEF)⁴, contained within these receptor groups and taken forward to assessment, are identified and presented in the baseline conditions, see Section 12.6.

12.4.4.4 Priority marine species and protected species, where identified, are considered within each relevant ecological group. These groupings provide a structured framework for assessing potential impacts on fish communities at an ecological level.

Table 12-4 Receptors requiring assessment for Fish Ecology

Receptor Group	Receptors included within group
Marine fish	Pelagic species including Atlantic herring, mackerel and European sprat (Section 12.6)
	Demersal species including anglerfish, Atlantic cod and sand eel (Section 12.6)
	Elasmobranchs including basking sharks, common skate complex (Section 12.6)
Diadromous fish and Freshwater Pearl Mussel (FWPM)	Atlantic salmon, sea trout and European eel (Section 12.6)

12.4.5 ACTIVITIES OR IMPACTS SCOPED IN TO THE ASSESSMENT

12.4.5.1 Potential impacts on Fish Ecology receptors that have been scoped in for assessment are summarised in **Table 12-5**.

⁴ Components of an ecosystem that are vital to its function and biodiversity. Such as, habitats, species, or processes.
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Table 12-5 Activities or impacts scoped into the assessment for Fish Ecology

Receptor	Activity or Impact	Potential Effect
Construction		
Marine fish and diadromous fish	Short term seabed habitat loss and/or disturbance during construction due to seabed preparation, cable laying, Horizontal Directional Drilling (HDD) bores and breakout locations, scour protection, anchor placements, impacts from jack-up operations and installation of temporary foundations.	Short term seabed habitat loss and disturbance may lead to the temporary degradation or loss of sensitive fish habitats, including foraging, spawning, and nursery grounds.
Marine fish and diadromous fish	Increases in suspended sediment concentration and associated sediment deposition during construction due to direct interaction with the seabed from the installation and/or removal of objects, including seabed preparation, cable laying, anchor placements, impacts from jack-up operations and drilling of the Wind Turbine Generator (WTG) jacket foundation piles.	Temporary increases in suspended sediments may affect the respiration mechanisms of some fish and reduce the success of pelagic spawning events. Reduced visibility may affect predator-prey interactions. The resettlement of suspended material may also lead to the smothering of less-mobile species (e.g., benthic species that burrow in the sediment) and/or vulnerable life stages (e.g., eggs and larvae).
Marine fish and diadromous fish	Underwater noise and vibration (as a source of noise within the water column) from impact piling, as well as continuous noise from vessel operations.	Underwater noise and vibration (as a source of noise within the water column) may cause mortality, recoverable injury, temporary impairment (referred to as temporary TTS) or behavioural changes (including barrier effects) in fish species.
Marine fish and diadromous fish	Trenchless techniques used for Offshore Cable installation at landfall during the construction phase may release drilling fluids into the water column, and construction of HDD exit pits may release sediment, contributing to temporary increases in suspended sediment concentration (SSC) and subsequent deposition	Temporary increases in suspended sediments may affect the respiration mechanisms of some fish and reduce the success of pelagic spawning events. Reduced visibility may affect predator-prey interactions. The resettlement of suspended material may also lead to the smothering of less-mobile species (e.g., benthic species that burrow in the sediment) and/or vulnerable life stages (e.g., eggs and larvae).
Operation and maintenance		
Marine fish and diadromous fish	Long term seabed habitat loss/change from the presence of permanent infrastructure, including wind WTGs, offshore substation, scour protection	Long term degradation or loss of sensitive fish habitats, including foraging, spawning, and nursery grounds.

Receptor	Activity or Impact	Potential Effect
	and cable protections, and associated maintenance activities.	
Marine fish and diadromous fish	Short term seabed habitat loss/change and/or disturbance from maintenance activities, including cable repair and replacement and associated placement of jack-up vessels (JUVs).	Short term degradation or loss of sensitive fish habitats, including foraging, spawning, and nursery grounds.
Marine fish and diadromous fish	Increases in suspended sediment concentration and associated sediment deposition during maintenance activities due to direct interaction with the seabed during maintenance of and/or removal of objects, including repair and reburial of cables, impacts from jack-up operations and associated seabed preparation and anchor placement.	Temporary short-term increases in suspended sediments and contaminants may affect the respiration mechanisms of some fish and reduce the success of pelagic spawning events. Reduced visibility may affect predator-prey interactions. The resettlement of suspended material may also lead to the smothering of less-mobile species (e.g., benthic species that burrow in the sediment) and/or vulnerable life stages (e.g., eggs and larvae).
Marine fish and diadromous fish	Continuous underwater noise and vibration (as a source of noise within the water column) from WTGs and vessel operations. Effects of seabed vibration from WTG operation on diadromous fish is also discussed.	Underwater noise and vibration (as a source of noise within the water column) may cause impairment, and/or behavioural changes in fish species. Effects of seabed vibration from WTG operation on diadromous fish is also discussed.
Marine fish and diadromous fish	Electromagnetic Field (EMF) generated through the subsea electrical cabling	EMF may affect electro or magneto-sensitive fish species, including navigation of migratory fish, and prey/predator relationships by inhibiting/interfering with fish behaviours.
Marine fish and diadromous fish	Aggregation effects due to the presence of infrastructure in the water column and on the seabed	Hard substrates and structures within the water column, and on the seabed, may attract fish over time due to biofouling and added habitat complexity resulting in potential localised increases in biodiversity and potential changes in prey-predator interactions.
Decommissioning		
Marine fish and diadromous fish	Short term seabed habitat loss and/or disturbance during decommissioning activities.	Short term loss of sensitive fish habitats, including key foraging, spawning, and nursery grounds.
Marine fish and	Increases in suspended sediment concentration and associated sediment	Temporary short-term increases in suspended sediments and contaminants may affect the

Receptor	Activity or Impact	Potential Effect
diadromous fish	deposition during decommissioning activities due to direct interaction with the seabed during removal of objects.	respiration mechanisms of some fish and reduce the success of pelagic spawning events. Reduced visibility may affect predator-prey interactions. The resettlement of suspended material may also lead to the smothering of less-mobile species (e.g., benthic species that burrow in the sediment) and/or vulnerable life stages (e.g., eggs and larvae).

12.4.6 ACTIVITIES OR IMPACTS SCOPED OUT OF ASSESSMENT

12.4.6.1 A number of potential impacts 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 wealth of evidence 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 12-6**.

Table 12-6 Activities or impacts scoped out of assessment for Fish Ecology

Activity or impact	Rationale for scoping out.
Ghost fishing due to the presence of lost fishing gear entangled/snagged by infrastructure	Lost fishing gear is known to cause entanglement, due to fish aggregation effects (i.e. passive/ghost fishing). However, as all WTGs will be fixed base there will be no mooring lines associated with the Offshore Project in the operational stage, and vessel mooring lines will be only temporary. MD-LOT agreed that Ghost fishing can be scoped out of the EIA in the Scoping Opinion.
Invasive Non-native Species (INNS)	In the Scoping Report, fish and shellfish ecology were presented together in a single chapter. Since then, the topics have been separated: shellfish ecology is now covered under the benthic ecology chapter (Chapter 11, Volume 2a , while Fish Ecology is addressed independently. INNS remains in-scope for benthic ecology (including shellfish) but is scoped out of the Fish Ecology assessment. Potential risks to fish receptors will be effectively managed through the Invasive Non-Native Species Management Plan, Volume 3 , which includes measures such as vessel biosecurity protocols and ballast water management. These controls are considered sufficient to manage the relevant risks, and further assessment under Fish Ecology is therefore not required.
Release of drilling fluid, drilling arisings or bentonite during the Operational and Maintenance and	Allowance for HDD, whereby there could be potential release of drilling mud, has been removed from the design envelope for the operational, maintenance and decommissioning phase. Therefore, there is no impact during Offshore Project phases. As such, this impact has only been assessed for the Construction Phase (refer Section 12.12).

Activity or impact	Rationale for scoping out.
Decommissioning phases.	
Effect of seabed vibration on fish during all stages of the development	<p>While vibration from percussive piling into the seabed will occur during construction, there is no practical methodology available to calculate or assess this potential mechanical impact in isolation. MD-LOT and NatureScot agreed that this impact pathway for benthic and demersal species can be scoped out in the Scoping Opinion, but it was requested that the effects of seabed vibration on migratory species be included (MD-LOT paragraph 5.2.2.2; Scoping Opinion, NatureScot – pg. 34; Appendix I Consultation representations).</p> <p>The migratory species scoped-in for assessment for the Offshore Project are Atlantic salmon, sea trout and European eel. Because they are present in the water column they do not directly detect mechanical seabed vibration. These species detect seabed vibration transmitted into the water column as particle motion through their auditory apparatus. Vibration as a contributory source of noise within the water column is assessed as part of the underwater noise and vibration assessment for all fish receptors (refer Section 12.8.4 and 12.9.4).</p>
Effect of lighting on migratory fish during all stages of the development	<p>Lighting will occur throughout the Offshore Project from vessels during construction, maintenance, and decommissioning activities, as well as from aviation and navigation lighting on structures (WTGs/OSP (if required)) during the O&M phase. There is potential that lighting can impact migrating fish due to increased predation and displacement effects.</p> <p>The Fish Ecology assessment has scoped-in and assessed potential displacement impacts of the Offshore Project on migratory fish during all project phases (see Sections 12.8.1, 12.8.2, 12.8.4, 12.9.1, 12.9.2, 12.10.1, and 12.10.2).</p> <p>The Offshore Project has included mitigation that reduces the potential impact on migratory fish, this includes embedded measures as part of the project design (restricting the percussive piling installation to the northern part of the site, and restricting the maximum duration of percussive piling per day) and commitments (M022 Development of a Navigational Safety and Vessel Management Plan, M033 Development of a Lighting and Marking Plan, A006 Development of a Piling Strategy that restricts percussive piling to avoid Atlantic salmon smolt migration periods and zones percussive piling during Atlantic salmon migration to reduce the ensonified area in the nearshore, and quiet periods to provide fish movement windows between percussive piling activity).</p> <p>Lighting from vessels is considered to be localised as it is likely that construction works will take place at specific locations for the installation of individual structures at any given time, or maintenance of individual structures.</p>

Activity or impact	Rationale for scoping out.
	<p>Therefore, the potential for barrier effects on fish migration will be spatially limited across the site.</p> <p>During the O&M phase, aviation and navigation lighting of structures is required for aircraft and vessel safety. An overview of the policy/guidance lighting required is provided in the Outline Lighting and Marking Plan, Volume 3. The lighting required will comprise of flashing lighting, which reduces the potential impact on migratory fish. The Applicant will consider reducing lighting requirements where possible (i.e. during clear weather conditions) to reduce potential impacts on a number of receptors including migratory fish. Further to this, lighting requirements for structures will be angled towards the intended receptor (aircraft/vessels) for safety. Therefore, minimal lighting will be angled directly downwards into the water.</p> <p>Overall, lighting from vessels is short-term and localised in nature, and lighting will be located high up on structures (i.e. tips of blades) and will be inherently incorporate measures to reduce the potential for effects on migratory fish. As such, further assessment is not required.</p>

12.5 METHODOLOGY FOR BASELINE DATA GATHERING AND IMPACT ASSESSMENT

12.5.1 METHODOLOGY FOR BASELINE DATA GATHERING

Overview

12.5.1.1 Baseline data collection has been undertaken to obtain information over the Study Area described in Section 12.4. The current baseline conditions presented in Section 12.6 sets out data currently available information from the Study Areas.

Desk study

12.5.1.2 The data sources that have been collected and used to inform this Fish Ecology assessment is summarised in **Table 12-7**. It does not provide an exhaustive list of all literature reviewed and rather focuses on primary data sources.

12.5.1.3 For the purpose of assessment, fish have been categorised into the following ecological groups:

- Pelagic fish species;
- Demersal fish species;
- Elasmobranchs species;
- Diadromous fish species.

12.5.1.4 Red listed, rare and/or legally protected marine species that were identified have been addressed in their respective ecological group as defined above.

Table 12-7 Data sources used to inform the Fish Ecology EIA

Source	Date	Summary	Coverage of Study Area
Distribution of spawning and nursery grounds defined by Coull <i>et al.</i> (1998) and Ellis <i>et al.</i> (2012)	2012 (<i>inclusive of Coull et al, 1998 data</i>)	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 <i>et al.</i> , 2014)	2014	Distribution of 'sensitive areas' of key commercial species based on evidence of aggregations of 0 group fish (first within their first year of life) and/or larvae.	Full coverage of the Marine Fish Study Area
ScotMER: Developing essential fish habitat maps (Franco <i>et al.</i> , 2022)	2022	Distribution of Essential Fish Habitat (EFH) (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
Sandeel models (Langton <i>et al.</i> 2021)	2021	Species distribution models developed to predict the occurrence and density of these species in parts of the Celtic Sea. This 'hurdle' model considers a number of factors including sediment silt and sand component percentage, seabed slope, and a depth range of 30-50 m as predictors of sandeel presence and density.	Partial coverage of the Marine Fish Study Area
Scottish Sea Fisheries Statistics 2023 Landings Data (Scottish Government, 2023)	2019 - 2023	Detailed information on landings (tonnage and value) of fish species by ICES rectangle.	Full coverage of the Marine Fish Study Area
International Bottom Trawl Survey (ICES, 2024b)	2020 - 2024	The International Bottom Trawl Survey Working Group (IBTSWG) fishery-independent multispecies bottom-trawl surveys by ICES rectangle.	Full coverage of the Marine Fish Study Area
Eggs and Larvae Database (ICES, 2024d)	2020 - 2024	The IBTSWG fishery-independent multispecies egg and larvae surveys by ICES rectangle. While no ICES Larvae Working Group or survey	Full coverage of the Marine Fish Study Area

Source	Date	Summary	Coverage of Study Area
		campaign currently focuses explicitly on the waters west of Scotland/ <i>Alba</i> , around the Isle of Lewis/ <i>Eilean Leòdhais</i> , historical surveys have covered this region and have been considered.	
Oyster Wave Array Environmental Statement (Royal Haskoning, 2012)	2012	Report identifies a fish and shellfish baseline and includes primary data (vantage point surveys) for basking shark.	Partial coverage of the Fish Ecology Study Area
Scottish Marine and Freshwater Science Volume 1 no. 14. Marine Directorate Science	2010	This report outlines major migration routes and behaviours of Atlantic salmon <i>Salmo salar</i> , brown trout <i>Salmo trutta</i> , and European eel <i>Anguilla anguilla</i> in and around the Diadromous Fish Study Area.	Full coverage of the Diadromous Fish Study Area
Rod fishery statistics - reported catch by Stock Assessment Area (Dataset) (Marine Scotland, 2024)	Salmon: 2011 to 2023 Sea trout: 2017-2023	Reported rod catches of salmon and sea trout provided by Stock Assessment Area and month.	Partial coverage of the Diadromous Fish Study Area
Stock estimates of salmonid populations (Dataset) (Marine Scotland, 2023)	2020-2024	Reported stock estimates of salmon and sea trout provided by Stock Assessment Area.	Partial coverage of the Diadromous Fish Study Area
Fish tagging and genetic studies and reviews on migratory fish published by Marine Scotland (Malcolm et al. 2010; Godfrey et al. 2014; Cauwelier et al. 2015; Downie et al. 2018; and Armstrong et al. 2018)	2010-2018	Research on the migratory patterns of salmonids and European eels within Scottish waters.	Full coverage of the Diadromous Fish Study Area.

12.5.1.5 To inform the baseline characterisation and support the assessment, fisheries data from the International Council for the Exploration of the Sea (ICES) has been used. ICES collates data and scientific reports on marine fisheries and ecosystems for the Atlantic Ocean, the Arctic, the Mediterranean and Baltic Seas. Information is organised in a grid system of statistical rectangles (ICES rectangles). Relevant data have been accessed for those rectangles which intersect the Marine

Fish Study. The specific ICES rectangles relevant to this assessment are ICES 47E2, 47E3, 47E4, 46E1, 46E2, 46E3, 46E4, 45E1, 45E2, 45E3, and 44E2 and are shown on **Figure 12.1, Volume 2b**.

Site Surveys

- 12.5.1.6 Several surveys were conducted to support the baseline characterisation of Fish Ecology in the Offshore Project Boundary. These included the collection of environmental DNA (eDNA), a juvenile salmonid acoustic fish tracking study, and baited remote underwater video (BRUV) sampling. Additionally, data from surveys carried out for benthic ecology and marine mammal baselines were used to inform the Fish Ecology baseline. This included seabed habitat characterisation to inform benthic ecology, such as particle size distribution data from grab samples, which helped assess the presence of suitable habitat for key fish species. Digital Aerial Surveys (DAS), conducted primarily for birds and marine megafauna, also recorded incidental detections of fish or fish-related activity.
- 12.5.1.7 The surveys that have been collected and used to inform this Fish Ecology assessment is summarised in **Table 12-8**.

Table 12-8 Site surveys undertaken

Survey type	Scope of survey	Coverage of Study Area
eDNA ⁵	Collection of water and sediment eDNA samples. Samples were analysed for marine fish (excluding sharks and rays).	A total of 30 water samples collected from 3 depths (surface, middle, and bottom) at 10 sampling stations, and sediment samples from 5 stations within the Offshore Project Boundary. Positioned specifically to target potential sensitive habitats.
Juvenile salmonid acoustic fish tracking study	Acoustic tracking of 100 juvenile salmon smolt caught, tagged and released at the lower River Grimersta to investigate the travel paths of out-migrating salmon post-smolts through East Loch Roag/ <i>Loch Ròg</i> and within the Array Area.	A total of 20 receiver stations within the Array Area and 13 within the Loch Roag/ <i>Loch Ròg</i> , located from the release site to the seaward limit of East Loch Roag/ <i>Loch Ròg</i> .
BRUV ⁶	BRUV surveys undertaken to provide information on the marine fauna using the Offshore Project Boundary.	A total of 7 BRUV deployments positioned across the Offshore Project Boundary, with 1 hour of film analysed per deployment.

⁵ eDNA sampling involves collecting water samples containing environmental DNA shed by organisms, such as scales, mucus, or waste, to detect the presence of fish and other aquatic species.

⁶ Baited underwater video surveys are a marine research technique where bait is used to attract aquatic species to a stationary underwater camera, allowing for non-invasive observation and assessment of fish abundance, diversity, and behaviour.

Digital Aerial Surveys (DAS)	Aerial surveys flown at 2.2 km spaced flight lines to visually detect birds and marine megafauna.	A total of 24 aerial surveys flown across the Array Area and a 10 km buffer (DAS Survey Area).
Grab samples and Drop-Down Camera (DDC) surveys	Co-located DDC and grab surveys for macrobenthic, sediment particle size distribution (PSD) and chemical contaminant analysis.	55 DDC stations were sampled (550 still images and 70 videos), and 11 grab samples were collected across the Offshore Project Boundary and analysed for particle size distribution.

12.5.2 DATA LIMITATIONS AND ASSUMPTIONS

Characterisation of Fish Assemblage

- 12.5.2.1 There are several general limitations in the use of eDNA analysis in the marine environment which was undertaken as part of the marine environmental survey (**Annex 12.1.2, Appendix 12.1, Volume 2c**). eDNA analysis only provides a qualitative understanding of community diversity because abundance is only represented as a 'strong/weak' DNA signal which cannot be directly interpolated as population size. Lack of understanding regarding the rate of degradation of eDNA, and the reliability of taxonomic reference databases for marine species introduce further inaccuracies. Specifically in relation to the fish analysis for the Offshore Project, there was low confidence in the identification of 15 of the most common fish taxa (out of a total of 50 species) based on fewer than 3 matches to sequences in the reference database. Species identified in the eDNA analysis were cross referenced with occurrences in other background data sets to ensure the robustness of the data set.
- 12.5.2.2 Further, BRUV surveys completed in support of the Offshore Project provide only a snapshot in time of the fish assemblage present (**Appendix 11.1, Volume 2c**). Species detected represent those attracted to the bait (which may be selective) and visible during the short deployment period, rather than the full diversity of fish that may occur across seasons or under different environmental conditions. It is important to note that these biases (both for eDNA and BRUV surveys) are not unique to the Offshore Project and are common limitations of all fish surveys.
- 12.5.2.3 Both eDNA and BRUV surveys provide valuable but partial insights into the fish community. To address this, the baseline characterisation integrates multiple sources of information to build a comprehensive and robust understanding of the fish assemblage relevant to the Offshore Project. These sources include site-specific surveys, regional databases and fisheries catch records (refer to **Table 12-7**, and detailed in **Appendix 11.1, Volume 2c** (BRUV surveys) and **Annex 12.1.2, Volume 2c** (eDNA)). Based on the combination of site-specific surveys and online sources, the baseline characterisation is considered robust and sufficient to inform the EIA and support the assessment of potential impacts on fish.

Migratory Behaviours and Population Size of Salmonids

- 12.5.2.4 Several limitations of the juvenile salmon acoustic tracking study should be noted. The detector array was configured to ensure that tagged fish were unable to pass without detection, based on the assumption of a maximum detection range of the receivers of between 300 m and 400 m. However, several factors such as boat traffic, wave action and bubble entrainment, fouling and debris can affect detection ranges. To reduce the impact of these factors, multiple zones were deployed to reduce the potential for missed detections.
- 12.5.2.5 In addition, only 100 post-smolts were tagged for the study, which limits the sample size and therefore the ability to fully capture variability in migratory behaviour across the population. While this provides valuable insight into movement patterns, it represents a subset of the overall population and should be interpreted accordingly. To address these limitations, the baseline characterisation draws on published literature and online data sources to describe the migratory behaviours of juvenile salmon. By integrating the acoustic tracking data with literature and regional datasets, the baseline characterisation is considered robust and sufficient to inform the EIA and to assess potential impacts on juvenile salmon migration within the Offshore Project Boundary.
- 12.5.2.6 The Atlantic salmon rod catch and stock assessment data (Marine Scotland 2023; Marine Scotland 2024) used to provide an insight into the patterns of adult salmon migrations (paragraph 12.6.1.20 to 12.6.1.24) is only collected during the angling season with potential inaccuracies in the way that rod returns are reported. A full description of the approach to the analysis and the limitations of the data sets is provided in **Appendix 12.2, Volume 2c**. However, no other data sets exist for returning adult salmon. Other data sets relating to Fish Ecology are considered to be robust as a baseline for this EIA.

12.5.3 METHODOLOGY FOR ENVIRONMENTAL IMPACT ASSESSMENT

Introduction

- 12.5.3.1 The project-wide generic approach to assessment is set out in **Chapter 5, Volume 1a**. The following sections provide the assessment methodology used to assess the potential impacts on Fish Ecology only.
- 12.5.3.2 The assessment presented in this chapter has been conducted in line with current good practice from the Chartered Institute of Ecology and Environmental Management's Guidelines for Ecological Impact Assessment (CIEEM, 2018). Each receptor has been evaluated within the geographic area relevant to Fish Ecology and against potential impacts from the construction, O&M and decommissioning phases of the Offshore Project.
- 12.5.3.3 A matrix approach as described in **Chapter 5, Volume 1a** has been used to determine the significance of effects, by comparing impact magnitude against receptor value and sensitivity.

Impact Assessment criteria

Magnitude

- 12.5.3.4 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 impact to each receptor. Magnitude is evaluated in accordance with the definitions set out in CIEEM's Guidelines, summarised in **Table 12-9**.
- 12.5.3.5 The following characteristics will be used to assess the magnitude of the impact on Fish Ecology as a result of the Offshore Project:
- Type of impact – beneficial or adverse;
 - Extent or spatial scope of the impact;
 - Reversibility of impact (i.e., how easily the environmental conditions return to a pre-activity state) - whether the impact is naturally reversible or reversible through mitigation measures;
 - Timing and frequency of the impact, in relation to ecological changes;
 - Likely duration of the impact – short term (< 5 year), medium term (5-10 years) or long term (10 or more years).

Table 12-9 Fish ecology definitions of impact magnitude classes

Magnitude of Impact	Definition
Negligible	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.
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 5-10 years.
High	Changes to natural conditions that alters 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.

Sensitivity (and value)

- 12.5.3.6 Four-point scales (high, medium, low or negligible) have been developed to define ecological sensitivity for fish species. These scales have been developed with reference to the Marine Life Information Network (MarLIN) Marine Evidence based Sensitivity Assessment (MarESA) (Tyler-Walters, 2023). Marine Directorate's Feature Activity Sensitivity Tool (FeAST, 2025) has also been used in assessment of sensitivities. FeAST has developed a sensitivity matrix of marine habitats and species to pressures taking place in the marine environment.

12.5.3.7 The sensitivity of a feature is dependent upon its adaptability (the degree to which a feature can avoid or adapt to an effect), 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). The scales for tolerance and recoverability are provided in **Table 12-10** and **Table 12-11** and the matrix of sensitivity scores is provided in **Table 12-12**.

Table 12-10 Assessment scale for tolerance to a defined intensity of pressure

Tolerance	Description
High	No significant effects on the physicochemical character of habitat and no effect on population viability of key/characterising species however may affect feeding, respiration and reproduction rates.
Medium	Some mortality of species (can be significant where these are not keystone structural/functional and characterising species) without change to habitats, this 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 in the extent, density or abundance of the selected habitat or species (i.e. up to 75% reduction in habitat area or reduction in population density).
None	Key functional, structural, characterising species severely decline and/or physicochemical parameters are also affected e.g. removal of habitats, causing a change in habitat types. A severe decline/reduction relates to the loss of 75% or more of the extent, density or abundance of the selected species or habitat component.

Table 12-11 Assessment scale for recovery

Recovery	Description
High	Full recovery (return to baseline levels) within 2 years.
Medium	Full recovery (return to baseline levels) within 2-10 years.
Low	Full recovery (return to baseline levels) within 10-25 years.
Very Low	Negligible or prolonged recovery possible, at least 25 years to recover structure and function.

Table 12-12 Sensitivity of a receptor (based upon tolerance and recovery alone)

	Tolerance			
Recovery	None	Low	Medium	High
Very low	High	High	Medium	Low
Low	High	High	Medium	Low
Medium	Medium	Medium	Medium	Low
High	Medium	Medium	Low	Negligible

- 12.5.3.8 The 'value' of a feature also requires consideration in the assessment. Nature conservation status is used for the definition of 'Value' as this not only considers the legal protection of species or habitats, but embedded within these designations are considerations of ecological and socio-cultural importance.
- 12.5.3.9 The definitions of value levels have been developed using a four-point scale with example definitions of the value levels provided in **Table 12-13**. The value of a receptor will be used as a modifier for the sensitivity assigned to the feature (where required).
- 12.5.3.10 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 (e.g. an Annex I habitat within a National Site Network (NSN) site) but have a low or negligible physical/ecological sensitivity to an effect – it is important not to inflate impact significance just because a feature is 'valued'. This is where the narrative behind the assessment is importance; the value can be used where relevant as a modifier for the sensitivity assigned to the feature.

Table 12-13 Examples of definitions of value levels for Fish Ecology

Value	Criteria
High	Internationally/nationally important/rare: Habitats and species protected under international instruments (e.g., qualifying features of an SAC) and habitats and species that are qualifying features of NSN sites located within the Fish Ecology Study Area.
Medium	Regionally important/rare: Habitats or species protected under national law but not within a NSN site within the Fish Ecology Study Area. Species or habitats listed as Priority Marine Features (PMFs) or on the Scottish Biodiversity List.
Low	Locally important/rare: Species that form an important prey item for other species of conservation value and that are key components of the fish assemblages within the Fish Ecology Study Area.
Negligible	Common habitats and species: Habitats and species that are not protected under any national, regional or local conservation programmes or designations and have widespread distribution in Scotland/ <i>Alba</i> .

Significance

- 12.5.3.11 Following the identification of the magnitude of impact, features value and sensitivity it is possible to determine the significance of effect. The matrix provided in **Table 12-14** (which aligns with Table 5-2 in **Chapter 5, Volume 1a**) is used as a framework to aid in determination of the impact assessment and provides further detail of what effect is considered to be significant.

Table 12-14 Significant of effect matrix

		Sensitivity of Receptor			
		Negligible	Low	Medium	High
Magnitude of Impact	Negligible	Negligible (Not Significant)	Negligible (Not Significant)	Negligible (Not Significant)	Negligible (Not Significant)
	Low	Negligible (Not Significant)	Negligible (Not Significant)	Minor (Not Significant)	Minor (Not Significant)
	Medium	Negligible (Not Significant)	Minor (Not Significant)	Moderate (Potentially Significant)	Moderate (Potentially Significant)
	High	Negligible (Not Significant)	Minor (Not Significant)	Moderate (Potentially Significant)	Major (Significant)

12.6 BASELINE CONDITIONS

12.6.1 CURRENT BASELINE

Overview

12.6.1.1 Baseline data collection has been undertaken to obtain information over the study areas described in Section 12.4. A summary of the baseline environment has been derived from the results of the desk study data and site specific surveys detailed in Section 12.5 and is outlined in this section. The baseline is presented in full in **Appendix 12.1, Volume 2c**.

Pelagic Fish

12.6.1.2 A total of 10 pelagic species were recorded within the Marine Fish Study Area, details of which are provided in **Annex A of Appendix 12.1, Volume 2c**. Potential spawning and nursery grounds were identified within the Marine Fish Study Area for the following species: Atlantic herring, Atlantic mackerel *Scomber scombrus*, Blue whiting *Micromesistius poutassou* and European sprat *Sprattus sprattus*. Main spawning periods for these species is shown in **Table 12-15**, and are discussed in further detail in Section 4.1.2 of **Appendix 12.1, Volume 2c**.

Table 12-15 Main periods of spawning activity for key pelagic species found within the Marine Fish Study Area. Light blue indicates spawning period, and dark blue indicates peak spawning period (Ellis et al., 2012).

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Atlantic herring*												
Atlantic mackerel												
Blue whiting												
European sprat												
*West of Scotland (WoS) populations												

- 12.6.1.3 Atlantic herring is of key ecological and commercial importance. Recent sensitivity mapping suggests a high probability of high Atlantic herring larvae concentrations across the Marine Fish Study Area, with the highest probability concentrated along the coastal extent of the Offshore Project Boundary, and to the north around the northern point of the Isle of Lewis/*Eilean Leòdhais*. Despite this, sampling conducted between 2020-2024 showed that the majority of the Offshore Project Boundary has unsuitable sediment for Atlantic herring spawning. Furthermore, recent larval Atlantic herring abundance surveys demonstrated no explicit records of Atlantic herring eggs or larvae within the Marine Fish Study Area. Subsequent modelling described the Offshore Project Boundary as generally of medium suitability for Atlantic herring spawning, though suitability decreases to low within the inshore portion of the Offshore Cable Area of Search (OCAS). Overall, Atlantic herring spawning is likely to occur in some parts of the Offshore Project Boundary and across the broader Marine Fish Study Area. The highest probability of spawning within the Offshore Project Boundary is in its southern region, predominantly in autumn (though some spawning may occur in spring).
- 12.6.1.4 Ocean sunfish are classified as vulnerable on the IUCN red list and have a decreasing population trend. The species has been recorded in low numbers off Scottish coasts due to winter temperatures falling below their thermal tolerance. DAS of the Offshore Project Boundary recorded 2 ocean sunfish, 1 in September 2022 and 1 in August 2023, although both recordings were not within the Array Area. However, Ocean sunfish eggs and larvae were recorded in 24 of 39 egg and larvae hauls undertaken across the Marine Fish Study Area between 2020-2024.
- 12.6.1.5 Atlantic bluefin tuna is an important species for commercial fisheries and are being increasingly observed within northeast Atlantic. DAS of the Offshore Project Boundary recorded 1 single Atlantic bluefin tuna in November 2023 and this was outside the Array Area.

Demersal Fish

- 12.6.1.6 A total of 74 demersal species were recorded within the Marine Fish Study Area, details of which are provided in **Annex A of Appendix 12.1, Volumes 2c**. Potential spawning and nursery grounds were identified within the Marine Fish Study Area for the following demersal species: Anglerfish *Lophius budegassa*, Atlantic cod, European hake *Merluccius merluccius*, European plaice *Pleuronectes platessa*, haddock *Melanogrammus aeglefinus*, lemon sole *Microstomus kitt*, ling *Molva molva*, Norway pout *Trisopterus esmarkii*, saithe *Pollachius virens*, sandeels, and whiting *Merlangius merlangus*. Main spawning periods for these species is shown in **Table 12-16**, and are discussed in further detail in Section 4.2.2 of **Appendix 12.1, Volume 2c**.

Table 12-16 Main periods of spawning activity for key demersal fish species in the Marine Fish Study Area. Light blue indicates spawning period, and dark blue indicates peak spawning period (Coull et al., 1998; Ellis et al., 2012).

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Anglerfish	Light Blue											
Atlantic cod	Light Blue	Dark Blue	Dark Blue	Light Blue								
European hake	Light Blue	Dark Blue	Dark Blue	Light Blue	Light Blue	Light Blue						
European plaice	Light Blue	Light Blue	Dark Blue									
Haddock		Dark Blue	Dark Blue	Dark Blue	Light Blue							
Lemon Sole			Light Blue	Dark Blue	Light Blue							
Ling		Light Blue	Light Blue	Light Blue	Light Blue							
Norway pout	Light Blue	Dark Blue	Dark Blue	Light Blue								
Saithe	Dark Blue	Dark Blue	Light Blue	Light Blue								
Sandeel	Light Blue	Light Blue									Light Blue	Light Blue
Whiting	Light Blue											

12.6.1.7 Sandeels are of high conservation importance with a total of 5 species found in Scottish waters. Sandeel from the genus *Ammodytes* were recorded adjacent to the OCAS and eDNA of Smooth sandeel was detected within the Offshore Project Boundary (for further information, see **Annex B of Appendix 12.1, Volumes 2c**). Modelling results indicate that the Offshore Project Boundary is generally of low suitability for sandeel species, with the exception of the southwest region which is indicated to be of medium potential. In addition, an area of prime habitat was identified from site-specific surveys in the northern portion of the Array Area. Survey data and modelling together suggest that sandeel are present within the Offshore Project Boundary, with the highest likelihood and densities occurring in the southwestern region of the Array Area.

Elasmobranchs

12.6.1.8 The elasmobranchs consist of sharks, skates, and rays. A total of 22 elasmobranch species were recorded within the Marine Fish Study Area, details of which are provided in **Annex A of Appendix 12.1, Volumes 2c**. Potential nursery grounds were identified within the Marine Fish Study Area for the following elasmobranchs: common skate complex (including both the blue skate *Dipturus batis* and flapper skate *Dipturus intermedius*), spotted ray *Raja montagui*, thornback ray *Raja clavata*, spurdog *Squalus acanthias*, and tope shark *Galeorhinus galeus*. Main spawning periods for these species is shown in **Table 12-17**, and are discussed in further detail in Section 4.3.2 of **Appendix 12.1, Volume 2c**.

Table 12-17 Main periods of spawning activity for key elasmobranch species found within the Marine Fish Study Area. Light blue indicates spawning period, and dark blue indicates peak spawning period (Ellis et al., 2012).

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Common skate complex*	Light blue	Light blue	Light blue	Light blue	Light blue	Light blue	Light blue	Light blue	Light blue	Light blue	Light blue	Light blue
Spotted ray				Light blue	Dark blue	Dark blue	Dark blue	Light blue				
Spurdog	Viviparous species (gravid females can be found all year round)											
Thornback ray		Light blue	Light blue	Dark blue	Dark blue	Dark blue	Dark blue	Dark blue	Light blue			
Tope shark	Viviparous species (gravid females can be found all year round)											
*As the spawning period for the common skate complex is unknown, a precautionary approach has been adopted, and it is assumed that spawning may be occurring all year round.												

12.6.1.9 The critically endangered common skate complex, which comprises 2 species (blue skate and flapper skate) has been observed in reef habitat off the Orkney Isles/*Arcaibh*. Although there are extensive areas of reef habitat within the Array Area and OCAS, the depth range of these areas of 25-72 m is considered unlikely to offer particularly favourable conditions for egg-laying across much of the Marine Fish Study Area. Observations in the Orkney Isles/*Arcaibh* indicate that skates favour egg-laying habitat characterised by reef habitat with boulder or cobbles in shallow waters <20 m.

12.6.1.10 Blue sharks are regarded as a near threatened species. DAS conducted in August 2022 and September 2022 for the Offshore Project recorded 1 and 25 blue sharks respectively. These sightings were within the DAS survey area which included the Offshore Project Boundary.

12.6.1.11 Basking sharks have legal protection under the Conservation of Offshore Marine Habitats and Species Regulations 2017 in Scotland/*Alba* and are also listed as a designated feature within the Sea of the Hebrides Marine Protected Area (MPA), located approximately 93 m to the south of the Offshore Project Boundary (by sea-distance). Basking sharks have been recorded in the vicinity of the Offshore Project along the northwest coast of the Isle of Lewis/*Eilean Leòdhais*, an area that overlaps with the Offshore Project Boundary. Additionally, site-specific surveys undertaken in support of the Oyster Wave Array Environmental Statement, conducted from September 2010 to September 2011, recorded basking sharks on 6 days between May and August. The Oyster Wave Array Project survey area overlaps with the Offshore Project Boundary. DAS conducted in July 2023 recorded basking shark within the DAS survey area although this was not within the Array Area.

Diadromous Fish

12.6.1.12 Diadromous fish spend part of their life in both freshwater and sea water, migrating between the 2 biotopes. Based on the review of desktop sources it is expected that Atlantic salmon, Sea trout *Salmo trutta* and European eel may be present within the Diadromous Fish Study Area of **Appendix 12.1, Volume 2c.**

Atlantic salmon

- 12.6.1.13 Atlantic salmon are widely distributed in Scotland/*Alba*, with the Scottish population recognised as being of both national and international importance. Two Special Areas of Conservation (SAC) designated for Atlantic salmon occur within the Diadromous Fish Study Area; Langavat SAC, and North Harris SAC. The assessment of potential impacts on these SACs is presented in the **Offshore RIAA**.
- 12.6.1.14 Spawning occurs in rivers within the Outer Hebrides/*Na h-Eileanan Sià*, from October to late February (Webb and McLay, 1996). Juveniles typically remain within natal rivers between 1-4 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).
- 12.6.1.15 Smolts migrating from the River Grimersta follow several possible migration routes, either northwards through East Loch Roag/*Loch Ròg* or via a westward channel towards West Loch Roag/*Loch Ròg*. Acoustic-tracking studies of smolts undertaken for the Offshore Project found that, of the 52 smolts that reached the junction of the two migratory paths, 81% (42 individuals) migrated through East Loch Roag/*Loch Ròg*, following a northerly route toward the Array Area. The remaining 10 smolts were last detected on the receiver within the channel leading to West Loch Roag/*Loch Ròg* and were therefore assumed to have taken the westerly migration route towards West Loch Roag/*Loch Ròg*.
- 12.6.1.16 Smolts migrating through West Loch Roag/*Loch Ròg* were not detected in the Array Area. Of the post-smolts that migrated through East Loch Roag/*Loch Ròg*, 15 were detected in the Array Area. There were large variations in the patterns of movement through the Array Area, with the majority of individuals passing through in a relatively direct manner (median time of 16 minutes), although 3 individuals (20% of those detected in the Array Area) spent over 80 minutes in the Array Area. Further, from the observed repeated movements into and out of the detection zone among a small number of individuals, it may be inferred that they were in the region of the Array Area for longer periods (up to 27 hours). The observed doubling-back, looping and east to west trajectories highlighted non-direct migration routes among a few individuals, which sometimes included extended periods spent in the vicinity of a single receiver.
- 12.6.1.17 The tracking study also recorded diel activity of smolts as they moved out of the River Grimersta through the Array Area. The majority of individuals were found to emigrate from Loch Roag/*Loch Ròg* during night time hours, although activity within the Array Area occurred during both the day and night. Results are described in detail in **Appendix 12.1, Volume 2c**; Section 4.4.2.
- 12.6.1.18 Adult salmon undertake long distance migrations between feeding grounds in the Norwegian Sea and west Greenland (Thorstad *et al.*, 2012) and natal rivers on the west coast of Scotland/*Alba*.

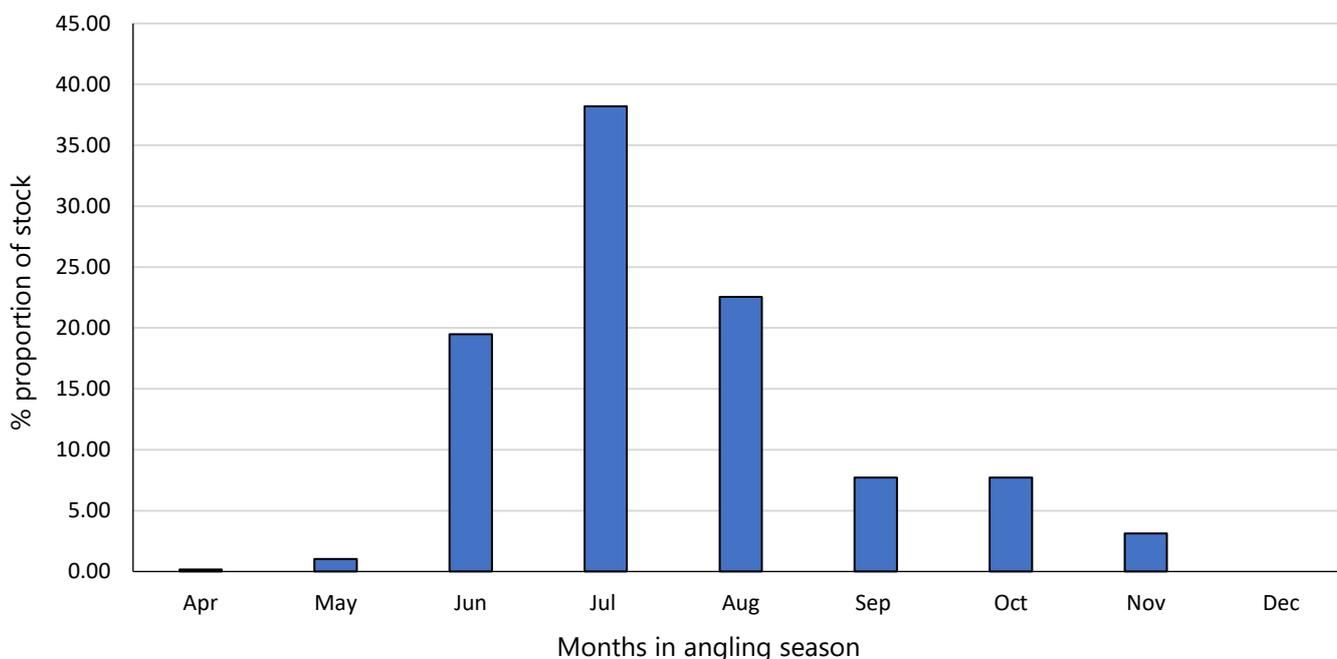
- 12.6.1.19 Adult Atlantic salmon return to freshwater over an extended period (Sparholt *et al.*, 2018). The earliest returning fish are older, multi-sea-winter salmon⁷, entering from the sea in late winter or early spring. Later in the season, from May onwards, grilse (1-sea-winter salmon (1SW)) enter the river, some returning only weeks before spawning, which takes place during late autumn and winter (Youngson *et al.*, 1994).
- 12.6.1.20 To provide further insight into the patterns of adult salmon migrations and support the assessment of underwater noise impacts an analysis of rod catch and stock assessment data from 2020 to 2024 (Marine Scotland, 2023; Marine Scotland, 2024) was undertaken. Stock assessments, used to support the sustainable management of salmon fisheries, are undertaken by spatial units referred to as stock assessment areas. An egg requirement (the numbers of eggs required to maintain sustainable salmon stocks) is set for each area, and an annual assessment undertaken to determine whether the egg requirement has been met. The stock assessment includes a conversion of rod catch data to number of returning Atlantic salmon and therefore can be used as the basis for estimating the size of the adult salmon population. This stock estimate data was extracted for rivers which comprise the Loch Roag salmon fishery district area.
- 12.6.1.21 The aim of the analysis was to provide further detail on the seasonal pattern of salmon returns and the extent to which they coincide with key project activities. One of the key limitations of the stock assessments is that the estimates for months outside the angling season are based on data from river systems with fish counters in mainland Scotland and may be inaccurate for specific for Hebridean rivers. Further detail of the analysis including the limitations of the rod catch and stock assessment data sets is provided in **Appendix 12.2, Volume 2c**.
- 12.6.1.22 Median monthly stock estimates (based on returning adult estimates) from rivers within the Loch Roag salmon fishery district area (River Barvat; River Carloway; Langavat SAC; River Blackwater; Loch Morsgail; Mhor a' Ghlinne Ruaidh and Geisiada; Forsa River, and Caslabhat and Tamanabhaigh) were summed across the 5 years (2020 to 2024) and proportions calculated for each month between April and December (**Table 12-7** and **Plate 12-1**). Langavat SAC (River Grimersta) had the highest stock estimate (sum of 19,159 fish across 5 years) with estimates for the other 4 river systems ranging between 739 and 5,418. The highest stock estimate across all river systems occurred in July, with the second highest predominantly falling in August with the exception of the Langavat SAC where the second highest was June.
- 12.6.1.23 The highest estimated proportion of stock (returning adults) present in all river systems occurred in July (38.2%), with the second highest in August (22.5%) and the third highest in June (19.5%) (**Plate 12-1**). Based on the stock assessment analysis 2SW fish represent the largest proportion of returning adults between January and May with 1SW the predominant age class from June to December.

⁷ Multi-sea-winter spawners are salmon that return to spawn after spending 2 or more winters at sea.
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Table 12-18 Median stock assessment (based on returning adult estimates) of Loch Roag salmon fishery district area by month summed across 5 years (2020 to 2024)

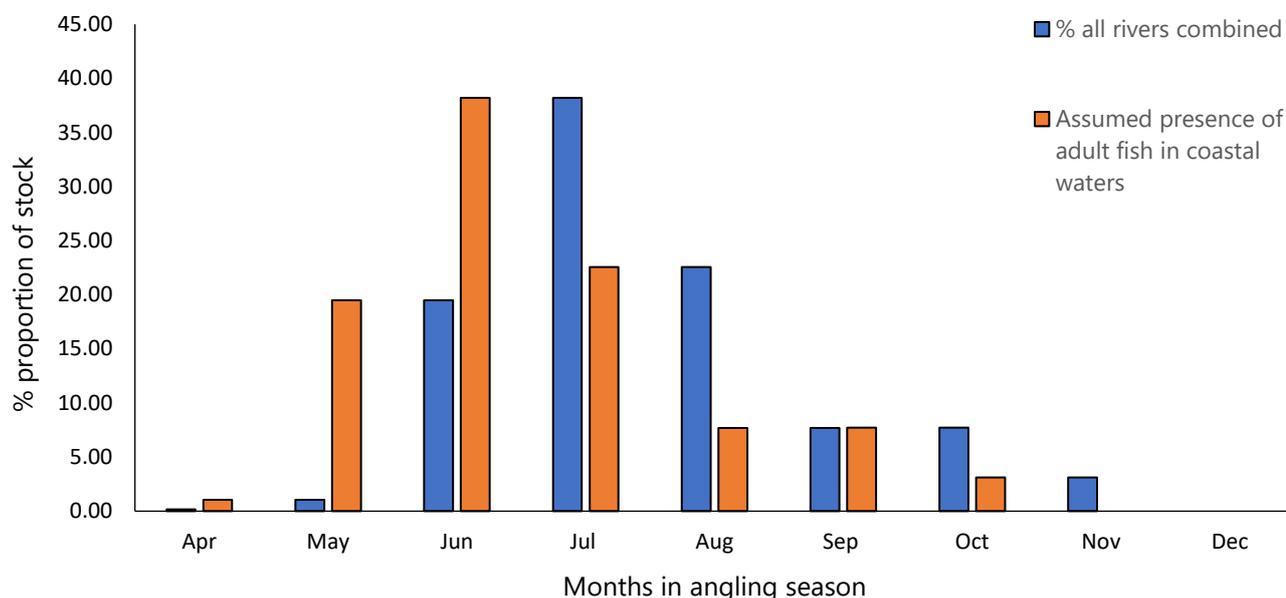
River	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
River Bravas	0	0	78	301	252	76	77	30	0
River Blackwater	11	65	105	315	108	77	77	31	0
River Grimersta/Langavat SAC	0	0	952	1444	848	301	301	123	0
Forsa River	0	0	82	278	132	16	16	6	0
Caslabhat and Tamanabhaigh	0	0	0	47	68	11	11	5	0
Summed median across all rivers	11	65	1217	2385	1408	481	482	195	0
% all rivers combined	0.18	1.04	19.49	38.20	22.55	7.70	7.72	3.12	0.00

Plate 12-1 Graph showing percentage proportion of stock by month within the angling season for all rivers in Loch Roag stock assessment area



12.6.1.24 A conservative assumption has been made that fish will pass through and may remain in coastal waters approximately 1 month before entering their natal rivers. **Plate 12-2** shows the monthly proportions of fish assumed to be in coastal waters based on this assumption. Based on this assumption approximately 80% of the stock (returning adults) will pass through coastal waters during May, June, and July, and approximately 99% between April and November.

Plate 12-2 Proportion of adult salmon assumed to be in coastal waters by month based on stock assessment data.



Sea trout

- 12.6.1.25 Recognised as a species of principal importance, sea trout is a priority marine feature in Scotland/*Alba* listed on the Scottish biodiversity list. Given the nearshore location of the Offshore Project and its proximity to estuarine habitats, it is likely that sea trout may pass through or utilise habitats within the Offshore Project Boundary.
- 12.6.1.26 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). Post-smolts move from rivers to sea lochs primarily between April and early June and subsequently move to the open sea in late June and July (Pemberton, 1976), where they tend to remain within close proximity (within 3.5km) of the shore. Given the nearshore location of the Offshore Project and its proximity to estuarine habitats, it is likely that sea trout post-smolts may pass through or utilise habitats within the Offshore Project Boundary. Although adult sea trout undertake longer migrations they generally remain within 80km of their natal rivers (Thorstad *et al.*, 2016).
- 12.6.1.27 Based on rod-catch data for sea trout within the Loch Roag salmon fishery district area (**Appendix 12.1, Volume 2c**; Table 4-13) the highest catches were recorded in the Caslabhat and Tamanabhaigh stock assessment area, with a mean annual catch of 597 between 2017 and 2023, falling to 213 in 2023 (Marine Scotland, 2024). The second-highest rod catches were recorded in the Langavat SAC/River Grimersta, with an annual average of 277 between 2017 and 2023 and 212 in 2023.

European eel

12.6.1.28 Considered to be critically endangered globally, European eel are highly migratory with western Scotland/*Alba* likely to be a key region of first landfall for a significant proportion of the returning eel population. Given the variability in migratory patterns exhibited by European eels it is considered likely that European eels may pass through the Offshore Project Boundary during migration, both as adults and as 'landing' glass eels.

Important Ecological Features

- 12.6.1.29 CIEEM (2022) introduces the concept of Important Ecological Features (IEFs). These are habitats, species, ecosystems, and their functions/processes that are considered to be important and potentially impacted by the Offshore Project. They are analogous, in general EIA terms, with key receptors though CIEEM places a greater emphasis on the context of nature conservation and ascribes a geographical ranking to them. This assessment has identified IEFs according to the CIEEM guidelines, alongside the use of other sensitivity criteria to capture all aspects of the fish ecology receptors pertinent to the Project.
- 12.6.1.30 The potential impacts of the Offshore Project which have been scoped into the assessment (see **Section 12.4**) have been assessed against the IEFs to determine whether or not the effect is considered significant. The IEFs assessed are those that are considered to be important and potentially affected by the Offshore Project. Importance (or value) may be assigned due to quality of extent of habitats, habitat or species rarity, or the extent to which they are threatened (CIEEM, 2022). Species and habitats are considered IEFs if they have a specific biodiversity importance recognised through the international or national legislation or through local, regional, or national conservation plans (e.g. Annex I habitats under the Habitats Directive, OSPAR, National Biodiversity Plan or the Marine Strategy Framework Directive, Scottish PMFs, and the Scottish Biodiversity list).
- 12.6.1.31 All of the IEFs within the Fish Ecology Study Area are listed in **Table 12-20**, providing justifications for importance rankings. The criteria used to inform this assessment are listed in **Table 12-19**.
- 12.6.1.32 Based upon this information, the Fish Ecology IEFs presented in **Table 12-20** will be assessed in **Sections 12.7 – 12.14**.

Table 12-19 Criteria used to inform the importance of IEFs in the fish ecology Study Area (derived from guidance published by CIEEM (2022))

IEF Importance	IEF criteria used to define importance
International	<ul style="list-style-type: none"> • Internationally designated sites, or species designated under international law (i.e., species designated under the OSPAR List of Threatened and/or Declining Species, or species listed as Critically Endangered, Endangered or Vulnerable on the IUCN Red List).
National	<ul style="list-style-type: none"> • Species protected under national law (i.e., Annex II species listed as features of SACs) within the National Site Network. Annex II species which are not listed as features of SACs in the Study Area. • Species protected under national legislation, including The Conservation of Salmon (Scotland) Regulations 2016 (as amended) and the Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003. • Species protected under the Scottish Eel Management Plan (2010). • Species protected under national policy, including the Scottish Wild Salmon Strategy (Scottish Government, 2022), and the Eel Management plans for the United Kingdom: Scotland River Basin District (Defra, 2010). • Species listed as a PMF: Scotland adopted a list of 81 PMFs in 2014, representing species and habitats on existing conservation lists that were assessed against a set of criteria, including the abundance of the feature in Scottish seas, the conservation status and the functional role played by the feature. • Scottish Biodiversity List species that continue to be regarded as conservation priorities in the subsequent UK Post-2010 Biodiversity Framework, species classified as features of conservation importance that have regionally important populations within the study area (are locally widespread and/or abundant). • NC MPA features, including species classified as features of conservation importance and broad-scale habitats. • Species that have spawning or nursery areas within the study area that are important nationally (e.g., may be primary spawning/nursery area for that species).
Regional	<ul style="list-style-type: none"> • Scottish Biodiversity List species that continue to be regarded as conservation priorities in the subsequent UK Post-2010 Biodiversity Framework, species classified as features of conservation importance that have regionally important populations within the study area (are locally widespread and/or abundant). • NC MPA features, including species classified as features of conservation importance and broad-scale habitats. • Species of commercial importance, to fisheries in the area. • Species of ecological importance (i.e., are an important prey item for other species of conservation or commercial value and that are key components of the fish assemblages in the study area. Species that have spawning or nursery areas within the study area that are important regionally.

IEF Importance	IEF criteria used to define importance
Local	<ul style="list-style-type: none"> Species of commercial importance, but do not form a key component of the fish assemblages within the study area. The spawning/nursery area for the species is located outside of the study area. The species is common throughout the UK but forms a component of the fish assemblages in the study area.

Table 12-20 IEFs within the Offshore Project Marine Fish, Basking Shark and Ocean Fish, and Diadromous Study Areas

IEF	Scientific name / representative species	Importance	Justification
Marine Fish Species			
<i>Pelagic species</i>			
Atlantic bluefin tuna	<i>Thunnus thynnus</i>	International	NERC, OSPAR, Bio List
Atlantic herring	<i>Clupea harengus</i>	National	NERC, PMF, Bio List
Atlantic mackerel	<i>Scomber scombrus</i>	National	NERC, PMF, Bio List
Blue whiting	<i>Micromesistius poutassou</i>	National	NERC, PMF, Bio List
Horse mackerel	<i>Trachurus trachurus</i>	National	NERC, PMF
European pilchard	<i>Sardina pilchardus</i>	Regional	IUCN Near Threatened
European sprat	<i>Sprattus sprattus</i>	Regional	IUCN Least Concern
Ocean sunfish	<i>Mola mola</i>	Regional	Data deficient
<i>Demersal species</i>			
Anglerfish (Sea monkfish)	<i>Lophius budegassa</i>	National	NERC, PMF, Bio List
Atlantic cod	<i>Gadus morhua</i>	International	IUCN Vulnerable, NERC, OSPAR, PMF, Bio List
Atlantic halibut	<i>Hippoglossus hippoglossus</i>	International	IUCN Vulnerable, NERC, PMF, Bio List
Black scabbard fish	<i>Aphanopus carbo</i>	National	NERC, PMF, Bio List
Blue ling	<i>Molva dypterygia</i>	International	IUCN Vulnerable, NERC, PMF, Bio List
Common sole	<i>Solea solea</i>	Regional	NERC, Bio List
European hake	<i>Merluccius merluccius</i>	Regional	NERC, Bio List
European plaice	<i>Pleuronectes platessa</i>	Regional	Low intensity nursery and spawning grounds

IEF	Scientific name / representative species	Importance	Justification
			<i>identified throughout Offshore Project fish and shellfish ecology Study Area. It is an important commercial species, but not in the local area.</i>
Ling	<i>Molva molva</i>	National	NERC, PMF, Bio List
Norway pout	<i>Trisopterus esmarkii</i>	National	PMF, Bio List
Roundnose grenadier	<i>Coryphaenoides rupestris</i>	National	NERC, PMF, Bio List
Saithe	<i>Pollachius virens</i>	National	PMF
Sandeel	<i>Ammodytes</i> sp.	Regional	No specific protections but high ecological value as prey species for a range of fish species including Atlantic salmon. Only 5% of the Marine Fish Study Area is suitable as nursery or spawning habitat.
Whiting	<i>Merlangius merlangus</i>	National	NERC, PMF, Bio List
Elasmobranchs			
Basking shark	<i>Cetorhinus maximus</i>	International	IUCN Endangered, NERC, OSPAR, PMF, Bio List
Blue shark	<i>Prionace glauca</i>	National/Near Threatened	NERC, Bio List
Spiny dogfish (spurdog)	<i>Squalus acanthias</i>	International	IUCN Endangered, NERC, OSPAR, PMF, Bio List
Tope shark	<i>Galeorhinus galeus</i>	International	IUCN Vulnerable, NERC, Bio List
Sandy ray	<i>Leucoraja circularis</i>	International	PMF, Bio List
Thornback ray	<i>Raja clavata</i>	National	OSPAR, Bio List
Common skate	<i>Dipturus batis</i>	International	NERC, OSPAR, PMF, Bio List
Flapper skate	<i>Dipturus intermedius</i>	International	PMF
White skate (bottlenosed skate)	<i>Rostroraja alba</i>	International	NERC, OSPAR

IEF	Scientific name / representative species	Importance	Justification
Diadromous Fish Species			
Atlantic salmon	<i>Salmo salar</i>	International	IUCN Vulnerable, PMF, OSPAR, Bio List, Annex II Habitats Directive, Protected under the BERN Convention, Protected under the Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003, nearby Langavat SAC and North Harris SAC designated for Atlantic salmon, transitional presence through the Study Area.
Sea trout	<i>Salmo trutta</i>	National	PMF
European eel	<i>Anguilla anguilla</i>	International	Appendix II of the Bonn Convention (The Convention on Migratory Species), Appendix II of Convention on International Trade in Endangered Species (CITES); IUCN Critically Endangered.



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12.6.2 FUTURE BASELINE

- 12.6.2.1 In the absence of the Offshore Project, the marine environment in the Fish Ecology 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 (e.g. rising sea temperatures) (Dulvy *et al.*, 2008) and non-climatic factors (e.g. changes in fishing patterns) (Jones *et al.*, 2023), with potential effects including geographical range shifts, habitat reduction, altering food webs and increased disease outbreaks.
- 12.6.2.2 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 (e.g., thermal preference or tolerance to ocean acidification), ecology, biogeography, and susceptibility to human impact (e.g., fishery target, bycatch). For example, 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 sand eels 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.
- 12.6.2.3 Given the long-term nature of such processes, changes are not likely to be significant between now and the commencement of the Offshore 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.

12.7 BASIS FOR ENVIRONMENT IMPACT ASSESSMENT

12.7.1 MAXIMUM DESIGN SCENARIO

- 12.7.1.1 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 consent applications. The assessment of the maximum design scenario for each receptor establishes the maximum potential adverse impact and as a result impacts of greater adverse significance would not arise should any other development scenario (as described in **Chapter 3, Volume 1a**) to that assessed within this Chapter be taken forward in the final scheme design.
- 12.7.1.2 The maximum parameters and assessment assumptions that have been identified to be relevant to Fish Ecology are outlined in **Table 12-21** and are in line with **Chapter 3, Volume 1a**.
- 12.7.1.3 Although pre-construction surveys may involve some limited and temporary interactions with the marine environment, the potential impacts of any such activities fall well within the MDS parameters assessed for this chapter. The MDS includes activities such as WTG foundation drilling

and grouting, and Offshore Cable installation which represent a conservative upper bound on seabed disturbance, and vessel presence. These MDS activities therefore encompass the environmental footprint of pre-construction survey methods, which are significantly lower in magnitude, duration, and spatial extent.

- 12.7.1.4 For this reason, the potential environmental interactions of pre-construction surveys are not separately assessed, as they are already inherently accommodated within the worst case assumptions underpinning the MDS for this topic.
- 12.7.1.5 The difference in timing between pre-construction surveys and construction activities does not affect the assessment because the MDS represents the maximum magnitude of change, independent of phasing or scheduling. The pre-construction surveys occur over a much shorter duration and at materially lower intensities than the MDS bounding activities, and therefore do not introduce any temporal additive effects beyond those already assessed.

Table 12-21 Maximum Design Scenario considered for impacts on Fish Ecology

Offshore Project Phase and Activity/Impact	Maximum Design Scenario	Maximum Assessment Assumptions	Justification
Construction			
Short term seabed habitat loss and/or disturbance	<p>The total short term seabed disturbance from all components of the Offshore Project is: 12,480,875 m² (12.481 km²). This includes:</p> <p>Total seabed disturbance from WTG boulder clearance and foundation installation: Seabed disturbance associated with the installation of up to 60 WTGs for Scenario 2 (no offshore substation):</p> <ul style="list-style-type: none"> • Area required for Jack up vessel installation for up to 60 WTGs; • Hybrid Gravity Base (HGB) foundations; • Number of JUV placements per WTG: 2. <p>Seabed footprint:</p> <ul style="list-style-type: none"> • Seabed disturbance per WTG boulder clearance (area includes for WTG foundation template, JUV placement and clearance): 60,000 m²; • Total seabed disturbance for WTG boulder clearance: 60,000 m² x 60 = 3,600,000 m² (3.6 km²). <p>Offshore Cable boulder clearance disturbance: Seabed disturbance associated with installation of up to 12 Array Cables to Final WTG and 12 Array Cables to Landfall for Scenario 2 (Onshore Landfall Substation):</p> <ul style="list-style-type: none"> • Maximum length of cables: 350 km; • Maximum seabed disturbance corridor width (area includes for cables, cable protection and stabilisation): 25 m; • Installation method: surface lay (across 100% of cable); • Total seabed disturbance for Offshore Cable boulder clearance: 350 km x 25 m = 8,750,000 m² (8.75 km²). <p>Exit Pit Construction: Seabed disturbance associated with HDD exit pits for Scenario 2 (Onshore Landfall Substation):</p> <ul style="list-style-type: none"> • Number of exit pits: excavation of up to 13 HDD exit pits (12 plus 1 spare) by rock cutting or grinding; • Exit pit area: 75 m x 5 m = 375 m²; • Total seabed disturbance for HDD exit pit: 375 m² x 13 = 4,875 m² (0.004875 km²). <p>Construction vessel anchorage disturbance: Anchored vessels may be utilised during the installation of the Offshore Cables within the Offshore Project Boundary. Assumes six-point mooring system with 3 m² anchors deployed every 500m of cable.</p> <ul style="list-style-type: none"> • Maximum seabed footprint per anchor: 3 m²; • Maximum number of anchor drops: 700; • Maximum seabed footprint: (3 m² x 6) x 700 = 126,000 m² (0.126 km²). <p>Repeat disturbance: Activities to install the WTGs and Offshore Cables will be undertaken within the total seabed disturbance area. However, activities will be undertaken sequentially and so result in repeat disturbance of the seabed. It has been assumed that repeat disturbance could occur for works associated with:</p> <ul style="list-style-type: none"> • WTG installation: up to 1,440,000 m² (1.44 km²); • Offshore Cable installation: up to 8,750,000 m² (8.75 km²); • Total repeat disturbance: up to 10,190,000 m² (10.19 km²). <p>Construction programme:</p>	N/A	<p>WTG boulder clearance and foundation installation: Represents the greatest number of WTGs (including associated ground disturbance) and the longest construction duration, resulting in the greatest extent of temporary seabed habitat loss/disturbance over the longest timeframe.</p> <p>Offshore Cable boulder clearance disturbance: Represents the greatest length of cable and assumes installation via surface lay, as this method results in the largest disturbance corridor (25 m) across the greatest proportion of the cable route (100%), leading to the maximum extent of temporary seabed habitat loss/disturbance over the longest timeframe.</p> <p>Exit Pit Construction: Represents the greatest number of HDD exit-pits leading to the maximum extent of temporary seabed habitat loss/disturbance over the longest timeframe.</p> <p>Construction vessel anchorage disturbance: Represents the maximum anchor footprint from construction vessels, leading to the maximum extent of temporary seabed habitat loss/disturbance over the longest timeframe.</p> <p>Repeat Disturbance: Represents the greatest area for repeated seabed disturbance for WTG installation (i.e. spud leg placement of jack-up vessels will occur following the boulder clearance works, this is expected to be a smaller area than the total seabed disturbance as the vessels won't disturb the prepared area), and Offshore Cable installation (i.e. cable installation will occur following the boulder clearance works, it has been assumed that repeat disturbance could occur across all of the total seabed disturbance area due to the potential number of Offshore Cables installed).</p> <p>Construction programme: Represents the maximum offshore construction duration, and parameters for construction within the Offshore Project Boundary.</p>

Offshore Project Phase and Activity/Impact	Maximum Design Scenario	Maximum Assessment Assumptions	Justification
	<ul style="list-style-type: none"> Construction programme: Maximum duration of offshore construction is up to 5 years. Working hours are expected to be 24 hours, 7 days a week. Offshore construction within the Offshore Project Boundary will only be undertaken during the April-October period, except for offshore Landfall construction works located within the Landfall Exit Pit Area. Installation of WTG foundations: will be undertaken between April-October over a 2 year period, totalling 14 months of active work. 		
Increases in SSC and associated sediment deposition	<p>WTG Foundation Installation: Scenario 2 (60 WTGs and 12 Array Cables to Landfall): the installation of up to 60 multi-leg jacket foundations with pin piles via drilling and grouting within the Turbine Area to support up to 60 WTGs.</p> <p>Number of piles per WTG and spacing: Each multi-leg jacket pile foundation will have up to 4 legs (1 pin pile per leg), each spaced 30-55 m apart at seabed level and 15-35 m apart at MSL;</p> <p>Pin pile diameter: Each pin pile will have a maximum diameter of up to 5 m;</p> <p>Drilling depths: Pin piles will be drilled below the seabed to a depth of 15-120 m, depending on location within the Turbine Area (i.e. whether it is inside or outside the buried channel);</p> <p>Volume of drill arisings: Per pin pile is 588 m³, and 141,120m³ for all 60 turbine multi-leg jacket foundations (assuming a 30 m average depth per drill event).</p>	<p>Drilling of Pin Piles to Install WTG Foundations modelling: modelling results of pin pile drilling activities to install WTG Foundations are presented in Appendix 9.2, Volume 2c and were used to inform this impact assessment.</p> <p>Volume of drill arisings: 4 piles per foundation are modelled in one location; with a volume of 1,374 or 2,356 m³/pile/day (for foundation depths of 70 m and 120 m, respectively);</p> <p>Concurrent pile drilling events: The model assumes that 3 pile drilling events will occur concurrently;</p> <p>Maximum pile depth assumption: Maximum depth of piles within the buried channel (deeper sections of seabed substrate within the Turbine Area) is 120 m and elsewhere within the Turbine Area it is 70 m;</p> <p>Tidal modelling assumption: A neap-spring tidal cycle is modelled with pile installation at the northeastern/southwestern extents of the Turbine Area;</p> <p>Sediment release: Sediment plumes associated with foundation installation construction activities are assumed to be limited to 2 m from the seabed (see justification in Section 2.3.3.2, Appendix 9.2, Volume 2c).</p>	<p>Scenario 2 (60 WTGs and 12 Array Cables to Landfall): represents the largest spatial extent of infrastructure and greatest volume of potential sediment disturbance during the construction phase;</p> <p>Number of piles per WTG and spacing: The resolution of the model mesh is not small enough for a spacing of sediment sources 30-55 m apart to influence the results. Therefore, spacing parameters were not included in the model, this ensures a reasonable computational run time;</p> <p>Concurrent pile drilling events: 3 piles are modelled simultaneously, with the single remaining pile for this location modelled on its own, which represents the maximum design scenario.</p> <p>Maximum pile depth and diameter assumption: Maximum pile depths and diameter have been modelled to ensure a worst-case volume of sediment disturbance;</p> <p>Volume of drill arisings: Maximum design scenario volume of drill arisings per pin pile value is based on a 30 m average embedment depth. Modelling has used depths of 70 m and 120 m to reflect the maximum depths pin piles will be buried e.g. in the buried channel representing worst case;</p> <p>Tidal modelling assumption: A neap-spring tidal cycle has been modelled to allow for an adequate range of tidal levels and current representation in the modelling exercise. Modelled locations at the edge of the Turbine Area shows the maximum extent of sediment disturbance outside the Offshore Project Boundary;</p> <p>Sediment release: Sediment disturbed by project construction activities is assumed to be released from the within 2 m of the seabed. This assumption enables a conservative assessment of the concentration of the total suspended sediments and subsequent sediment deposition thickness (see Section 2.3.3, Appendix 9.2, Volume 2c).</p>
Increases in SSC and associated sediment deposition	<p>Offshore Cable Installation: Scenario 2 (60 WTG and 12 Array Cables to Landfall): the installation of 12 66 kV Array Cable to Final WTG (within Array Area) and 12 66 kV Array Cables to Landfall (within OCAS) via jet trenching.</p> <p>Array Cables:</p> <ul style="list-style-type: none"> Array Cables to Final WTG have a maximum length of 160 km; 	<p>Array Cable burial modelling: modelling results of Array Cable Burial activities are presented in Appendix 9.2, Volume 2c and were used to inform this impact assessment.</p> <p>Sediment release: Assumes Array Cables will be installed at</p>	<p>Scenario 2 (60 WTGs and 12 Array Cables to Landfall): equates to the greatest length (350 km) of Array Cables to be installed and greatest area of potential sediment disturbance during the construction phase;</p> <p>Installation method: jet trenching is the worst-case cable installation method as the sediment release is likely to be at a greater height above</p>

Offshore Project Phase and Activity/Impact	Maximum Design Scenario	Maximum Assessment Assumptions	Justification
	<ul style="list-style-type: none"> • Array Cables to Landfall have a maximum length of 190 km; • Maximum length of Array Cables is therefore 350 km and maximum diameter of 300 mm. <p>Installation method:</p> <ul style="list-style-type: none"> • Assumes 60% of cable length (210 km) requires installation via jet trenching. • Jetting trench has a maximum width of 7 m and depth of 2 m. Seabed disturbance footprint from jet trenching is anticipated to be approximately 1.47 km². <p>Site Preparation:</p> <ul style="list-style-type: none"> • Assumes 60% of cable length (210 km) requires boulder clearance to facilitate jet trenching; • Boulder clearance width of 15 m. • Seabed disturbance footprint from boulder clearance is anticipated to be approximately 3.15 km <p>Construction programme: Maximum duration of offshore construction is up to 5 years. Working hours are expected to be 24 hours, 7 days a week. Work will only be undertaken within the Turbine Area between April and October, totalling 35 months of active work.</p>	<p>300 m/hr with 20% of sediment released into the water column.</p>	<p>the seabed (than the other Array Cable burial methods) where current speeds are higher and therefore sediment has the potential to be dispersed over a greater distance (see paragraph 9.7.1.2 in Chapter 9, Volume 2a for further details);</p> <p>Jet trenching extent: Jet trenching 60% of the Offshore Cable length represents a worst case-scenario as it is the maximum amount of jet trenching that could be undertaken to install the Array Cables;</p> <p>Sediment release: Speed and percent of sediment released are reasonable worst-case values based on similar assessments. See Table 2-3 in Appendix 9.2, Volume 2c for details on sediment mass flux in different locations within the Study Area.</p> <p>Seabed preparation: The potential impacts of seabed preparation activities, including boulder clearance using a boulder plough or boulder grab, were considered as part of the identification of the maximum design scenario for the Physical and Coastal Processes assessment. These activities were reviewed alongside the full range of potential cable installation methods.</p> <p>As outlined in Section 9.7.1.2 of Chapter 9, Volume 2a, a comparison of ploughing, jetting and mechanical cutting indicated that jet trenching would result in the greatest sediment disturbance and seabed change, due to the volume of sediment mobilised.</p> <p>On this basis, jet trenching was selected as the basis for the modelling assessment as it represents a conservative worst-case scenario for sediment mobilisation associated with either cable installation or seabed preparation activities.</p> <p>The potential impacts of seabed preparation are therefore inherently encompassed within the modelling of jet trenching, which captures the upper bound of sediment disturbance and seabed change that could reasonably arise from these activities. Separate modelling of seabed preparation is not required, as it would not result in impacts greater than those already assessed under the maximum design scenario.</p>

Offshore Project Phase and Activity/Impact	Maximum Design Scenario	Maximum Assessment Assumptions	Justification
Release of drilling fluid during trenchless construction and construction of HDD exit pits.	<p>Exit Pit Construction: Excavation of up to 13 HDD Exit Pits by rock cutting or grinding.</p> <p>Sediment volume:</p> <ul style="list-style-type: none"> Maximum volume of sediment excavated per HDD Exit Pit: 75 m length x 5 m width x 3.5 m depth = 1,312.5 m³. Maximum volume of sediment excavated from all 13 exit pits is 17,062.5 m³. <p>HDD drill cutting release:</p> <p>Number of bores and volume: Up to 13 bores drilled with a maximum volume of 1,285m³ per bore;</p> <p>Number of rigs: 2 drill rigs;</p> <p>Drill release duration: 24 hours working, 7 days a week;</p> <p>Drill fluid density: Volume of suspended cuttings varies dependent on drilling fluid density.</p>	<p>HDD activities modelling: modelling results of HDD activities are presented in Appendix 9.2, Volume 2c and were used to inform this impact assessment.</p> <p>Exit pit construction:</p> <p>Sediment types: Assessment considers range of sediment sizes which could be released by rock cutting or grinding;</p> <p>HDD drill cutting release:</p> <p>Single bore modelled: Single representative bore release modelled at a central point within the Landfall Exit Pit Area.</p> <p>Tidal modelling assumption and drill release duration: Drill releases of entire bore over 1 hour at a peak spring tide and during slack water on a neap spring tide;</p> <p>Drill fluid density: Assumed 27% cuttings in a very dirty drilling fluid.</p>	<p>Exit pit construction:</p> <p>Number of Exit Pits: 13 exit pits equates to 1 per each of the 12 Array Cables and an additional contingency exit pit to account for exit pit collapse, reflecting the maximum number of exit pits the Offshore Project may construct;</p> <p>Sediment volume: Represents greatest volume of sediment that could be released into the water column during the excavation of a single exit pit. The HDD drill cutting release models a similar volume of sediment release for fine sediment in the same location and likewise with Array Cable trenching for coarse sediment;</p> <p>Sediment types: The methods (cutting or grinding) for constructing the HDD exit pit construction may release fine or coarse sediment in to the water column. There is also uncertainty around sediment properties in the Exit Pit Area and therefore it is appropriate to assess a range of sediment sizes. Coarse and fine sediments behave in different ways and so represent a worst-case for different situations (for example finer sediments can be advected over a greater distance by currents, however coarser sediments will settle in smaller areas with larger deposition thicknesses).</p> <p>HDD drill cutting release:</p> <p>Number of rigs and single bore modelled: Whilst the Project Design Envelope allows for concurrent HDD activities, works will be managed so that break out activities will occur sequentially (i.e. 1 break out activity is undertaken at once). Although there will be up to 13 HDD bores, only 1 activity has been modelled in a central location to provide a representative drill release scenario.</p> <p>Drill release duration: Release over 1 hour is a reasonable worst-case for SSCs;</p> <p>Tidal modelling assumption: The modelled release point at mid-tide on a peak spring has the potential to transport the sediment plume furthest. This is a worst-case impact in terms of extent. The HDD release at slack water on a neap tide is also modelled which will likely result in a higher SSCs. However, this will likely be over a smaller area;</p> <p>Drill fluid density: 27% represents worst case drill cutting percent.</p>
Underwater noise and vibration (impulsive noise)	<p>Maximum number of foundations: The installation of up to 60 multi-leg jacket foundations with pin piles to support up to 60 WTGs and 1 multi-leg jacket foundation to support 1 OSP within the Turbine Area.</p> <ul style="list-style-type: none"> Percussive piling exclusion area: percussive piling will not be undertaken in the southwest portion of the Turbine Area. <p>Percussive Piling:</p> <p>Percussive Piling Area: percussive piling will only be undertaken within the northeast portion of the Turbine</p>	Underwater noise modelling: percussive piling of foundation pin piles was modelled and the results are presented in Appendix 13.3, Volume 2c and were used to inform this impact assessment. The parameters are presented in Section 3.4 of Appendix 3.1 Percussive Piling Installation Approach, Volume 1c .	Represents the maximum number of piles, the maximum possible duration of percussive piling and the greatest hammer energy (leading to the greatest propagation of noise into the water column) as defined in Appendix 13.3, Volume 2c over the longest timeframe.

Offshore Project Phase and Activity/Impact	Maximum Design Scenario	Maximum Assessment Assumptions	Justification
	<p>Area. A maximum of 35 WTG foundations and 1 OSP foundation will be installed via percussive piling in the northeast portion of the Turbine Area.</p> <ul style="list-style-type: none"> Maximum number of WTG foundations requiring percussive piling: a maximum of 35 multi-leg jacket foundations, with up to 4 pin piles each equates to a total of 140 pin piles to be installed via percussive piling. Maximum number of OSP foundations requiring percussive piling: 1 OSP foundation with up to 16 pin piles to be installed via percussive piling. Maximum number of pin piles to be installed via percussive piling: 156. <p>Duration: Limited the length of percussive piling installation of pin piles to 5.5 hours and casings to 4.5 hours per 24-hour period. This is inclusive of soft start and ramp up procedures.</p> <p>Concurrent piling: No concurrent percussive piling events are permitted.</p> <p>Maximum hammer energy: Variable maximum hammer energy across the Percussive Piling Area. This area is split into 3 zones to limit the maximum hammer energy, zones have increase maximum hammer energy of 2,500kJ, 3,500kJ, and 5,000kJ increasing towards the north of the site.</p> <p>Construction programme: Installation of WTG foundations (drilling or percussive piling): will be undertaken between April-October over a 2 year period, totalling 14 months of active work (see Appendix 3.1, Volume 1c).</p>		
Underwater noise and vibration (continuous noise)	<p>Installation of Offshore Project infrastructure will generate continuous underwater noise: Activities include cable laying, drill and grout of WTG foundations in the southwest portion of the Turbine Area, grinding, rock placement, trenching, vessel movements and water jetting.</p> <p>Duration of construction noise:</p> <ul style="list-style-type: none"> Construction programme: Maximum duration of offshore construction is up to 5 years. Working hours are expected to be 24 hours, 7 days a week. Offshore construction within the Offshore Project Boundary will only be undertaken during the April-October period, except for offshore Landfall construction works located within the HDD Exit Pit Area. Installation of WTG foundations: will be undertaken between April-October over a 2 year period, totalling 14 months of active work. 	Underwater noise modelling of possible noise making activities (cable laying, cutting of piles, drilling, rock placement, trenching, and vessel noise was modelled and the results are presented in Appendix 13.3, Volume 2c and were used to inform this impact assessment.	Represents the key activities producing sustained, non-impulsive noise- such as vessel movements, dredging, and drilling- resulting in the highest levels of continuous underwater noise, over the longest time frame.
Operation and Maintenance			
Long term seabed habitat loss/change	<p>Presence of up to 60 WTGs and Offshore Cables: (Scenario 2 without OSP) across the project lifetime up to 35 years. Maximum long-term habitat loss = 2,411,500 m² (2.411 km²)</p> <p>WTG:</p> <ul style="list-style-type: none"> Up to 60 WTGs; Hybrid Gravity Base (HGB) foundations; Seabed footprint per WTG (including foundation area and scour protection) = 105 m x 105m; Maximum long term seabed habitat loss of WTGs: (105 m x 105 m) x 60 = 661,500 m² (0.662 km²) <p>Offshore Cables:</p> <ul style="list-style-type: none"> Cable length: 12 Array Cables to Final WTG (within the Array Area) and 12 Array Cables to Landfall (within the OCAS) equating to a maximum cable length of 350 km; Maximum corridor width = 5 m; Maximum long term seabed disturbance habitat loss for Offshore Cables: 350 km x 5 m = 1,750,000 m² (1.75 km²). 	N/A	Represents the maximum number of WTGs, assuming the foundation type with the greatest seabed footprint, along with associated scour protection and the maximum length of cables and cable protection, and thus the greatest extent of long term habitat loss.

Offshore Project Phase and Activity/Impact	Maximum Design Scenario	Maximum Assessment Assumptions	Justification
	Under the maximum design scenario for impact duration for this impact-pathway, the WTG scour protection, WTG foundations located below seabed level, and the Offshore Cables (including associated scour protection) are assumed to remain in-situ permanently. All other project components located above the seabed are assumed to remain in place throughout the operational period and until decommissioning, with their duration of presence extending until such decommissioning activities commence.		
Short term seabed habitat loss and/or disturbance	<p>Total short-term seabed disturbance from all components of the Offshore Project: 27,610,800m² (27.610km²):</p> <p>Maintenance activities includes major/minor component replacement and repairs, scheduled inspections and unscheduled maintenance of offshore infrastructure, with repairs and replacement required on an ad hoc basis. It is estimated that the maintenance activities will require:</p> <p>WTG short term disturbance:</p> <ul style="list-style-type: none"> Major component replacements: up to x 3 per WTG over lifetime (180 total) Minor component replacements: up to x 10 per WTG per year (21,000 total) Seabed disturbance per replacement using Jack Up Vessel: Area of spun cans (280m²) x number of positions (2) = 560 m² Total short term seabed disturbance of WTGs: 21,180 x 560 m² = 11,860,800 m² (11.860 km²) <p>Array Cables short term disturbance:</p> <ul style="list-style-type: none"> Repair and replacement of Array Cables required: up to 9 times during lifetime; Seabed disturbance for Array Cables (as per construction): 1,750,000 m² (1.75 km²); Total short term seabed disturbance of Offshore Cables: 9 x 1,750,000 m² = 15,750,000 m²; (15.750 km²). 	N/A	Maintenance activities are expected to occur with a lower intensity than those during construction. It is assumed that Array Cables will require reburial/protection up to 6 times across the Offshore Project lifetime, and will be repaired or replaced up to 9 times across the Offshore Project lifetime. As such, construction activities are assumed to represent a maximum design scenario.
Increases in suspended sediment concentration and associated deposition	The maximum design scenario used for this assessment are identical to those detailed for the Offshore Project Phase and Activity/Impact ' <i>Short-term seabed habitat loss and/or disturbance</i> '	N/A	<p>The justification is the same as that provided for the Offshore Project Phase and Activity/Impact '<i>Short-term seabed habitat loss and/or disturbance</i>'.</p> <p>No modelling has been done for SSC during the O&M phase, but levels are expected to be equal to or lower than during construction (see Chapter 9, Volume 2a). This is because the 'multiple activities' modelling scenario, during the construction phase, simulated a maximum suspended sediment concentration during drilling of 4 WTG foundations (each with 4 piles), and burial of cables (assuming drilling and cable burial activities happen sequentially) per month. It is not expected that such large-scale works will be undertaken during the O&M phase. Therefore, temporary increase in suspended sediment concentrations and sediment deposition during operation and maintenance will be of lower magnitude and frequency than that of construction.</p>
Underwater noise and vibration	<p>WTG operation: Continuous operation of the largest WTGs (up to 44 WTGs) or smallest WTGs (up to 60 WTGs), 24 hours a day, 7 days a week, over the Offshore Project lifetime of up to 35 years.</p> <p>Rotor diameter:</p> <ul style="list-style-type: none"> Largest WTGs: 238 m rotor diameter; Smallest WTGs: 280 m rotor diameter. 	Noise propagation estimated using the Tougaard et al., 2020) method, assuming an average wind speed of 11 m/s. (see Appendix 13.3, Volume 2c for further detail).	Represents the maximum production of continuous noise from the operation of the maximum number of WTGs (leading to the greatest propagation of noise into the water column) as defined in Appendix 13.3, Volume 2c .
	O&M vessel movements	N/A	O&M vessel movements produce sustained, non-impulsive noise that can contribute to the ambient underwater soundscape over extended

Offshore Project Phase and Activity/Impact	Maximum Design Scenario	Maximum Assessment Assumptions	Justification
	Continuous underwater noise generated by the movement of O&M vessels, assuming maximum number of vessels on site any one time would be 10 over the Offshore Project lifetime of up to 35 years. Total maximum O&M vessels movements (return trips) is up to 32,034 over the Offshore Project lifetime.		periods. Represents the maximum expected vessel traffic during O&M phases, over longest timeframe.
EMF	<p>EMF analysis has determined that the two scenarios outlined below equate to the maximum design scenario:</p> <p>Scenario 1 - Offshore Substation:</p> <ul style="list-style-type: none"> 10 Array Cables (66 kV, 900 A, 300 mm) running from WTGs to an OSP (Array Cables located within the Array Area); 2 Export Cables (220 kV, 1,400 A, 400 mm) extending from the OSP to Landfall (Export Cables located in Array Area and OCAS). <p>Scenario 2 - No Offshore Substation:</p> <ul style="list-style-type: none"> 10 Array Cables (66 kV, 900 A, 300 mm) running from WTGs to the final WTG in the string (Array Cables located within the Array Area); 6 Array Cables to Landfall (132 kV, 900 A, 300 mm) running from the final WTG in the string to Landfall (Array Cables to Landfall located in Array Area and OCAS). 	<p>Each scenario was modelled under the following installation and environmental conditions:</p> <p>Array Cables: Array Cables are comparable between Scenarios 1 and 2 as it is assumed that these cables will be directed to a central location within the Array Area before being connected to shore.</p> <p>Cable installation scenarios:</p> <ul style="list-style-type: none"> Buried cables at a depth of 0.5 m; Surface-laid cables (i.e. no burial). <p>Tidal current scenarios:</p> <ul style="list-style-type: none"> Maximum tidal current: 0.9 knots (kn); Minimum tidal current: 0.1 kn; Average tidal current: 0.4 kn. <p>See Section 12.9.5.4 to 12.9.5.6 of this assessment for further details on EMF modelling assumptions.</p>	<p>Two scenarios representing the greatest voltages being considered, have been modelled to ensure we have understood and assessed the Array Cable scenario that generates the EMF with the greatest strength.</p> <p>The two maximum design scenarios represent the greatest amount of current and voltage flowing through the Offshore Cables during the O&M phase and therefore will produce the greatest strength electric fields (E-fields) and magnetic fields (B-fields) and therefore greatest potential to disrupt electrosensitive and magneto sensitive fish.</p>

Offshore Project Phase and Activity/Impact	Maximum Design Scenario	Maximum Assessment Assumptions	Justification
Fish aggregation effects	<p>Total volume of hard substrates introduced: 10,877,500 m³ Presence of up to 60 WTGs with hybrid multi-leg jacket gravity base foundations with scour protection (Scenario 2: WTG and 12 Array Cables to Landfall)</p> <p>WTG: Hard substrate introduced consists of WTG foundation and shaft, and scour protection required. WTG shaft hard substrate:</p> <ul style="list-style-type: none"> • Maximum size top of shaft (S1) 10 m x 10 m • Maximum size bottom of shaft (S2) 55 m x 55 m • Maximum height (h) 65 m • Volume per WTG (frustrum of square pyramid) = 79,625 m³ (rounded to 80,000 m³) [calculation: $V = 1/3h(S21 + S22 + S1S2)$] • Total volume of hard substrate for OWF: 80,000 m³ x 60 WTGs = 4,800,000 m³ <p>WTG foundation hard substrate:</p> <ul style="list-style-type: none"> • Foundation size: 55 m (l) x 55 m (w) x 5 m (h) = 15,125 m³ • Total volume of hard substrate for OWF: 15,125 m³ x 60 WTGs = 907,500 m³ <p>WTG scour protection hard substrate:</p> <ul style="list-style-type: none"> • Scour protection area per WTG: 105 m (l) x 105 m (w) x 3 m (h) = 24,000 m³ • Total volume of hard substrate: for OWF: 24,000 m³ x 60 WTGs = 1,440,000 m³ <p>Total volume of hard substrates introduced (WTGs): 7,147,500 m³</p> <p>Array Cables:</p> <ul style="list-style-type: none"> • Cable length: 12 Array Cables to Final WTG (within the Array Area) and 12 Array Cables to Landfall (within the OCAS) equating to a maximum cable length of 350 km. • 100% of Array Cable surface laid. Therefore, Offshore Cables are present on the seafloor and require protection and stabilisation. • Cable stabilisation: Pre lay carpet will have a maximum width of 5 m, height of 0.3 m and volume of 1,130,000 m³. Cable protection: will be achieved using rock berms, rock bags, concrete mattresses or other inert material and will have a maximum width of 3 m, height of 1.1 m and volume 2,600,000 m³. • Total volume of hard substrates introduced (Offshore Cables): 3,730,000m³ <p>Under the maximum design scenario for impact duration for this impact-pathway, the WTG scour protection, WTG foundations located below seabed level, and the Offshore Cables (including associated scour protection) are assumed to remain in-situ permanently. All other project components located above the seabed are assumed to remain in place throughout the operational period and until decommissioning, with their duration of presence extending until such decommissioning activities commence.</p>	N/A	Represents the maximum number of WTGs, using the foundation type with the largest area, along with associated scour protection and the longest length of cables and cable protection, resulting in the greatest extent of permanent infrastructure in the marine environment, which may lead to fish aggregation effects.
Decommissioning			
Short term seabed habitat loss and/or disturbance during decommissioning activities.	<p>The decommissioning sequence will generally be the reverse of the construction sequence and involve similar types and numbers of vessels and equipment. Activities equivalent to or less than the Construction phase. This is because, unlike construction, seabed clearance is not expected to be required for foundation installation or along cable routes. Any seabed clearance during decommissioning is likely to be limited to the placement of jack-up vessel legs. The assumptions for the construction phase therefore apply.</p> <p>Following the operation and maintenance phase, components of the Offshore Project may be left in-situ to avoid unnecessarily disturbing the seabed (i.e. where marine habitat has formed). This could include scour protection associated with the WTG foundations and sections of the Offshore Cable. The potential for infrastructure to remain <i>in-situ</i> will be confirmed through consultation on the Decommissioning Programme to ensure the most suitable approach is taken. At this stage it is unconfirmed which components (if any) would</p>	N/A	Decommissioning activities are expected to occur with a lower intensity than those during construction, as such, construction activities represent a maximum design scenario.

Offshore Project Phase and Activity/Impact	Maximum Design Scenario	Maximum Assessment Assumptions	Justification
	<p>remain in-situ. As such, under the maximum design scenario for short term seabed habitat loss and/or disturbance during decommissioning it has been assumed that all infrastructure would be removed.</p> <p>Decommissioning programme: Duration is up to 5 years.</p>		
<p>Increases in suspended sediment concentration and associated sediment deposition</p>	<p>The decommissioning sequence will generally be the reverse of the construction sequence and involve similar types and numbers of vessels and equipment. Activities equivalent to or less than the Construction phase. This is because, unlike construction, seabed clearance is not expected to be required for foundation installation or along cable routes. Any seabed clearance during decommissioning is likely to be limited to the placement of jack-up vessel legs. The assumptions for the construction phase therefore apply.</p> <p>Following the operation and maintenance phase, components of the Offshore Project may be left in-situ to avoid unnecessarily disturbing the seabed (i.e. where marine habitat has formed). This could include scour protection associated with the WTG foundations and sections of the Offshore Cable. The potential for infrastructure to remain in-situ will be confirmed through consultation on the Decommissioning Programme to ensure the most suitable approach is taken. At this stage it is unconfirmed which components (if any) would remain in-situ. As such, under the maximum design scenario for increases in SSC and associated deposition during decommissioning it has been assumed that all infrastructure would be removed.</p> <p>Decommissioning programme: Duration is up to 5 years.</p>	<p>N/A</p>	<p>Decommissioning activities are expected to occur with a lower intensity than those during construction, as such, construction activities represent a maximum design scenario.</p>

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12.7.2 EMBEDDED MITIGATION MEASURES

- 12.7.2.1 As part of the Offshore Project design process, a number of embedded mitigation measures have been adopted to reduce the potential for impacts on Fish Ecology and these have evolved over the development process as the EIA has progressed and in response to consultation.
- 12.7.2.2 The embedded mitigation 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 the embedded mitigation, 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 EIAR.
- 12.7.2.3 **Table 12-22** sets out the relevant embedded mitigation measures within the design and how these affect the Fish Ecology assessment. In addition, certain elements of the Project design inherently reduce the potential for environmental effects but are not presented as standalone embedded mitigation measures. These aspects form part of the fundamental engineering design – specifically, the use of drilled and grouted foundations in certain parts of the Turbine Area rather than percussive piling, limitations on maximum hammer energy across parts of the Turbine Area, and the use of noise-abatement technology to achieve a 12 dB reduction — and therefore have not been assigned individual mitigation codes. Where such design characteristics are relevant to a specific impact-pathway, they are described and considered within the corresponding assessment section (Section 12.8). Further details relating to the Project design are provided in **Chapter 3, Volume 1**, and the narrative behind design refinements (including the process for site selection and design optimisation) is presented in **Chapter 4: Consideration of Alternatives, Volume 1**.
- 12.7.2.4 For the purposes of this EIA, effects are assessed on a conservative worst-case basis and no reliance is placed on the avoidance elements of the embedded measures at this stage (M001, M002). This approach reflects the fact that the extent to which sensitive areas can be avoided, or optimal burial achieved, cannot be quantified until detailed design and further site-specific investigations are complete; the assessment therefore does not assume full avoidance and remains robust under conditions of uncertainty.

Table 12-22 Relevant Fish Ecology embedded mitigation measures

ID	Environmental measure proposed	Project phase measure introduced	How the environmental measures will be secured	Relevance to Fish Ecology assessment
M001	The outputs of the project-specific site investigation surveys, will be reviewed to ensure that the final design and location of key project infrastructure takes full account of the physical environment and considers the potential for long-term changes. The mitigation hierarchy will be applied to avoid any sensitive areas identified, as far as is possible, by micrositing wind turbine generators (WTG) and cables.	Pre-Construction, construction	To be secured through a condition of the Section 36 consent and/or Marine Licence.	Reduce impacts on sensitive fish habitats (e.g., spawning grounds or key feeding habitats) through micrositing. For the purposes of the assessment, a potential reduction in impacts associated with avoiding sensitive habitats under this measure has not been assumed. The assessment applies a conservative worst-case scenario (i.e. assuming no avoidance is possible), as the extent to which sensitive areas can be avoided through micrositing cannot be quantified until detailed design and further site-specific investigations are completed.
M002	A Cable Installation Plan will be produced to confirm routing, method of installation and aspects such as target Depth of Burial and need for/location/type of external cable protection. This Plan will also contain the outputs of a formal Cable Burial Risk Assessment (CBRA). Data from the project-specific geophysical surveys will be used to identify the preferred route, with the use of natural crevasses or channels within the bedrock proposed, where feasible, and areas of thicker Quaternary sediments identified (to maximise opportunities for cable burial).	Pre-construction, construction	Secured in the Section 36 Consent and/or Marine Licence conditions. Details will be provided within the Cable Installation Plan.	Reduce impacts on fish to EMF by maximising opportunities for cable burial, while minimising generation of suspended solids and localised disturbance where natural options are available. For the purposes of the assessment of impacts on fish from EMF, the potential reduction in exposure associated with increased cable burial depth under this measure has not been taken into account. A conservative worst-case scenario (i.e. assuming burial depth cannot be increased beyond the minimum achievable, as outlined under the maximum design scenario in Table 12-21) is applied, as the extent to which burial depth can ultimately be optimised to reduce EMF exposure cannot be determined until detailed design and further site-specific investigations are undertaken.
M003	A final Marine Mammal Mitigation Protocol (MMMP) will be developed prior to commencement of construction (building on the Outline MMMP, Volume 3) in compliance with legislative requirements and/or best practice standards and guidance and adhered to.	Construction, Operation and Maintenance and Decommissioning	Secured in the Section 36 Consent and/or Marine Licence via the condition for an MMMP to be submitted to MD-LOT for approval.	Reduce noise impacts on fish through implementation of use of soft start and ramp-up procedures.
M004	Accidental release of construction material and/or litter to be addressed via the development of procedures to retrieve the accidental deposit of an object at sea.	Construction, operation (including maintenance), and decommissioning	To be secured through a condition of the Section 36 consent and/or Marine Licence.	Reduces the risk of pollution-related impacts on fish by ensuring that any accidentally deposited construction materials or litter are retrieved from the marine environment.
M005	Relevant best practice techniques for seabed excavations, employed through all phases of the Project, and suspended solids monitoring to aid responsible management of excavation activities.	Construction	To be secured through a condition of the Section 36 consent and/or Marine Licence.	Reduces potential impacts on fish by minimising suspended solids and protecting water quality through best-practice.
M006	A Invasive Non-Native Species (INNS) Management Plan will be developed prior to commencement of construction (building on the INNS Management Plan, Volume 3) in compliance with legislative requirements and/or best practice standards and guidance and adhered to.	Construction, Operation and Maintenance and Decommissioning	Secured in the Section 36 Consent and/or Marine Licence conditions. Details will be provided within the INNS Management Plan	Reduces the impact on fish and fish habitats by minimising the introduction and spread of invasive species.
M019	A final Offshore Environmental Management Plan (OEMP) will be developed prior to commencement of construction (building on Outline Offshore EMP, Volume 3) in compliance with legislative requirements and/or best practice standards and guidance and adhered to.	Pre-Construction and Construction	Secured in the Section 36 Consent and/or Marine Licence via the condition for an OEMP to be submitted to MD-LOT for approval.	Reduces the risk of pollution-related impacts on fish through the implementation of best-practice measures for waste management, and the storage, handling and use of oils, fuels and chemicals, supported by appropriate environmental monitoring.

ID	Environmental measure proposed	Project phase measure introduced	How the environmental measures will be secured	Relevance to Fish Ecology assessment
M020	A Decommissioning Plan will be developed prior to the construction of the Project in compliance with legislative requirements and/or best practice standards and guidance and adhered to.	Decommissioning	Secured in the Section 36 Consent and/or Marine Licence via the condition for a Decommissioning Plan to be submitted to MD-LOT for approval and the Energy Act 2004	Reduce impacts on fish through adhering to best practice standards and guidance during decommissioning activities.
M021	Adherence to requirements of the International Convention for the Prevention of Pollution from Ships (MARPOL) 73/78/. Best practice techniques employed through all phases of the Project, and measures provided in a Marine Pollution Contingency Plan (MPCP) (see MPCP, Volume 3). All vessels associated with the Project will comply with IMO/MCA codes for prevention of oil pollution and, where appropriate, will have onboard Shipboard Oil Pollution Emergency Plans (SOPEPs) (i.e. vessels over 400 gross tonnes (GT)) ⁸ .	Construction, Operation and Maintenance and Decommissioning	Secured in the Section 36 Consent and/or Marine Licence conditions. Details will be provided within the MPCP	Reduces pollution risks to fish by applying best practice vessel operations and contingency measures to prevent and manage accidental releases.
M023	Offshore construction within the Offshore Project Boundary will only be undertaken during the April-October period, except for offshore Landfall construction works located within the HDD Exit Pit Area.	Construction	To be secured through a condition of the Section 36 consent and/or Marine Licence.	Reduce impacts on fish by scheduling of construction activities to avoid sensitive periods for some fish species (e.g., sandeel) and reduces overall temporal disturbance by limiting activity to a defined portion of the year.
M031	A Marine Pollution Contingency Plan (MPCP) will be developed prior to commencement of construction (building on MPCP, Volume 3) in compliance with legislative requirements and/or best practice standards and guidance and adhered to.	Pre-Construction, Construction, Operation and Maintenance and Decommissioning	Secured in the Section 36 Consent and/or Marine Licence via the condition for an MPCP to be submitted to MD-LOT for approval.	Reduces pollution risks to fish by applying best practice vessel operations and contingency measures to prevent and manage accidental releases.
M033	A Lighting and Marking Plan (LMP) will be developed prior to commencement of construction (building on the Outline LMP, Volume 3) in compliance with legislative requirements and best practice standards and guidance and adhered to.	Pre-Construction, Construction, Operation and Maintenance and Decommissioning	Secured in the Section 36 Consent and/or Marine Licence conditions via the condition for a LMP to be submitted to MD-LOT for approval.	Reduces risk of predator aggregation and minimises behavioural disruption to migratory fish caused by artificial lighting and infrastructure barriers
M038	Adherence to best practice guidance with regards to damage or loss of fishing gear that is attributable to the Offshore Project.	Pre-Construction, Construction, Operation and Maintenance and Decommissioning	Secured in the Section 36 Consent and/or Marine Licence via the condition for an FMMCP to be submitted to MD-LOT for approval.	Reduces the risk of entanglement or ghost-fishing impacts on fish by supporting timely management and retrieval of fishing gear lost or damaged as a result of the Project, in accordance with recognised best-practice guidance.

⁸ MARPOL is enacted in the UK through the Merchant Shipping Act 1995 and a series of related regulations to cover the various Annexes of the convention.
Sporad na Mara EIAR Chapter 12: Fish Ecology, Volume 2a

12.8 ASSESSMENT OF EFFECTS: CONSTRUCTION PHASE

12.8.1 SHORT TERM SEABED HABITAT LOSS AND/OR DISTURBANCE

12.8.1.1 Short term seabed habitat loss and/or disturbance will occur during the construction phase of the Offshore Project from activities such as boulder clearance the use of jack up vessels and laying of cables. The maximum design scenario relating to short term seabed habitat loss and/or disturbance of seabed habitats during the construction phase are presented in **Table 12-21**.

12.8.1.2 Short term seabed loss and/or disturbance has the potential to degrade or remove 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 short term loss and/or change in benthic habitats that support key prey species or provide ecological functions critical to early life stages.

Magnitude

12.8.1.3 Construction activities within the Offshore Project Boundary will lead to short term seabed habitat loss and/or disturbance. The maximum design scenario is for up to 12,480,875 m² (12.481 km²) short term seabed habitat loss and/or disturbance during the construction phase. The Offshore Project Boundary comprises of the Array Area (161 km²) and the Offshore Cable Area of Search (OCAS) (47 km²). This equates to 6.00% of the Offshore Project Boundary.

12.8.1.4 Of this, approximately 8,750,000 m² (8.75km²) of short term seabed habitat loss/disturbance is expected from the installation of up to 350 km of Offshore Cables (including associated seabed preparation), 4,875 m² (0.004875 km²) from HDD exit pits, 3,600,000 m² (3.6km²) from seabed preparation for WTG foundations and jack-up vessel placement and 126,000m² (0.126 km²) of seabed habitat will be disturbed over the short term from construction vessel anchorage.

12.8.1.5 In addition, up to 10,190,000 m² of repeat disturbance is expected. Repeat disturbance refers to a second phase of disturbance occurring within the same spatial footprint previously disturbed, rather than affecting new areas of seabed.

12.8.1.6 Two situations give rise to repeat disturbance:

- **Array Area** – boulder clearance disturbs the seabed, and the later placement of jack-up spud legs within the same cleared footprint results in a second disturbance event. It has been assumed that up to 1,440,000m² (1.44 km²) of repeat disturbance could occur in the Array Area.
- **Offshore Cables** – where boulder clearance and cable installation are undertaken as separate activities, cable installation causes a second phase of disturbance within the previously disturbed clearance footprint. It has been assumed that up to 8,750,000m² (8.75 km²) of repeat disturbance could occur along the Offshore Cable route.

- 12.8.1.7 This repeat disturbance therefore represents an additional disturbance event, but not additional seabed area beyond the footprints already described.
- 12.8.1.8 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). Sandy sediments are limited to the southwest corner of the Array Area. Coarse, mixed, or muddy sediments are also limited across the Offshore Project Boundary, with only small pockets across the Array Area and within the southern part of the OCAS (see Figure 51 of **Appendix 11.1, Volume 2c**). The remainder of the Offshore Project Boundary comprise non sedimentary substrates including rock outcrop, cobbles and boulders that by their nature are not vulnerable to sediment disturbance.
- 12.8.1.9 The placement of jack-up vessel spud cans during foundation installation results in localised compression and indentation of seabed sediments. Evidence from post-construction monitoring at UK offshore wind farms (e.g., BOWind, 2008; EGS, 2011) indicates that these depressions naturally infill over time. At the Barrow Offshore Wind Farm, spud can footprints were nearly entirely infilled within 12 months (BOWind, 2008). At the Lynn and Inner Dowsing sites, partial infilling was recorded, although shallow depressions (tens of centimetres deep) remained visible after a few years (EGS, 2011). In areas dominated by mobile sands or coarse sediments, these features are likely to be short-lived and may persist only for several months to a few years. Studies examining spud can penetration in layered soils demonstrate that penetration resistance increases in harder layers (e.g., stiff clay over sand), limiting the depth of penetration (Lee and Choo, 2024). Therefore, in areas with harder substrata, spud cans are expected to penetrate less deeply, creating shallower depressions. However, these may persist longer due to reduced sediment mobility.
- 12.8.1.10 Based on the maximum design scenario detailed in **Table 12-21** the impacts to fish will likely be adverse, medium-term in duration (over a period of 5 years commencing in 2028 or 2029), but intermittent (restricted to the months of April to October each year except for offshore Landfall construction works located within the HDD Exit Pit Area which may occur all year round). Short term seabed loss/disturbance is considered to be localised and reversible through natural recovery processes. Considering the embedded Offshore Project mitigation measures detailed within **Table 12-22**, specifically M001 (micrositing), M023 (construction timing) and M005 (best practice techniques for seabed excavations), the magnitude of impact from short term seabed loss/disturbance during the construction phase is predicted to be **Low**. The magnitude of impact reflects the extent of habitat disturbance expected during the construction phase.

Sensitivity or value of receptor

12.8.1.11 The sensitivity described for each receptor is based on the criteria provided in **Table 12-12**.

High value receptors

12.8.1.12 The majority of fish receptors are considered of low to medium value. Diadromous fish (Atlantic salmon, sea trout and European eel) and the common skate complex have been assigned a high value. This has been considered when determining the overall sensitivity of the receptors to short term seabed habitat loss and/or disturbance during the construction phase of the Offshore Project. The value and sensitivity is based upon the criteria detailed in Section 12.5.

Marine fish

Atlantic herring

12.8.1.13 Atlantic herring are demersal spawners that depend on suitable seabed substrates, coarse sands, gravels and/or small rocks (ICES, 2015), for egg deposition (Frost and Diele, 2022). The majority of the Array Area was classified as either moderate or low value as spawning habitat with only small areas of high value spawning habitat towards the south of the Array Area where sedimentary substrate occurs. The species is considered to have low tolerance to seabed disturbance, 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 over several years following disturbance, supported by pelagic larval dispersal and relatively short generation times (Hay *et al.*, 2001; Wright *et al.*, 2000). Accordingly, Atlantic herring are considered to have low tolerance and medium recoverability and to be of medium value. Therefore, Atlantic herring sensitivity to short term seabed habitat loss and/or disturbance is considered to be **Medium**.

Common skate complex and spotted ray

12.8.1.14 Oviparous elasmobranchs such as blue skate and flapper skate (the common skate complex), and spotted ray have identified nursery grounds within the Offshore Project Boundary and lay demersal egg cases. Demersal egg-laying behaviour makes these species vulnerable to seabed disturbance that may damage deposited egg cases. Due to the species life-history traits – slow growth, late maturity and generally low fecundity (Ellis *et al.*, 2021) both elasmobranch species are considered to have low recoverability to potential loss of egg cases from short term seabed loss/disturbance. The Scottish Government FeAST tool and MarLIN categorises common skate as moderately sensitive to surface abrasion (FeAST, 2025; Tyler-Walters, 2023), due to the species' mobility at adult life stages and ability to avoid areas of temporary disturbance. However, these tools do not fully account for heightened vulnerability during early life stages (egg-cases) or for impacts within known spawning habitats.

- 12.8.1.15 Overall, the common skate complex is considered of high value, medium tolerance and low recoverability. Based on these attributes, sensitivity is assessed as Medium. However, considering the high conservation value of this species, declining population and identified nursery ground within the area affected by this impact, the sensitivity of the common skate complex is considered to be **High**. Spotted ray is considered to have lower conservation concern, a broader habitat range, greater fecundity (can deposit 60-70 egg capsules over one spawning season), and higher growth rate. It is therefore considered to have low tolerance, medium recoverability and to be of low value. Therefore, spotted ray sensitivity to short term seabed habitat loss and/or disturbance is considered to be **Medium**.

Sandeel

- 12.8.1.16 The Scottish Government FeAST tool identifies sandeel as highly sensitive to sub-surface abrasion and penetration, and of medium sensitivity to surface abrasion (Wright *et al.*, 2000). Short term 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). Site-specific survey data and desktop analysis indicate that sandeel are present within the Offshore Project Boundary, with the highest likelihood and densities occurring in the southwestern region of the Array Area. In addition, a small patch of suitable habitat was also identified in the northern section of the Array Area. Due to the predominance of hard substrate across much of the remaining Offshore Project Boundary, including the OCAS (which includes the HDD Exit Pit Area), significant sandeel densities are unlikely outside these identified areas (refer to Section 4.2.2 of **Appendix 12.1, Volume 2c** for further discussion on the distribution of sandeel habitat across the Marine Fish Study Area). 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.
- 12.8.1.17 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 short term seabed disturbance, provided suitable habitat conditions are restored. As such, sandeel of medium value, are considered to have low tolerance and high recoverability to this impact. Therefore, sandeel sensitivity to temporary seabed habitat loss and/or disturbance is considered to be **Medium**.

Atlantic cod

- 12.8.1.18 Atlantic cod is a species designated as a Priority Marine Feature. Atlantic cod are pelagic spawners, releasing buoyant eggs into the water column. However, cod spawning activity is strongly associated with specific near-seabed spawning ‘arenas’, where adults aggregate over suitable substrates, typically coarse sand, and males establish and defend small territories in a lek-like mating system (Nordeide & Folstad, 2000; Windle & Rose, 2007; Dean et al., 2014). These spawning arenas are selected based on a combination of substrate type (typically coarse sand) and environmental conditions including cold temperatures (5–7 °C), high salinity, and low-moderate current flow (González-Irusta & Wright, 2016).
- 12.8.1.19 Spawning grounds of undetermined intensity have been identified within the Marine Fish Study Area, including across both the Array Area and OCAS (which includes the HDD Exit Pit Area) (Coull *et al.*, 1998). However, given that the Array Area and OCAS are predominantly characterised by hard substrate (**Appendix 11.1, Volume 2c**), intensity for cod spawning within these areas is expected to be low.
- 12.8.1.20 Atlantic cod is considered to have low tolerance to short term seabed habitat loss or disturbance, as spawning behaviour relies on specific seabed substrates, with short term seabed habitat loss and/or disturbance potentially displacing spawning aggregations and/or affecting spawning habitats. Recoverability is assessed as medium, as cod exhibit strong spawning site fidelity, but populations can recover over multiple years where recruitment and broader regional stocks support replenishment. Overall, Atlantic cod of medium value, is considered to have low tolerance and medium recoverability to this impact. Therefore, Atlantic cod sensitivity to temporary seabed habitat loss and/or disturbance is considered to be **Medium**.

All other marine fish species (not discussed individually)

- 12.8.1.21 Marine fish species not discussed individually – such as, but not limited to, other gadoids (e.g. haddock and whiting), flatfish (e.g. European plaice), pelagic species (e.g. Atlantic mackerel), viviparous elasmobranchs or those oviparous species with no known nursery ground within the Offshore Project Boundary (e.g. tope and basking shark) – are considered to have a lower likelihood of exposure to short term seabed habitat loss and disturbance. 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 short term changes in habitat structure. In terms of recoverability, these species are expected to recover rapidly following periods of short term 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 species to short term seabed habitat loss and/or disturbance is considered to be **Low**.

Diadromous species

Atlantic salmon, sea trout and European eel

- 12.8.1.22 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 short term and spatially limited habitat disturbance in offshore environments, particularly where such areas are not essential to critical life stages (e.g., spawning or feeding). The Offshore Project Boundary does not overlap with any known important foraging areas for diadromous species. Consequently, their reliance on benthic habitats within the development footprint is low, and short term habitat disturbance is unlikely to result in more than minor effects. These species are therefore expected to have high tolerance to this impact.
- 12.8.1.23 Indirect effects may occur through changes in prey availability. Diadromous 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).
- 12.8.1.24 Given their ability to avoid disturbed areas, opportunistic feeding behaviour, and the resilience of prey populations, diadromous fish species exhibit high tolerance to short term seabed 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 short term seabed habitat loss and/or disturbance is considered **Low**.

Significance of effect

- 12.8.1.25 Short term seabed habitat loss and/or disturbance is anticipated to take place during the construction phase of the Offshore Project. Considering the embedded mitigation described in **Table 12-22**, the residual effects of short term seabed habitat loss and/or disturbance on Fish Ecology receptors are summarised in **Table 12-23**.

Table 12-23 Significance of effect of short term seabed habitat loss and/or disturbance to Fish Ecology during the construction phase

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
Marine Fish						
Atlantic herring	Low	Medium	M001 M023 M019	Minor	Not Significant	The spatial extent of the impact is limited and the overlap with suitable spawning substrate within the area restricted. Considering the availability of suitable spawning grounds across the broader region, the area of Atlantic herring spawning ground affected by short term seabed habitat loss and/or disturbance is small. Disturbance is considered reversible, with recovery of spawning habitats and populations expected post-construction.
Common skate complex	Low	High	M001 M023 M019	Minor	Not Significant	Suitable egg-laying habitats for the common skate complex are spatially restricted within the area affected by short term seabed habitat loss and/or disturbance, being limited to shallow nearshore waters (<20 m depth; as discussed in Section 4.3.2 of Appendix 12.1, Volume 2c). As these areas constitute only a small proportion of the area affected by short term seabed habitat loss and/or disturbance, the extent of potential impact on spawning habitats is very limited. Disturbance to egg-laying habitats is reversible, with the seabed expected to recover post-construction; any egg cases directly affected would represent a small, localised loss, and given the very limited spatial

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
						overlap with suitable habitat, population-level effects are not expected.
Spotted ray	Low	Medium	M001 M023 M019	Minor	Not Significant	Limited information is available on egg-case distribution for this species, which is used to identify spawning grounds for oviparous species. However, where suitable habitat exists, spawning areas are expected to broadly overlap with nursery grounds (Ellis <i>et al.</i> , 2012). Spawning habitats, as identified in Plate 4-6b of Appendix 12.2, Volume 2c are very spatially restricted within the Marine Fish Study Area, and none lies within the Array Area or OCAS. Disturbance to egg-laying habitats is reversible, with the seabed expected to recover post-construction; any egg cases directly affected would represent a small, localised loss, and given the very limited spatial overlap with suitable habitat, population-level effects are not expected.
Sandeel	Low	Medium	M001 M023 M019	Minor	Not Significant	Suitable sandeel habitat is restricted within the Offshore Project Boundary, with the highest likelihood and densities occurring in the southwestern region of the Array Area (refer paragraph 12.8.1.16). Construction, where suitable sandeel habitat has been identified (the Array Area), is scheduled to avoid key sensitive periods of sandeel life history, including the spawning season (November–February), demersal egg phase

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
						(November–March), and overwintering period (winter). Although some construction will occur during these periods within the HDD Exit Pit Area, this area is spatially restricted (approximately 1 km ²) and is not considered optimal habitat (refer paragraph 12.8.1.16). As such, the presence of sandeel is expected to be unlikely, or limited to very low, localised densities where small pockets of suitable sediment may occur. Effects are spatially limited, as only a small proportion of suitable habitats within the Marine Fish Study Area will be affected, especially when considering the availability of habitats across the broader region. Disturbance is considered reversible, and sandeel populations are expected to recover rapidly following construction.
Atlantic cod	Low	Medium	M001 M023 M019	Minor	Not Significant	Spawning grounds have been identified within the Marine Fish Study Area, including across both the Array Area and OCAS (which includes the HDD Exit Pit Area) (Coull <i>et al.</i> , 1998). The construction schedule will avoid the majority of the cod spawning period (January–April), which peaks in February and March (Ellis <i>et al.</i> , 2012). Although offshore Landfall construction works located within the HDD Exit Pit Area may coincide with a greater proportion of the spawning period, this is a spatially restricted location (approximately 1 km ²). Cod spawning occurs over a

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
						very wide area along Scotland/ <i>Alba's</i> west coast and spawning is expected to be of low intensity in the Marine Fish Study Area. Disturbance is considered reversible, with spawning habitats recovering post-construction.
All other marine fish species (not discussed individually)	Low	Low	M001 M023 M019	Negligible	Not Significant	Due to their limited reliance on specific benthic habitats for key life stages, all other marine fish species are considered to have a lower likelihood of exposure to short term seabed habitat loss and disturbance.
Diadromous Fish						
Atlantic salmon, sea trout, European eel	Low	Low	M001 M023 M019	Negligible	Not Significant	Diadromous species are highly mobile and therefore able to avoid disturbed areas. High tolerance and recoverability to short term seabed habitat loss due to opportunistic feeding behaviour, and resilience of prey populations. Impacts are temporary and reversible.

Further Environmental Mitigation and Residual Effect

- 12.8.1.26 No additional Fish Ecology mitigation is considered necessary to address impacts from short term seabed habitat loss and/or disturbance because the likely effect in the absence of further mitigation (beyond the embedded commitments outlined in **Table 12-22**) is **Not Significant** in EIA terms.

12.8.2 INCREASES IN SUSPENDED SEDIMENT CONCENTRATION AND ASSOCIATED SEDIMENT DEPOSITION

- 12.8.2.1 Temporary increases in SSC and subsequent sediment deposition are predicted to occur during construction activities such as seabed preparation, foundation installation, and the laying of Offshore Cables (Array and Export). 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 changes, such as avoidance behaviours, leading to temporary displacement from affected areas. Increased turbidity associated with elevated SSC also has the potential to reduce foraging efficiency by impairing prey detection in visually hunting species (Wenger *et al.*, 2016). Although no Environmental Quality Standard (EQS) exists for suspended solids in the marine environment, the 25 mg/L and 0.5 mg/L thresholds used in the European Freshwater Fisheries Directive are referenced throughout the magnitude section below only to provide context for the relative magnitude and temporal change of predicted concentrations. These values are not considered ecologically applicable to marine fish, but offer some relevance for diadromous species during freshwater or transitional phases. Their use is therefore solely as a comparative benchmark to illustrate how quickly project-related suspended sediment concentrations decline over time. The maximum design scenario relating to increases in SSC and associated sediment deposition during the construction phase are presented in **Table 12-21**.
- 12.8.2.2 The resettlement of suspended material (deposition) may result in the smothering of less-mobile species or vulnerable life stages (e.g., 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.
- 12.8.2.3 This impact pathway includes increased SSC and associated deposition from cable installation up to HDD exit pits (-16.5 m LAT) and the installation of WTGs. Increases in SSC and associated deposition related to the construction of the HDD exit pits, including the release of drilling fluid (mud) and cuttings during trenchless construction techniques, are assessed separately in Section 12.8.5.

Magnitude

- 12.8.2.4 Installation of infrastructure within the Offshore Project 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:

- Cable installation using a jet trenching;
- Drilling of the WTG jacket pile foundations; and
- Multiple activities - drilling of piles to install wind turbine generator foundations and cable burial (sequentially).

12.8.2.5 Full details of the modelling undertaken to inform this assessment is presented **Chapter 9: Physical and Coastal Processes, Volume 2a** and **Appendix 9.2: Physical Processes Modelling Results Report, Volume 2c**, including the individual scenarios considered and assumptions within these and full modelling outputs for suspended sediments and associated sediment deposition. A summary of the findings is presented below.

Cable installation

12.8.2.6 For cable installation, the maximum design scenario assumes jet trenching along a corridor up to 7 m wide and to a depth of 2 m, with construction taking place during peak spring tidal conditions. Under these conditions, sediment plumes are generally constrained within 2 m of the seabed. Within the OCAS, suspended sediment may travel up to approximately 200 m, while in the Array Area maximum transport distances range from 500 m to 10 km. Peak SSC (3,400 mg/l) rapidly declines following cessation of trenching, typically falling to between 2 and 25 mg/l within 3 hours (**Figure A 4-3 of Appendix 9.2, Volume 2c**). Seabed deposition from cable installation is generally limited to less than 1 cm at a maximum distance of up to approximately 5 km within the Array Area and up to 250 m within the OCAS, with maximum deposition of approximately 10 cm occurring in the immediate vicinity of the construction activity (<400 m in the Array Area and <100 m in the OCAS).

12.8.2.7 The impacts of cable burial activities from adjacent cables may occur within the OCAS as this is where Array Cables to Landfall will be located in close proximity to each other (in comparison to the Array Cables to Final WTGs). In the case of suspended sediment concentrations, maximum values occur at the location of the cable burial and decrease rapidly with distance in the direction of the tidal current. Assuming that cables are buried equally spaced at 150 m across the width of the OCAS (2 km), the impacts of adjacent cables are not expected to be greater than the maximum impacts along the individual cables. This is based on the model between Landfall and the Array Area indicating a potential zone of influence of approximately 100 m centred on the cable burial route (see **Appendix 9.2, Volume 2c**).

Drilling of the WTG jacket pile foundations

12.8.2.8 Drilling for WTG foundation piles also generates localised elevated SSC and deposition. For WTG installation, the maximum design scenario for foundation installation assumes all WTG and Offshore Substation Platform (OSP) foundations will be installed by drilling 5.0 m diameter piles for jacket foundations (4 piles installed per jacket foundation, each spaced 20-55 m apart) to a seabed

depth of 15-120 m (depending on location within the Turbine Area). Modelling of SSC during and after drilling was undertaken for the simultaneous installation of 3 WTG piles at a single location. The model was run for 3 locations across the Array Area, each representing the dominant physical environmental conditions within the Turbine Area.

- 12.8.2.9 Sediment plumes varied across the Array Area, with greatest transport distances (up to 12-15 km) occurring in the southwest portion of the Array Area where finer sediments dominate. In the central and northeastern areas of the Array Area, sediment transport distances are more limited (3 km and <500 m, respectively). Peak SSC were also highest in the southwest portion of the Array Area, reflecting the greater proportion of fine material. Even in the worst-case scenario, SSC values decline significantly within hours of drilling, with concentrations falling to below 25 mg/l after 26 hours (assuming re-suspension), and to below 5mg/l in less than 46 hours. Deposition from foundation drilling is also highly localised, with the vast majority of sediment settling close to the point of disturbance. While localised deposition depths of up to 30 cm may occur immediately adjacent to drilling sites, deposition across most of the area is generally less than 1 cm.

Multiple activities - drilling of piles to install wind turbine generator foundations and cable burial

- 12.8.2.10 In addition to the activities considered individually above, multiple activities have also been assessed and modelled to determine maximum suspended sediment concentration and sediment deposition thickness concentration arising during the drilling of pin piles and cable burial activities. These activities, which have been assumed to occur sequentially within the Array Area, have been modelled as a maximum design scenario (see paragraph 9.1.7.5 and Section 4.6 of **Appendix 9.2, Volume 2c** for further details).
- 12.8.2.11 The maximum suspended sediment concentration during drilling of 4 WTG foundations (each with 4 piles), and burial of cables (assuming drilling and cable burial activities happen sequentially) per month, was modelled in the southwest Array Area, buried channel and northeastern area of the Array Area.
- 12.8.2.12 Overall, the combined extent of suspended sediment concentrations is mainly constrained to the Turbine Area, however the SSC plume does extend outside the Turbine Area by approximately 3 km in the southwest corner of the Turbine Area (see **Plate 4-32** in **Appendix 9.2, Volume 2c**).
- 12.8.2.13 When considering the drilling of pin piles to install WTG Foundations and burial of Array Cables to Final WTG, the worst-case scenario in terms of increase in suspended sediment concentration results from the southwest drilling of piles to install WTG foundations and sequential Array Cables to Final WTG burial, reaching up to 450 mg/l for a brief period (less than hour) within 500 m and will exceed the background concentration of 0.5 mg/l for around 13 days within 500m. This will exceed the 25 mg/l threshold for around 3 days and exceeds background concentrations of 0.5 mg/l for around 13 days.

- 12.8.2.14 When considering the maximum sediment deposition from the modelling of multiple activities (drilling of pin piles to install WTG Foundations and burial of Array Cables to Final WTG), deposition does not exceed the deposition from individual activities given the temporal and spatial variation between activities in relation to the tidal cycle, and potential for resuspension of sediment between subsequent activities.
- 12.8.2.15 Based on the maximum design scenario detailed in **Table 12-21** the impacts to marine fish and diadromous species will likely be adverse, medium-term in duration (over a period of 5 years commencing in 2028 or 2029), but intermittent (restricted to the months of April to October each year). Increases in SSC and associated sediment deposition are considered to be highly localised and naturally reversible through tidal processes.
- 12.8.2.16 Although there are no embedded mitigation measures specifically aimed at minimising emissions of SSC, the adherence to industry best practice with regard to accidental release of contaminants through sediment disturbance is beneficial. Considering the embedded Offshore Project mitigation measures detailed within **Table 12-22**, specifically M001 (micrositing), M002 (pre-construction geophysical surveys), M023 (construction timing) and M005 (best practice techniques for seabed excavations), the magnitude of impact from increases in SSC and associated deposition during the construction phase is predicted to be **Low** because of its localised nature, with recovery occurring in <5 years.

Sensitivity or value of receptor

- 12.8.2.17 The sensitivity described for each receptor is based on the criteria provided in **Table 12-12**.

High value receptors

- 12.8.2.18 The majority of fish receptors are considered of low to medium value. Diadromous fish (Atlantic salmon, sea trout, and European eel), and the common skate complex have been assigned a high value. This has been considered when determining the overall sensitivity of the receptor/s to increases in suspended sediment concentrations and associated sediment deposition during the construction phase of the Offshore Project. The value and sensitivity is based upon the criteria detailed in Section 12.5.

Marine fish

- 12.8.2.19 In the context of the impacts of suspended sediment, it is useful to distinguish groups of marine fish receptors for assessment due to distinct ecological and life-history traits that influence their responses to elevated SSC and associated deposition. These groups include:
- Species with nursery grounds within the area affected by SSC and sediment deposition;
 - Species with spawning grounds within the area affected by SSC and sediment deposition;
 - Species with both spawning and nursery grounds within the area affected by SSC and sediment deposition;
 - Sandeel (which depend on sandy sediments for burrowing and overwintering);

- All other marine fish receptors not discussed individually (least sensitive).

12.8.2.20 Sensitivity for these groups are discussed separately below.

12.8.2.21 Species with both spawning and nursery grounds are considered separately because multiple early life stages may be exposed simultaneously, resulting in greater potential sensitivity than for species with only one life stage present within the affected area.

Species with nursery grounds (only) within the area affected by SSC and deposition

12.8.2.22 Species with nursery grounds (only) within the area affected by elevated SSC and deposition (indicating presence of juveniles), includes Atlantic mackerel, blue whiting, anglerfish, European hake, haddock, ling, whiting and spurdog. Juvenile fish, while capable of some avoidance behaviour, have reduced mobility compared to adults and are therefore less able to avoid areas of elevated SSC and associated sediment deposition, resulting in lower tolerance to these conditions. Physiological and physical effects are also more likely at this life stage (Park *et al.*, 2025). Their presence in coastal and shelf areas characterised by winter storms, tidal currents and naturally elevated SSC indicates some inherent tolerance to episodic turbidity. Regardless, in consideration of the reduced ability of this life-stage to avoid areas of elevated SSC and associated sediment deposition and increased vulnerability to physiological and physical stressors, tolerance to elevated SSC and deposition has been assessed as low.

12.8.2.23 In terms of recoverability, Atlantic mackerel, blue whiting, anglerfish, European hake, haddock, ling, and whiting exhibit high fecundity, broad distribution ranges, and relatively short generation times. Such biological traits support a strong capacity for recovery from any potential lethal, physiological and/or behavioural impacts from elevated SSC, and as such are considered to have high recoverability. Spurdog, by contrast, has a slower growth rate, later maturity, and lower fecundity. As such, although tolerant to some short-term SSC changes, its recoverability is considered lower and is assessed as medium.

12.8.2.24 As such, Atlantic mackerel, blue whiting, anglerfish, European hake, haddock, ling and whiting of medium to low value are considered to have low tolerance and high recoverability. Therefore, sensitivity of these species is considered to be **Medium**. Spurdog, of medium value, is considered to have low tolerance and medium recoverability. Therefore, sensitivity for this species is considered to be **Medium**.

Species with spawning grounds (only) within the area affected by SSC and deposition

12.8.2.25 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 (Corell *et al.*, 2023). Species with spawning grounds (only) within the area affected by elevated SSC and deposition include European sprat, the common skate and spotted ray.

12.8.2.26 Pelagic spawners (European sprat) release their eggs into the water column and do not display substrate dependency for egg depositing. They are therefore generally less affected by deposition;

however, larvae may still be exposed to elevated SSC in the water column which can affect egg development (Corell *et al.*, 2023). Demersal spawners (common skate complex and spotted ray), 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). With regards to SSC, Appleby and Scarratt (1989) found that egg and larval development may be impaired at concentrations exceeding 1,000 mg/L. However, Kiørboe *et al.*, 1981 found no impact on Atlantic herring eggs from exposure to concentrations of 5-300 mg/L over 10 days, and short-term exposure to 500 mg/L also produced no measurable effects, indicating some natural tolerance, at least for this species.

- 12.8.2.27 In terms of recoverability, European sprat exhibits high fecundity, broad distribution ranges, and relatively short generation times, 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 the rate of full population recovery. For the common skate complex and spotted ray, due to the species life-history traits – slow growth, late maturity and generally low fecundity (Ellis *et al.*, 2021) both elasmobranch species are considered to have low recoverability to potential impacts on deposited egg cases from increases in SSC and sediment deposition.
- 12.8.2.28 European sprat are considered to have low tolerance and medium recoverability. Therefore, their overall sensitivity to increases in SSC and deposition is considered to be **Medium**. The common skate complex and spotted ray, of high to medium value, have low tolerance and low recoverability. Based on these attributes, sensitivity to increases in SSC and deposition is assessed as **High**.

Species with spawning and nursery grounds within the area affected by SSC and deposition

- 12.8.2.29 Species with both spawning and nursery grounds within the area affected by elevated SSC and associated deposition include Atlantic herring, Atlantic cod, lemon sole and Norway pout. For these species, multiple early life stages (eggs/larvae and juveniles) may be exposed to increases in SSC and deposition.
- 12.8.2.30 Juvenile fish exhibit reduced mobility compared to adults and are considered more susceptible to physiological and physical stressors associated with elevated SSC and deposition, as described in paragraph 12.8.2.22. Eggs and larvae are the considered the most sensitive life stages, due to limited or absent mobility and prolonged contact with affected substrates or turbid waters, as outlined in paragraph 12.8.2.25. Atlantic herring is a demersal spawner, depositing adhesive eggs directly onto coarse substrates, making them particularly vulnerable to smothering and impaired gas exchange if fine sediments accumulate. Atlantic herring spawning is likely to occur in some parts of the Offshore Project Boundary and across the broader Marine Fish Study Area. The highest

probability of spawning within the Offshore Project Boundary has been identified in its southern region (refer Section 4.1.2 of **Appendix 12.1, Volume 2c** for further details on Atlantic herring spawning across the Marine Fish Study Area). Atlantic cod, lemon sole and Norway pout are broadcast spawners, which release buoyant eggs into the water column; while these eggs are generally less sensitive to seabed deposition, elevated SSC may still impact egg development. Considering both impacts on juvenile and egg/larvae development stages, tolerance to elevated SSC and deposition for these species is assessed as medium on a precautionary basis.

- 12.8.2.31 In terms of recoverability, Atlantic herring, Atlantic cod, lemon sole and Norway pout all exhibit moderate to high fecundity and broad distribution ranges, that would typically support medium recoverability when life stages are affected in isolation. However, as both spawning and nursery grounds overlap with the area potentially affected by elevated SSC and deposition, impacts on eggs/larvae and juveniles have the potential to constrain recruitment more strongly than impacts on a single life stage. Given their high fecundity, recoverability for these species is assessed as medium
- 12.8.2.32 Atlantic herring, Atlantic cod, lemon sole and Norway pout are considered to have medium tolerance and medium recoverability and are of low to medium value. Therefore, the overall sensitivity of these species to increases in SSC and deposition is considered to be **Medium**.

Sandeel

- 12.8.2.33 Sandeel are strongly associated with sandy seabed habitats throughout their life cycle, such as for burrowing or overwintering. Deposition of fine sediments may reduce oxygen availability or change substrate composition, thereby reducing suitability for burrowing. The Scottish Government FeAST tool identifies sandeel as highly sensitive to heavy deposition (5–30 cm of fine material), and of low sensitivity to light deposition (≤ 5 cm) (FeAST, 2025). Sediment deposition associated with the Offshore Project is predicted to fall largely within the lower end of this scale, with most areas experiencing less than 2 cm and only localised peaks (as discussed in Section 12.8.2.1 to 12.8.2.14). Site-specific survey data and desktop analysis indicate that sandeel are present within the Offshore Project Boundary, with the highest likelihood and densities occurring in the southwestern region of the Array Area. In addition, a small patch of suitable habitat was also identified in the northern section of the Array Area. Due to the predominance of hard substrate across much of the remaining Offshore Project Boundary, including the OCAS (which includes the HDD Exit Pit Area), significant sandeel densities are unlikely outside these identified areas (refer to Section 4.2.2 of **Appendix 12.1, Volume 2c** for further discussion on the distribution of sandeel habitat across the Marine Fish Study Area).
- 12.8.2.34 On this basis, sandeel are deemed to be of medium value, low tolerance and high recoverability. Therefore, the sensitivity of sandeel is considered to be **Medium**.

All other marine fish species (not discussed individually)

- 12.8.2.35 Marine fish species not discussed individually – that is, those without identified spawning grounds 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. Mobile adult fish typically exhibit avoidance behaviours, enabling them to detect and actively avoid turbid areas, thereby limiting exposure to potential physiological effects such as gill irritation or respiratory stress (Messieh *et al.*, 1981). As such, these species are considered unlikely to experience significant lethal or physiological effects from short-term exposure. Sediment deposition is also unlikely to impact these species directly, though it may temporarily reduce foraging efficiency if prey becomes obscured or displaced. In terms of recoverability, these species have a high capacity to recover following exposure to elevated SSC and associated deposition.
- 12.8.2.36 As such, all other marine fish, are considered to be of high tolerance and have medium to high recoverability to this impact. Therefore, the overall sensitivity of these species is considered to be **Low**, regardless of value.

Diadromous species

Atlantic salmon, sea trout and European eel

- 12.8.2.37 Diadromous fish species including Atlantic salmon, sea trout, and European eel 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. Although salmonids are highly sensitive to fine sediments during their freshwater egg and alevin stages, these life stages occur exclusively in rivers and are therefore not affected by SSC or deposition associated with offshore construction activities.
- 12.8.2.38 Indirect effects may arise through changes in prey availability. Species, including 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 SSC 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 (e.g., Jensen *et al.*, 2004; BOWL, 2021). Diadromous species are also opportunistic feeders and capable of altering foraging patterns across broad spatial scales (Rikardsen and Dempson, 2011), thereby reducing the likelihood of foraging disruption.
- 12.8.2.39 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**.

Significance of effect

- 12.8.2.40 Temporary increases in SSC and subsequent sediment deposition is anticipated to take place during the construction phase of the Offshore Project. Considering the embedded mitigation described in **Table 12-22**, the residual effects of Temporary increases in SSC and subsequent sediment deposition on Fish Ecology receptors are summarised in **Table 12-24**.

Table 12-24 Significance of effect of temporary increases in SSC and subsequent sediment to Fish Ecology during the construction phase

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
Marine Fish						
Species with nursery grounds (only) within the area affected by SSC and sediment deposition						
Atlantic mackerel Blue whiting Anglerfish European hake Haddock Ling, Whiting Spurdog	Low	Medium	M001 M002 M023 M005	Minor	Not Significant	<p>Considered to have some tolerance to elevated levels of SSC due to natural high SSC caused by winter storms and tidal currents. Species have broad distribution ranges and high fecundity and therefore high recoverability. Intermittent medium-term impact highly localised and naturally reversible through tidal processes.</p>
Species with spawning grounds (only) within the area affected by SSC and sediment deposition						
European sprat	Low	Medium	M001 M002 M023 M005	Minor	Not Significant	<p>Spawning grounds for this species are known to partially overlap with the Offshore Cable and Array Areas, but are widespread along the west coast of Scotland/Alba. Intermittent medium-term impact highly localised and naturally reversible through tidal processes.</p>

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
Common skate complex	Low	High	M001 M002 M023 M005	Minor	Not Significant	Suitable egg-laying habitats for the common skate complex are spatially restricted within the area affected by temporary increases in SSC and subsequent deposition, being limited to shallow nearshore waters (<20 m depth; as discussed in Section 4.3.2 of Appendix 12.1, Volume 2c). As these areas constitute only a small proportion of the area affected by elevated SSC and associated deposition, the extent of potential impact on spawning habitats is very limited. Disturbance to egg-laying habitats is reversible, with the seabed expected to recover post-construction; any egg cases directly affected would represent a small, localised loss, and given the very limited spatial overlap with suitable habitat, population-level effects are not expected.
Spotted ray	Low	High	M001 M002 M023 M005	Minor	Not Significant	Limited information is available on egg-case distribution for this species, which is used to identify spawning grounds for oviparous species. However, where suitable habitat exists, spawning areas are expected to broadly overlap with nursery grounds (Ellis <i>et al.</i> , 2012). Spawning habitats, as identified in Plate 4-6b of Appendix 12.2, Volume 2c are very spatially restricted within the Marine Fish Study Area, and none lies within the Array Area or OCAS. Disturbance to egg-laying habitats is reversible, with the seabed expected to recover post-construction; any egg cases directly affected would represent a small, localised loss, and given the very limited

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
						spatial overlap with suitable habitat, population-level effects are not expected.
Species with spawning and nursery grounds within the area affected by SSC and sediment deposition						
Atlantic herring	Low	Medium	M001 M002 M023 M005	Minor	Not Significant	The highest probability of Atlantic herring spawning within the Offshore Project Boundary is in its southern region. Disturbance to spawning habitats is reversible, with the seabed expected to recover post-construction; any eggs and/or larvae directly affected would represent a small, localised loss, and given the high fecundity of this species and the naturally high background mortality characteristic of early life stages, such impacts are not expected to influence population recruitment. Intermittent medium-term impact highly localised and naturally reversible through tidal processes.
Atlantic cod Lemon sole Norway pout	Low	Medium	M001 M002 M023 M005	Minor	Not Significant	Spawning grounds for these species are known to partially overlap with the OCAS and Array Areas, but are widespread along the west coast of Scotland/ <i>Alba</i> . Intermittent medium-term impact highly localised and naturally reversible through tidal processes.
Sandeel						
Sandeel species	Low	Medium	M001 M002 M023 M005	Minor	Not Significant	Sandeel are relatively insensitive to light levels of deposition (≤ 5 cm). Most areas expected to experience less than 2 cm deposition from construction activities. Impacts are of limited spatial extent and short-term.

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
						Restricting cable and turbine installation to April-October avoids key sensitive periods for sandeel including spawning (November-February), demersal egg phase (November-March), and the overwintering period (winter).
All other marine fish species (not discussed individually)						
All other marine fish species (not discussed individually)	Low	Low	M001 M002 M023 M005	Negligible	Not Significant	The majority of marine fish species are not particularly sensitive to temporary increases in SSC. Intermittent medium-term impact highly localised and naturally reversible through tidal processes.
Diadromous Fish						
Atlantic salmon Sea trout European eel	Low	Low	M001 M002 M023 M005	Negligible	Not Significant	Sensitive life-stages (egg and alevin stages) are not exposed to elevated SSC or deposition associated with offshore construction activities. Adult and juvenile counterparts interacting with the area impacted by elevated SSC and deposition are habituated to estuarine and nearshore coastal habitats where SSC are naturally elevated. Able to avoid areas of maximum disturbance. Intermittent medium-term impact highly localised and naturally reversible through tidal processes.

Further Environmental Mitigation and Residual Effect

- 12.8.2.41 No additional Fish Ecology mitigation is considered necessary to address impacts from SSC because the likely effect in the absence of further mitigation (beyond the embedded commitments outlined in **Table 12-22**) is Not Significant in EIA terms.

12.8.3 RELEASE OF DRILLING FLUID DURING TRENCHLESS CONSTRUCTION AND CONSTRUCTION OF HDD EXIT PITS

- 12.8.3.1 Horizontal direct drilling (HDD) is proposed for the trenchless installation of the Offshore Cables (either Scenario 1: Export Cables or Scenario 2: Array Cables to Landfall) to connect with the Onshore Export Cable. Although direct seabed habitat loss will be greatly reduced by using HDD, there is the potential for other impacts to arise, including from the release of drilling fluid (commonly termed “mud”) following breakout at the HDD Exit Pit location. This is a water-based slurry of bentonite, a naturally occurring clay mineral used to support bore stability and to carry the cuttings (fragments of rock generated by the action of the drill head) out of the bore. While bentonite is non-toxic, and the cuttings are inert, any release contributes to temporary increases in SSC and subsequent deposition. Heavier cuttings will fall out of suspension relatively quickly and be deposited in the pit near the exit point. Increases in SSC and associated deposition related to the construction of the HDD exit pits is also assessed here. The maximum design scenario relating to release of drilling fluid (including entrained cuttings) and construction of HDD exit pits during the construction phase is presented in **Table 12-21**.

Magnitude

- 12.8.3.2 Under the maximum design scenario for SSC and sediment deposition from the release of drilling fluid during trenchless construction and HDD exit pit construction, the following activities were considered, and used for the purpose of sediment transport modelling:
- release of drilling fluid;
 - exit pit construction; and
 - multiple activities - HDD construction activities (both release of drilling mud and HDD Exit Pit construction).
- 12.8.3.3 Full details of the modelling undertaken to inform this assessment is presented **Chapter 9: Physical and Coastal Processes, Volume 2a** and **Appendix 9.2: Physical Processes Modelling Results Report, Volume 2c**, including the individual scenarios considered and assumptions within these and full modelling outputs for suspended sediments and associated sediment deposition. A summary of the findings is presented below.

Release of drilling fluid

- 12.8.3.4 A worst-case release of drilling fluid has been modelled, assuming the full length (1,100 m) of the largest HDD bore is discharged over 1 hour, resulting in a total release volume of approximately

1,285 m³. Under this scenario, a fine sediment release rate of approximately 230 kg/s was assumed, based on the worst-case discharge volume and the drilling fluid being 'very dirty' with 27% fine sediment by mass. Peak SSC values are predicted to reach ~270 mg/l during spring tides and ~650 mg/l during neap tides.

- 12.8.3.1 Maximum SSCs of 1,000 mg/l were recorded up to 1 km from the HDD modelling location (plume width up to 250 m) and up to 50 mg/l 6 km away with plume width up to 2 km. During a neap tide current velocity window, sediment in this location could travel approximately 3 km. Maximum SSCs from individual releases are 1,000 mg/l up to 1 km from the HDD modelling location (plume width up to 300 m) and up to 50 mg/l up to 3 km away (plume width up to 1 km).
- 12.8.3.1 The sediment transport modelling (**Appendix 9.2, Volume 2c**) shows that sediment deposition thicknesses resulting from HDD drill cutting release are up to 7 mm in the immediate vicinity (<500 m) of the HDD construction activity. Generally, deposition thickness is less than 1 mm at a maximum distance of 4 km depending on the tidal conditions during construction. It is noted in Section 3.4.2 of **Appendix 9.2, Volume 2c** that the sediments are frequently mobilised by tidal currents and waves. Therefore, any deposited sediments on the seabed are likely to be mobilised within a short period of time by hydrodynamic forces.
- 12.8.3.2 Based on prevailing sediment transport conditions, both suspended and deposited sediments are expected to return to background levels within 1–2 days. Whilst the Project Design Envelope allows for concurrent HDD activities, works will be managed so that only 1 break out activity is undertaken at once. Therefore, although there will be up to 13 HDD bores only one activity has been modelled.

Exit pit construction

- 12.8.3.3 For HDD exit pit construction, the maximum design scenario assumes that each exit pit is prepared by rock cutting and/or grinding to the required depth, with up to 13 pits constructed, each approximately 75 m long, 5 m wide and 3.5 m deep. Increases in SSC and subsequent deposition from the construction of the HDD Exit Pits have been assessed using outputs of sediment plume modelling conducted for the burial of Array Cables and HDD drill cutting release.
- 12.8.3.4 The maximum suspended sediment concentrations caused by HDD exit pit construction are expected to range between 350 mg/l (within 200 m of HDD exit pit construction) and 1,000 mg/l (within 1 km of HDD exit pit construction) for coarse and fine sediment respectively. Suspended sediment concentrations are expected to be elevated above baseline conditions for up to 2 days. Maximum sediment deposition thicknesses are expected to range between 3 cm (within 400 m of HDD exit pit construction) and 7 mm (within 500 m of HDD exit pit construction) for coarse and fine sediment respectively. Finer sediments are expected to be resuspended quickly (within an hour).

Multiple activities - HDD construction activities (both release of drilling fluid and exit pit construction)

- 12.8.3.5 Multiple activities to assess cumulative SSC and associated deposition resulting from sequential HDD exit pit construction and release of drilling fluid from HDD has also been considered (see Section 4.6.2 in **Appendix 9.2, Volume 2c**). For HDD exit pit construction, the same maximum design scenario described in paragraph 12.8.3.5 applies to the cumulative assessment, and likewise the maximum design scenario for drilling-fluid release described in paragraph 12.8.3.4 applies.
- 12.8.3.6 If multiple HDD construction activities occur within 2 days, then there could be accumulation of suspended sediment within 1 km of the activities. Suspended sediment concentrations are expected to return to baseline conditions within 2 days of a construction activity taking place. This is based on a worst-case assumption that the activities are aligned in the direction of the tidal current (i.e. the direction where sediment advection distances are the largest).
- 12.8.3.7 The potential impacts of sediment deposition from multiple activities occurring in a single location or multiple locations have been considered in **Appendix 9.2, Volume 2c**.
- 12.8.3.8 In a single location, the worst-case sediment deposition thickness from multiple activities (i.e. exit pit construction and release of drilling fluid) is limited by the by the natural re-mobilisation of sediments by tidal currents and waves. The maximum deposition thickness resulting from HDD exit pit construction or drill cutting release is 7 mm for fine sediments. The sediment will be re-mobilised by tidal currents and waves under normal conditions so preventing accumulation even where activities overlap. For coarse sediments, combined deposition from overlapping HDD exit pit construction and release of drilling fluids could reach up to 4 cm. This will be limited to the location where the HDD exit pit and release of drill cuttings overlap.
- 12.8.3.9 Sediment may accumulate due to multiple activities occurring in multiple locations within the Exit Pit Area. Sediment deposition thickness decreases with distance from the construction activity in the direction of the tidal current. Sediment deposited due to release of drill cuttings is assumed to be re-mobilised by tidal currents and waves in normal conditions so is expected to not accumulate significantly across different locations. This also applies to fine sediments released by HDD exit pit construction. For coarser sediments released by HDD exit pit construction, sediment could accumulate by up to a maximum of 3 cm per HDD exit pit within 400 m of each other if 100% of the sediment is assumed to be coarse, and the HDD exit pit locations are directly aligned in the direction of the tidal current.
- 12.8.3.10 Overall, elevated suspended sediment concentrations as a result of the release of drilling fluid from HDD exit pits and associated with HDD exit pit construction are expected to be adverse, and medium-term (over a period of 5 years commencing in 2028 or 2029. Deposition is predicted to be localised and naturally reversible through tidal processes. Considering the embedded Offshore Project mitigation measures detailed within **Table 12-22**, specifically M001 (micrositing), M002 (pre-construction geophysical surveys) and M005 (best practice techniques for seabed excavations),

the magnitude of this impact is predicted to be **Low** because of its localised nature, with recovery occurring within <5 years.

Sensitivity or value of receptor

12.8.3.11 The sensitivity described for each receptor is based on the criteria provided in **Table 12-12**.

High value receptors

12.8.3.12 The majority of fish receptors are considered of low to medium value. Diadromous fish (Atlantic salmon, sea trout and European eel) and the common skate complex have been assigned a high value. This has been considered when determining the overall sensitivity of the receptors to release of drilling fluids during trenchless construction and construction of HDD exit pits during the construction phase of the Offshore Project. The value and sensitivity is based upon the criteria detailed in Section 12.5.

Marine fish

12.8.3.13 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 Offshore Cables in Section 12.8.2. As the impacts from the release of drilling fluid muds and very low levels of bentonite during trenchless construction techniques 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.

Species with nursery grounds (only) within the area affected by SSC and deposition

12.8.3.14 Atlantic mackerel, blue whiting, anglerfish, European hake, haddock, ling and whiting of medium to low value are considered to have low tolerance and high recoverability. Therefore, sensitivity of these species is considered to be **Medium**. Spurdog, of medium value, is considered to have low tolerance and medium recoverability. Therefore, sensitivity for this species is considered to be **Medium**.

Species with spawning grounds (only) within the area affected by SSC and deposition

12.8.3.15 European sprat are considered to have low tolerance and medium recoverability. Therefore, the overall sensitivity of these species to increases in SSC and deposition is considered to be **Medium**. The common skate complex and spotted ray of high to medium value, have low tolerance and low recoverability. Based on these attributes, sensitivity to increases in SSC and deposition is assessed as **High**.

Species with spawning and nursery grounds within the area affected by SSC and deposition

12.8.3.16 Atlantic herring, Atlantic cod, lemon sole and Norway pout are considered to have *medium tolerance and medium recoverability and are of low to medium value. Therefore, the overall sensitivity of these species to increases in SSC and deposition is considered to be **Medium**.*

Sandeel

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

All other marine fish species (not discussed individually)

- 12.8.3.18 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, sensitivity of these species is considered to be **Low**.

Diadromous species

- 12.8.3.19 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 in Section 12.8.2. Since the release of drilling fluid muds and low levels of bentonite during trenchless construction results in the same pressures (increased SSC and deposition), sensitivity is considered unchanged. For clarity, the diadromous fish sensitivity statement is repeated below.

Atlantic salmon, sea trout and European eel

- 12.8.3.20 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**.

Significance of effect

- 12.8.3.21 Release of drilling muds during trenchless construction is anticipated to take place during the construction phase of the Offshore Project. Considering the embedded mitigation described in **Table 12-22**, the residual effects of release of drilling muds during trenchless construction on Fish Ecology receptors are summarised in **Table 12-25**.

Table 12-25 Significance of effect of release of drilling muds on Fish Ecology during the construction phase

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
Marine Fish						
Species with nursery grounds (only) within the area affected by SSC and sediment deposition						
Atlantic mackerel Blue whiting Anglerfish European hake Haddock Ling, Whiting Spurdog	Low	Medium	M001 M002 M005	Minor	Not Significant	Considered to have some tolerance to elevated levels of SSC due to natural high SSC caused by winter storms and tidal currents. Species have broad distribution ranges and high fecundity and therefore high recoverability. Intermittent medium-term impact highly localised and naturally reversible through tidal processes.
Species with spawning grounds (only) within the area affected by SSC and sediment deposition						
European sprat	Low	Medium	M001 M002 M005	Minor	Not Significant	Spawning grounds for this species are known to partially overlap with the OCAS (which includes the HDD Exit Pit Area), but spawning grounds are widespread along the west coast of Scotland/Alba. Intermittent medium-term impact highly localised and naturally reversible through tidal processes.
Common skate complex	Low	High		Minor	Not Significant	Suitable egg-laying habitats for the common skate complex are spatially restricted within the area affected by temporary increases in SSC and subsequent deposition from HDD activities, being limited to shallow nearshore waters (<20 m depth; as discussed in Section 4.3.2 of Appendix 12.1, Volume 2c). As the area affected by elevated SSC and associated deposition from the release of drilling fluids and HDD exit pit construction is

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
						spatially limited, the extent of potential impacts on spawning habitats is limited. Disturbance to egg-laying habitats is reversible, with the seabed expected to recover post-construction; any egg cases directly affected would represent a small, localised loss, and given the limited spatial overlap with suitable habitat, population-level effects are not expected.
Spotted ray	Low	High		Minor	Not Significant	Limited data is available on egg-case distribution for this species, which is used to identify spawning grounds for oviparous species. However, where suitable habitat exists, spawning areas are expected to broadly overlap with nursery grounds (Ellis <i>et al.</i> , 2012). Spawning habitats, as identified in Plate 4-6b of Appendix 12.2, Volume 2c are very spatially restricted within the Marine Fish Study Area, and none lies within the OCAS (which includes the HDD Exit Pit Area). Disturbance to egg-laying habitats is reversible, with the seabed expected to recover post-construction; any egg cases directly affected would represent a small, localised loss, and given the very limited spatial overlap with suitable habitat, population-level effects are not expected.

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
Species with spawning and nursery grounds within the area affected by SSC and sediment deposition						
Atlantic herring	Low	Medium	M001 M002 M005	Minor	Not Significant	The highest probability of Atlantic herring spawning within the Offshore Project Boundary is in its southern region, however the inshore areas of the OCAS (which includes the HDD Exit Pit Area) was identified with low potential (refer Figure A4.2 of Appendix 12.1, Volume 2c). Disturbance to spawning habitats is reversible, with the seabed expected to recover post-construction; any eggs and/or larvae directly affected would represent a small, localised loss, and given the high fecundity of this species and the naturally high background mortality characteristic of early life stages, such impacts are not expected to influence population recruitment. Intermittent medium-term impact highly localised and naturally reversible through tidal processes.
Atlantic cod Lemon sole Norway pout	Low	Medium		Minor	Not Significant	Spawning grounds for these species are known to partially overlap with the Offshore Cable and Array Areas, but are widespread along the west coast of Scotland/ <i>Alba</i> . Intermittent medium-term impact highly localised and naturally reversible through tidal processes.
Sandeel						
Sandeel species	Low	Medium	M001 M002 M005	Minor	Not Significant	Sandeel are relatively insensitive to light levels of deposition (≤ 5 cm). Most areas expected to experience less than 2 cm deposition from construction activities. Although offshore Landfall construction works located within the HDD Exit Pit Area may occur during the spawning season (November–February), demersal egg phase (November–March), and overwintering

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
						period (winter), this area is not considered optimal habitat (as discussed in paragraph 12.8.2.33). As such, the presence of sandeel across the area affected by the release of drilling fluid during trenchless construction and the construction of HDD exit pits is expected to be unlikely, or limited to very low, localised densities where small pockets of suitable sediment may occur. Impacts are of limited spatial extent and short-term.
All other marine fish species (not discussed individually)						
All other marine fish species (not discussed individually)	Low	Low	M001 M002 M005	Negligible	Not Significant	The majority of marine fish species are not particularly sensitive to temporary increases in SSC. Intermittent medium-term impact highly localised and naturally reversible through tidal processes.
Diadromous Fish						
Atlantic salmon Sea trout European eel	Low	Low	M001 M002 M005	Negligible	Not Significant	Sensitive life-stages (egg and alevin stages) are not exposed to elevated SSC or deposition associated with offshore construction activities. Adult and juvenile counterparts interacting with the area impacted by elevated SSC and deposition are habituated to estuarine and nearshore coastal habitats where SSC are naturally elevated. Able to avoid areas of maximum disturbance. Intermittent medium-term impact highly localised and naturally reversible through tidal processes.

12.8.4 UNDERWATER NOISE AND VIBRATION (IMPULSIVE NOISE)

- 12.8.4.1 Assessment of effects from underwater noise and vibration (as a source of noise within the water column) has been undertaken using a modified approach from the structure outlined in Section 12.5.3. This is because the assessment is informed by sound exposure guidelines for fish (Popper *et al.*, 2014; expanded in Popper *et al.*, 2019), which define exposure thresholds according to groups of fish with differing sensitivities to underwater sound. As such, the magnitude of impact is presented in the context of these thresholds, integrating both the predicted biological effect (e.g. injury or behavioural change; paragraph 12.8.4.4) and the differing sensitivities of the fish groups (summarised in **Table 12-26**). A further departure from the standard structure is the grouping of species for the purpose of assessment. Rather than using the typical ecological groupings applied elsewhere in this Chapter, species are grouped into “hearing groups” defined by the guidelines (defined in **Table 12-26**), reflecting differences in hearing ability and thus sensitivity to underwater noise.
- 12.8.4.2 For diadromous fish specifically, the significance of effect is presented narratively rather than through the standard sensitivity table. This is because the assessment for diadromous species, such as Atlantic salmon, requires consideration of multiple life stages and migratory behaviours, each with differing ecological sensitivities. These threshold-specific relationships and stage-specific behaviours cannot be clearly conveyed within the standard tabular format, necessitating a more detailed narrative explanation of how magnitude and sensitivity combine to determine significance for this receptor group.
- 12.8.4.3 Despite these structural differences, the core assessment methodology set out in Section 12.5.3 is still applied to determine magnitude, receptor sensitivity and value, and ultimately the significance of effect; this section is simply informed by the sound exposure criteria necessary for assessing underwater noise.

Biological effects of noise

- 12.8.4.4 Underwater noise 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 5 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 (e.g., 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.
- **Temporary Threshold Shift (TTS):** TTS refers to a temporary, reversible reduction in hearing sensitivity. TTS is defined as a measurable shift in hearing threshold of ≥ 6 dB 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 (e.g. 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 (e.g., 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 6 dB 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.

- 12.8.4.5 Fish perceive underwater noise through two main mechanisms: detection of particle motion and detection of sound pressure (Popper *et al.*, 2019). 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.
- 12.8.4.6 All fish detect the particle motion component of underwater sound. Particle motion refers to the physical displacement of water particles caused by a sound wave. This motion is sensed directly by the fish's inner ear (otolith organs) and, in some species, also by the lateral line system. Detection of particle motion is fundamental to fish hearing and spatial orientation and occurs even in species without specialised hearing adaptations.
- 12.8.4.7 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. Sound pressure detection allows for enhanced hearing sensitivity and the ability to detect higher-frequency components of noise, broadening the range and potential responsiveness of such species to underwater noise stimuli.
- 12.8.4.8 Sound exposure guidelines for fish have been developed to reflect the varying hearing ability of species based on their auditory anatomy and mechanisms of sound detection. The Sound Exposure Guidelines for Fish and Sea Turtles (Popper *et al.*, 2014), expanded by Popper and Hawkins (2019), are considered the most relevant guidelines. These guidelines, agreed upon with NatureScot and MD-LOT during scoping (refer **Table 12-2**), group fish into categories based on hearing ability and mechanisms of sound detection. **Table 12-26** presents these categories and details the fish species relevant to the Offshore Project within each of these categories.

Table 12-26 Hearing ability as defined Popper *et al.* (2014) and summarised by Popper and Hawkins (2019) and relevant fish species relevant to the Offshore Project within each of these categories

Hearing Group	Hearing ability	Relevant fish species
1	Fish with no swim bladder or other gas chamber detecting only particle motion. Narrow frequency sensitivity.	<p>Pelagic species: Atlantic mackerel, horse mackerel and ocean sunfish</p> <p>Demersal species: Atlantic halibut, common sole, lemon sole, European plaice, sandeels, Anglerfish and the black scabbard fish</p> <p>All elasmobranchs (sharks, skates, and rays), including basking shark</p>
2	Fish with a swim bladder that does not aid in hearing. Limited to detecting particle motion and have a narrow hearing bandwidth.	<p>Pelagic species: Atlantic bluefin tuna</p> <p>Diadromous species: Atlantic salmon and sea trout</p>
3	Fish with a swim bladder (or other gas-filled structure) involved in hearing. can detect both sound pressure and particle motion and are considered more sensitive to underwater noise. Hearing frequency ranges are broader than in Hearing groups 1 and 2.	<p>Demersal species: Atlantic cod, blue whiting, whiting, Norway pout, saithe, blue ling, ling, European hake and roundnose grenadier</p> <p>Diadromous species: European eel</p>
4	Specialist hearing adaptation comprising prootic auditory bullae, gas-filled ducts that extend from the swim bladder into the skull and connect directly to the inner ear.	<p>Pelagic species: Atlantic herring, European sprat and European pilchard</p>
5	Eggs and larvae - fish eggs and larvae are separated for special consideration because of their reduced mobility, and small size.	<p>Species with spawning grounds within ZoI for underwater noise (indicative of the presence of eggs and larvae) –</p> <ul style="list-style-type: none"> - Pelagic species: Atlantic herring, Atlantic mackerel, blue whiting, European sprat. - Demersal species: Atlantic cod, European hake, haddock, lemon sole, Norway pout, whiting - Elasmobranchs (oviparous species only): common skate complex, spotted ray.

Defining underwater noise

12.8.4.9 Impulsive underwater noise and vibration will be generated during the construction phase of the Offshore Project. The most significant contributor is percussive piling associated with the installation of WTG and OSP foundations, foundations which generates high-intensity impulsive sound.

12.8.4.10 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 percussive piling, the 2 primary metrics used in impact assessments are Peak Sound Pressure Level (dB Peak) and Cumulative Sound Exposure Level (SEL_{cum}). 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.

Peak Sound Pressure Level (dB Peak or $L_{p,pk}$)

12.8.4.11 Peak Sound Pressure Level refers to the maximum instantaneous pressure recorded during a sound event. It is expressed in decibels relative to 1 microPascal (dB re. 1 μ Pa). This metric does not account for the duration of the sound - only the highest-pressure spike in the waveform.

12.8.4.12 Peak pressure is particularly relevant for assessing the risk of death or acute injury of fish located close to the sound source. High peak levels can result in immediate physical damage such as ruptured swim bladders or barotrauma (tissue injury from rapid pressure change).

Sound Exposure Level (SEL)

12.8.4.13 SEL represents the total acoustic energy a fish is exposed to over a defined time period. It integrates both intensity (pressure squared) and duration of the sound. It is expressed in decibels relative to 1 microPascal squared second (dB re 1 μ Pa²s).

12.8.4.14 Two types of SEL are relevant:

- SEL_(single strike) or SEL_{ss}: This refers to the sound energy from a single impulsive event (e.g., 1 pile-driving hammer strike). It provides a useful building block for understanding the accumulation of exposure over time;
- SEL_(cumulative) or SEL_{cum}: This is the sum of the SEL_{ss} values over a defined time window. It represents the total noise energy exposure a fish receives during a longer exposure scenario, such as repeated percussive piling across a construction shift or day.

12.8.4.15 SEL_{cum} is important for assessing mortality, and both acute and recoverable injury, but also for effects such as short-term or long-term changes in hearing sensitivity, and changes in behaviour. It reflects the accumulative nature of sound exposure, which is key in understanding impacts over prolonged activities. Further information is provided in **Appendix 13.3, Volume 2c**.

Magnitude

12.8.4.16 The Popper *et al.* (2014) guidelines include thresholds to distinguish when biological effects of noise (as defined in paragraph 12.8.4.4) may be caused to different types of fish (as defined in **Table 12-26**). **Table 12-27** summarises the fish injury criteria recommended for percussive piling based on these guidelines.

Table 12-27 Criteria for Onset of Injury to Fish due to Impulsive Piling (Popper *et al.*, 2014)

Hearing group	Parameter	Mortality /potential mortal injury	Recoverable injury	TSS
Group 1 (fish without a swimbladder)	SEL, dB re 1 $\mu\text{Pa}^2\text{s}$	>219	>216	>186
	Peak, dB re 1 μPa	>213	>213	N/A
Group 2 (fish with swimbladder not involved in hearing)	SEL, dB re 1 $\mu\text{Pa}^2\text{s}$	210	203	>186
	Peak, dB re 1 μPa	>207	>207	N/A
Group 3 and 4 (fish with swimbladder involved in hearing)	SEL, dB re 1 $\mu\text{Pa}^2\text{s}$	207	203	186
	Peak, dB re 1 μPa	>207	>207	N/A
Group 5 (eggs and larvae)	SEL, dB re 1 $\mu\text{Pa}^2\text{s}$	>210	(N) Moderate	(N) Moderate
	Peak, dB re 1 μPa	>207	(I) Low (F) Low	(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; i.e. 10 s of metres), intermediate (I; i.e. 100 s of metres), and far field (F; i.e. 1,000 s of metres) (Popper <i>et al.</i> , 2014).				

Project noise modelling

12.8.4.17 Underwater noise modelling has been undertaken to define the maximum spatial extent of underwater noise impacts (the magnitude of impact) that will not be exceeded during construction. The modelling incorporates the component of vibration transmitted into the water column, therefore vibration is not assessed separately. To define this maximum extent, 6 representative percussive piling locations were selected across the Turbine Area (**Figure 12-2, Volume 2b**). The locations are at the outermost positions within the Array Area where percussive piling is proposed thus reflecting the maximum potential spatial extent of underwater noise exposure. They also capture spatial variability in bathymetry, sediment type, and propagation conditions (see **Appendix 13.3, Volume 2c** for further details).

12.8.4.18 Details of the modelling input parameters are described in Section 3.2.3 and Tables 3-2 to 3-6 of **Appendix 13.3, Volume 2c**. Percussive piling will include a system for noise abatement, which will provide a reduction in the noise that can spread to the surrounding water. The Offshore Project has committed to a noise reduction of 12dB. Full details are given in **Appendix 3.1, Volume 1c**.

- 12.8.4.19 As part of the design of the Offshore Project, no percussive piling will take place at the southwestern end of the Array Area, within the Percussive Piling Exclusion Area (refer Plate 3-1 of **Appendix 3.1, Volume 1c**). Additionally, the Percussive Piling Area has been split into 3 zones (2,500 kJ Max; 3,500 kJ Max; 5,000 kJ Max) to limit the maximum hammer energy. The hammer energy reduces towards the southeast of the Percussive Piling Area that is closest to the mouth of Loch Roag/Loch Ròg (refer Plate 3-2 of **Appendix 3.1, Volume 1c**). A full explanation of the rationale for applying reduced hammer blow energies is provided in Section 3.2.1.3 of **Appendix 13.3, Volume 2c** and the percussive piling installation approach is detailed in full in **Appendix 3.1, Volume 1c**.
- 12.8.4.20 As these parameters either form embedded mitigation (soft start procedures) or are inherent to the design of the Offshore Project (-12dB noise abatement, limitations on hammer energy), the modelling results described in this assessment include the 12dB noise reduction and varied hammer energy described above.
- 12.8.4.21 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 fish:
- 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.
- 12.8.4.22 The application of stationary and moving receptor assumptions within the underwater noise modelling, and their relevance to both marine fish and diadromous species, is set out in the sections below. In addition, an explanation is provided for diadromous species to outline how the appropriate noise threshold is identified and applied when presenting the modelled results relevant to potential effects on migration.
- Marine fish*
- 12.8.4.23 Marine fish species, particularly those with acute audition due to the use of their swim bladders or an accessory hearing organ (e.g. fish within hearing group 3 and 4) might be expected to move away rapidly from an ensonified area. However, there is relatively limited evidence for fish fleeing from high noise source levels in the wild. Whether an animal swims or remains stationary in response to a loud noise will differ between species, with those most likely to remain stationary expected to be benthic species or those without a swim bladder, due to their reduced hearing capabilities, making these species the least sensitive to noise (e.g., Goertner *et al.*, 1994, 1978; Stephenson *et al.*, 2010; Halvorsen *et al.*, 2012).
- 12.8.4.24 While field evidence for marine fish actively 'fleeing' from impulsive noise sources is limited and often highly context-dependent, relying solely on a stationary receptor assumption in the context

of cumulative exposure (SEL_{cum}) would likely overestimate risk for mobile or migratory species capable of sustained swimming. For this reason, model outputs in the subsequent sections are presented for both a 'fleeing' receptor, using a representative sustained swim speed of 0.6 m s⁻¹ and 1.5 m·s⁻¹ (Hirata, 1999), and a 'stationary' receptor. Species with greater sustained swimming ability, such as fast-moving pelagic fish such as Atlantic mackerel are broadly representative of the higher speed assumption (1.5 m·s⁻¹) (Olla *et al.*, (1976).

12.8.4.25 However, given the limited and variable evidence for consistent avoidance behaviour in the wild, uncertainties regarding species-specific movement responses, and the need to apply a precautionary approach, the assessment of effect significance is based on the stationary receptor scenario, representing the worst-case cumulative exposure. The fleeing model outputs are provided to contextualise a more realistic behavioural response for many species, but they are not used to determine significance.

Diadromous fish

12.8.4.26 While field evidence of fish 'fleeing' from impulsive noise is limited and context-dependent, using only a stationary receptor model in the context of cumulative exposure (SEL_{cum}) would overestimate the risk for migrating species. For Atlantic salmon, that actively migrate during relevant life stages (e.g., post-smolts and returning adults), the assumption that individuals remain stationary during percussive piling activity is unrealistic. These fish, are by definition moving through the marine environment, and therefore less likely to remain in a given area of high noise exposure for extended periods.

12.8.4.27 As such, for Atlantic salmon post-smolts, a 'moving' receptor model was modelled and initially assumed a swimming speed of 1.5 m/s (based on Hirata, 1999). Advice was sought from NatureScot and MD-SEDD (see **Appendix 12.2, Volume 2c**) on the assumptions regarding Atlantic salmon post-smolt swim speeds and behavioural responses that should be used to inform the assessment. A sustained swim speed of 1.2 body lengths per second (BL s⁻¹) equivalent to 0.165 m·s⁻¹ based on Grimersta River smolt data (n = 677), was recommended and was subsequently modelled.

12.8.4.28 It is important to note, however that this 1.2 BL s⁻¹ is based on fish not exposed to noise impacts and therefore implies a limited (if any) behavioural motion response to noise from percussive piling. As such, an intermediate speed of 0.6 m s⁻¹ was also modelled to provide impact ranges for post-smolts responding to impulsive noise. This intermediate swim speed is based on a sustained swimming performance of 4.4 body-lengths per second applied to the mean length of individual Atlantic salmon post-smolts leaving the Grimersta system. Further detail on the derivation of post-smolt swim speeds, including the underlying calculations and supporting evidence, is provided in **Appendix 12.2, Volume 2c**.

12.8.4.29 Sea trout, European eel 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 prior to their dispersal and therefore tend to “linger” in an area (thus have increased residence time). As such, their movement patterns may not conform neatly to the mobile receptor model. Migratory behaviours of diadromous fish are further discussed in **Appendix 12.1, Volume 2c**.

12.8.4.30 As such, multiple receptor scenarios (stationary and moving models with various movement rates) are presented in the following section to reflect the differing behaviours of diadromous species during migration and coastal residency. These scenarios provide context for how movement could influence cumulative exposure. However, the precautionary principle is applied when determining the significance of effect. A stationary receptor scenario, representing the worst-case cumulative exposure, is used for adult Atlantic salmon, kelts, sea trout and European eel. For post-smolts, the most conservative swim speed of 0.165 is applied to represent a precautionary exposure duration. The higher swim-speed model outputs (0.6 m/s and 1.5 m/s) are presented to contextualise more realistic behavioural responses for these species, but they are not used to determine significance.

Assessing impacts on migration

12.8.4.31 For diadromous fish, including Atlantic salmon, sea trout, and European eel, a key established threshold is not currently known that reliably predicts a behavioural response in Atlantic salmon sufficient to impede migration. While Atlantic salmon rely on acoustic cues for predator avoidance, and spatial orientation, evidence demonstrating that noise alone can cause a significant migratory barrier is lacking, likely due in part to the strong biological imperative driving their migratory movement (Knudsen *et al.*, 1992, 1994, Harding *et al.*, 2016). In the absence of a recognised behavioural threshold, TTS has been applied as a precautionary proxy. TTS represents a reversible elevation in hearing sensitivity and therefore provides a more relevant biological mechanism by which noise could plausibly interfere with orientation or environmental cue detection during migration.

Model results

12.8.4.32 The following section presents the model outputs in the context of the biological effects on fish receptors (i.e. mortal injury, recoverable injury, temporary threshold shift and behavioural effects; as defined in paragraph 12.8.4.4) based on the outputs of noise modelling at 6 locations within the Array Area (**Appendix 13.3, Volume 2c**).

Mortality (including potential mortal injury) and recoverable injury effects

Stationary receptor

12.8.4.33 **Table 12-28** presents mortality and recoverable injury levels based on peak sound pressure levels (peak SPL or peak pressure metric), and **Table 12-29** presents mortality and recoverable injury levels based on cumulative exposure (SEL_{cum}) for the maximum (5,000 kJ; Location 6) and minimum (2,500 kJ; Location 1) percussive piling hammer energies.

Table 12-28: Injury ranges for fish (stationary receptor) due to percussive piling based on the maximum (5,000 kJ; Location 6) and the minimum (2,500 kJ; Location 1) percussive piling hammer energies based on the peak pressure metric $L_{p,pk}$ (Southall et al. 2019)

Hearing group	Response	Range (m)	
		Max hammer energy (5,000 kJ)	Minimum hammer energy (2,500 kJ)
Group 1	Mortality	<50	<50
	Recoverable injury	<50	<50
Group 2	Mortality	65-70	60-70
	Recoverable injury	65-70	60-70
Group 3 & 4	Mortality	65-70	60-70
	Recoverable injury	65-70	60-70
Group 5	Mortality	65-70	60-70

Table 12-29: Injury ranges for fish (stationary receptor) due to percussive piling based on the maximum (5,000 kJ; Location 6) and minimum (2,500 kJ; Location 1) for percussive piling hammer energy scenarios based on the cumulative SEL metric

Hearing group	Response	Range (m)	
		Max hammer energy (5,000kJ)	Minimum hammer energy (2,500kJ)
Group 1	Mortality	100	100
	Recoverable injury	200	150-200
Group 2	Mortality	400	400
	Recoverable injury	1,200	1,100
Group 3&4	Mortality	600-700	600
	Recoverable injury	1,200	1,100
Group 5	Mortality	400	400

- 12.8.4.34 At both model locations mortality and recoverable injury may occur based on the stationary receptor model at <50 m of the percussive piling activity for hearing Group 1 fish species (flatfishes, sandeels, anglerfish, and all sharks, skates, and rays), and at a maximum of 70 m for hearing Group 2, 3, 4 and 5 species (including salmonids, gadoids, eels, clupeids, and eggs and larvae) (**Table 12-28**).
- 12.8.4.35 Based on cumulative exposure, mortality for hearing Group 1 species may occur within 100 m for both the maximum (5,000 kJ; Location 6) and minimum (2,500 kJ; Location 1) hammer energy; and at 400 m for hearing group 2 and 5 species. For hearing Groups 3 and 4 species mortality may occur at 600-700 m for the maximum hammer energy, and at 600 m for the minimum hammer energy (**Table 12-29**).
- 12.8.4.36 For cumulative exposure, recoverable injury for hearing Group 1 species may occur at 200 m for the minimum hammer energy and at between 150 – 200 m for the maximum hammer energy.

Recoverable injury for hearing Groups 2 to 4 species may occur at 1,100 m for the minimum hammer energy, and 1,200 m for the maximum hammer energy (**Table 12-29**).

12.8.4.37 **Figure 12-3, Volume 2b** and **Figure 12-4, Volume 2b** shows the extent of the mortality and recoverable injury ranges for Locations 1, 2, 3, 4 and 5 based on a stationary receptor using the cumulative SEL metric. Locations 3 and 5 lie closest to the shoreline (**Figure 12-2, Volume 2b**). The maximum range for recoverable injury in hearing Group 2 to 4 species for Location 3 is 1,300 m and 1,100 m for Location 5. Given that the Array Area lies approximately 8,000 m offshore, there remains a corridor of approximately 6,700 m between the recoverable injury contour and the coast (**Figure 12-3, Volume 2b** and **Figure 12-4, Volume 2b**).

Moving receptor

12.8.4.38 For a moving receptor with a swim speed of 0.165 ms^{-1} (i.e. the precautionary swim speed to be used for post-smolts as specified by Nature Scot; paragraph 12.8.4.27) the predicted impact ranges for mortality and recoverable injury are approximately the same as those for a stationary receptor across all pile locations (refer **Table 12-29**). As such, results from the moving-receptor model at this swim speed are not presented separately here.

12.8.4.39 **Table 12-30** presents mortality and recoverable injury levels based on cumulative exposure (SEL_{cum}) for the maximum (5,000 kJ; Location 6) and minimum (2,500 kJ; Location 1) percussive piling hammer energies for a moving receptor with a swim speed of 0.6 ms^{-1} and 1.5 ms^{-1} . As the predicted injury ranges for both of these swim-speeds were less than 100 m, which is the minimum distance over which noise from the piling source can be accurately modelled, only one set of values is presented in **Table 12-30**.

Table 12-30: Injury ranges for fish (moving receptor at 1.5 ms⁻¹ and 0.6 ms⁻¹) due to percussive piling based on the maximum (5,000 kJ; Locations 3 and 6) and minimum (2,500 kJ; Location 1) for percussive piling hammer energy scenarios based on the cumulative SEL metric

Hearing group	Response	Range (m)	
		Max hammer energy (5,000kJ)	Minimum hammer energy (2,500kJ)
Group 1	Mortality	<100	<100
	Recoverable injury (203 dB SEL _{cum moving})	<100	<100
Group 2	Mortality	<100	<100
	Recoverable injury (203 dB SEL _{cum moving})	<100	<100
Group 3&4	Mortality	<100	<100
	Recoverable injury 203 dB SEL _{cum moving})	<100	<100

12.8.4.40 In the case of a moving receptor with swim speed of 0.6 m/s, considered to be appropriate for post-smolts responding to impulsive noise, migrating adult Atlantic salmon and some marine fish (as discussed in paragraphs 12.8.4.23 to 12.8.4.30) mortality and recoverable injury occur at less than 100 m for all hearing groups (**Table 12-30**). For the faster swim-speed scenario (1.5 m s⁻¹), considered appropriate for more mobile fish species (e.g., Atlantic mackerel) the predicted ranges for mortality and recoverable injury are equivalent, remaining below 100 m.

Summary

12.8.4.41 Overall, underwater noise (impulsive) causing mortality and recoverable injury during construction is expected to be adverse, short-term (maximum duration of percussive piling is 2 years commencing in 2028 or 2029), but intermittent (restricted to the months of April to October each year). The spatial extent of underwater noise causing mortality and recoverable injury is predicted to be localised (mortality may extend up to ~700 m from individual piles, and recoverable injury may extent up to 1,200m for the most sensitive hearing groups (3&4) and where the maximum hammer energy is used; less than 100 m of individual piles for moving receptors). Considering the embedded Offshore Project mitigation measures detailed within **Table 12-22**, specifically M003 (Marine Mammal Mitigation Protocol) and M023 (construction timing), the magnitude of this impact is predicted to be **Low**, because of its localised nature, with recovery occurring within <5 years.

Temporary Threshold Shift (TTS)

Stationary receptor

12.8.4.42 **Table 12-31** presents TTS levels based on cumulative exposure (SEL_{cum}) for the maximum (5,000 kJ; Location 6) and minimum (2,500 kJ; Location 1) percussive piling hammer energies.

Table 12-31: TTS ranges for fish (stationary receptor) due to percussive piling based on the maximum (5,000 kJ; Location 6) and minimum (2,500 kJ; Location 1) for percussive piling hammer energy scenarios based on the cumulative SEL metric

Hearing group	Response	Range (km)	
		Max hammer energy (5,000kJ)	Minimum hammer energy (2,500kJ)
All groups	TTS (186 dB SEL _{cum stationary})	12-15	11-13

12.8.4.43 Based on the precautionary stationary receptor model, TTS for all hearing groups occurs at between 12 – 15 km for the maximum hammer energy (5,000 kJ) and between 11 – 13 km for the minimum hammer energy (2,500 kJ) (**Table 12-31**).

12.8.4.44 **Figure 12-3, Volume 2b** shows the extent of the TSS ranges for Locations 2, 3, 4 and 5 based on a stationary receptor using the cumulative SEL metric. Locations 3 and 5 lie closest to the shoreline.

12.8.4.45 The TTS impact contours for Locations 2, 3, 4, and 5 intersect with the west coast of Lewis/*Eilean Leòdhais* north of Loch Roag over a total length of approximately 25 km (**Figure 12-3, Volume 2b**). This length of coastline, which includes the mouths of the River Barvas, *Carloway/Càrlabagh* and Blackwater as well as potential coastal migratory pathway to Loch Roag, would lie within the TTS ensonified zone assuming a stationary receptor.

Moving receptor

12.8.4.46 For a moving receptor with a swim speed of 0.165 ms⁻¹ (i.e. the precautionary swim speed to be used for post-smolts as specified by Nature Scot; paragraph 12.8.3.34) the predicted impact ranges for TSS are approximately the same as those for a stationary receptor across all pile locations (refer **Table 12-31**). As such, results from the moving-receptor model at this swim speed are not presented separately here.

12.8.4.47 **Table 12-32** presents TSS levels based on cumulative exposure (SEL_{cum}) for the maximum (5,000 kJ; Location 6) and minimum (2,500 kJ; Location 1) percussive piling hammer energies for a moving receptor with a swim speed of 0.6 ms⁻¹ and 1.5 m s⁻¹.

Table 12-32: TTS ranges for fish (moving receptor at 0.6 ms⁻¹ and 1.5 m s⁻¹) due to percussive piling based on the maximum (5,000 kJ; Locations 3 and 6) and minimum (2,500 kJ; Location 1) for percussive piling hammer energy scenarios based on the cumulative SEL metric

Hearing group	Response	Range (km)	
		Max hammer energy (5,000kJ)	Minimum hammer energy (2,500kJ)
Swimming speed of 0.6 ms⁻¹			
All groups	TTS (186 dB SEL _{cum stationary})	3.4 – 10.5	5.4 – 7.9
Swimming speed of 1.5 ms⁻¹			
All groups	TTS (186 dB SEL _{cum stationary})	0.4 – 4.85	1.2 – 2.7

- 12.8.4.48 In the case of a moving receptor with swim speed of 0.6 m s^{-1} , considered to be appropriate for post-smolts responding to impulsive noise, migrating adult Atlantic salmon and some marine fish (as discussed in paragraphs 12.8.4.23 to 12.8.4.30), TTS may occur at a range of between 5.4 – 7.9 km for the minimum hammer energy (2,500 kJ) and up to 10.5 km for the maximum hammer energy (5,000 kJ) (**Table 12-32**). Under this scenario the TTS contour would be a minimum of approximately 2.8 km and a maximum of 5 km from the west coast of the Hebrides/Innse Gall. In relation to Locations 1 and 4, which are the southernmost WTGs that will be piled, the TTS contours lie approximately 9 km from the mouth of Loch Roag based on the moving receptor model of 0.6 m s^{-1} .
- 12.8.4.49 If the faster swimming speed for a moving receptor of 1.5 m s^{-1} is assumed, considered appropriate for more mobile species (e.g., Atlantic mackerel), the range at which the onset of TTS may occur for the minimum hammer energy (Location 1) was found to reduce from a maximum of 7.9 km to a maximum of 2.7 km, and for the maximum hammer energy (Location 3 and 6) from 10.5 km to 4.85 km (**Table 12-32**).

Summary

- 12.8.4.50 Overall, underwater noise (impulsive) causing TTS occurring during construction is expected to be adverse, short-term (maximum duration of percussive piling is 2 years commencing in 2028 or 2029), but intermittent (restricted to the months of April to October each year). TTS impacts are likely to occur over a wide spatial area (may extend up to ~15 km from individual piles where the maximum hammer energy is used, with the cumulative footprint expected to be broader across the full percussive piling programme).
- 12.8.4.51 Considering the embedded Offshore Project mitigation measures detailed within **Table 12-22**, specifically M003 (Marine Mammal Mitigation Protocol) and M023 (construction timing), the magnitude of this impact is predicted to be **Medium** for hearing group 2 diadromous species (Atlantic salmon and sea trout) due to the overlap between the TTS impact area critical migratory pathways for these species. The low recoverability of Atlantic salmon populations (paragraph 12.8.4.67) has also been considered in assigning a Medium impact magnitude rating since although this aspect also relates to sensitivity, it is a consideration in the impact definitions presented in Table 12-9. An impact magnitude rating of **Low** has been assigned to all other species in hearing Groups 1 and 2 (flatfishes, anglerfish, sharks, skates, and rays, pelagic species such as Atlantic bluefin tuna, and sand eels) and Group 3 and 4 (gadoids, eels and clupeids) because the TTS zone will affect a relatively low proportion of their critical habitat areas such as spawning and nursery grounds and due to their rapid recovery potential.

Behavioural effects

- 12.8.4.52 Behavioural effects in response to construction related underwater noise (impulsive) 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. The Popper *et al.* (2014) guidelines provide qualitative behavioural criteria for fish from a range of noise sources. These categorise the risks of effects in relative terms as “high”, “moderate” or “low” at 3 distances from the source: “near” (i.e. 10s of metres), “intermediate” (i.e. 100s of metres) or “far” (i.e. 1,000s of metres). These categories are shown in **Table 12-33**.

Table 12-33: Potential risk for the onset of behavioural effects in fish from percussive piling (Popper *et al.*, 2014)

Hearing 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 & 4	(N) High (I) High (F) Moderate	(N) High (I) High (F) Moderate
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; i.e. 10s of metres), intermediate (I; i.e. 100s of metres), and far field (F; i.e. 1,000s of metres)		

12.8.4.53 Overall, underwater noise (impulsive) causing behavioural effects occurring during construction is expected to be adverse, short-term (maximum duration of percussive piling is 2 years commencing in 2028 or 2029), but intermittent (restricted to the months of April to October each year). Spatial extent of underwater noise causing behavioural effects is expected to be relatively large (1,000s of metres from individual piles). Considering the embedded Offshore Project mitigation measures detailed within **Table 12-22**, specifically M003 (Marine Mammal Mitigation Protocol) and M023 (construction timing), the magnitude of this impact is, however predicted to be **Low**, with recovery occurring within <5 years.

Sensitivity or value of receptor

12.8.4.54 The sensitivity described for each receptor is based on the criteria provided in **Table 12-12**.

High value receptors

12.8.4.55 The majority of fish receptors are considered of low to medium value. Diadromous fish (Atlantic salmon, sea trout and European eel) and the common skate complex have been assigned a high value. This has been considered when determining the overall sensitivity of the receptors to underwater noise and vibration during the construction phase of the Offshore Project. The value and sensitivity is based upon the criteria detailed in Section 12.5.

Marine fish

Hearing group 1 and 2

- 12.8.4.56 Group 1 and 2 fishes are only sensitive to sound particle motion, are less susceptible to barotrauma (tissue injury from rapid pressure change) and show sensitivity to only a narrow band of frequencies. These species are considered the least sensitive to underwater sound (Popper *et al.*, 2014), and as such tolerance is considered high. It is acknowledged, however, that although the hearing ability of sandeel is considered low (Popper *et al.*, 2014), their life-history characteristics, particularly burrowing behaviour during spawning and overwintering, mean individuals may be less able to avoid disturbance during these periods, potentially increasing their exposure to continuous sound while buried in the seabed. As such, tolerance has been assessed as medium for this species.
- 12.8.4.57 Recovery potential is considered to be medium for hearing group 1 and 2 species as they generally show high fecundity and can replenish over several years following temporary disturbance from underwater noise (Hay *et al.*, 2001; Wright *et al.*, 2000). Due to the species life-history traits – slow growth, late maturity and generally low fecundity (Ellis *et al.*, 2021) elasmobranch species are rather considered to have low recoverability.
- 12.8.4.58 As such, group 1 and 2 marine fish species with spawning grounds within the Array Area (excluding elasmobranchs and sandeel) are considered to have high tolerance and medium recoverability and are of low to medium value. Therefore, group 1 and 2 species (excluding elasmobranchs and sandeel) sensitivity to underwater noise and vibration (impulsive noise) is considered to be **Low**. Sandeel are considered to have medium tolerance and medium recoverability, and are of medium value. As such, sensitivity of sandeel to underwater noise and vibration (impulsive noise) is considered to be **Medium**. Group 1 and 2 marine fish species (elasmobranchs) are considered to have high tolerance and low recoverability and are of low to high value. Therefore, Group 1 and 2 marine fish species (elasmobranchs) sensitivity to underwater noise and vibration (impulsive noise) is considered to be **Low**.

Hearing group 3 and 4

- 12.8.4.59 Several fish species relevant to the Offshore Project are within hearing Groups 3 and 4. Of these, Atlantic herring, European sprat and European pilchard (hearing Group 4 species) 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. This combination of anatomical sensitivity and extended frequency range makes these species among the most acoustically sensitive marine fishes. Despite their hearing ability, such species are highly mobile and wide ranging, and therefore better able to avoid or vacate ensonified areas. However, considering the hearing ability of these species tolerance to underwater noise is considered to be low. In terms of recoverability, these species are considered to have a high recoverability as they generally show high fecundity and can replenish over several years following disturbance (Hay *et al.*, 2001; Wright

et al., 2000). Overall, group 3 and 4 marine fish species, of low to medium value are considered to have medium tolerance and high recovery, and therefore a **Medium** sensitivity overall.

Hearing group 5 (eggs and larvae)

- 12.8.4.60 While few data are available on larval fishes, those species studied appear to have hearing frequency ranges similar to those of adults (Wright *et al.*, 2011), and similar acoustic startle thresholds (Zeddies and Fay 2005). Swim bladders may develop during the larval stage and may render larvae susceptible to pressure-related injuries (e.g., barotrauma).
- 12.8.4.61 Current concern over the effects of sound upon eggs, and especially for larvae containing gas bubbles, is focused on barotrauma rather than hearing (Popper *et al.*, 2014). Energy propagation from vibrations are thought to be most damaging to fish eggs and larvae found in or close to substrates. Thresholds for impacts are set at peak particle velocity of 13 mm s^{-1} for incubating eggs (Popper *et al.*, 2014).
- 12.8.4.62 Spawning grounds for several fish have been identified within the Zol for underwater noise as identified in Section 12.6, indicating the presence of eggs and larvae. The Popper criteria discussed previously are the same for hearing Groups 5 and 2, and are assigned the same overall sensitivity of **Low**.

Diadromous species

Atlantic salmon (hearing group 2)

- 12.8.4.63 Atlantic salmon and sea trout fall into hearing Group 2, the category of fish with a swim bladder not involved in hearing. These species exhibit relatively low auditory sensitivity compared to the more sensitive fish with a swim bladder involved in hearing, detect a narrower range of frequencies and primarily perceive particle motion rather than pressure waves.
- 12.8.4.64 Atlantic salmon are only sensitive to particle motion (not sound pressure) and were found to be sensitive to relatively low frequencies within a narrow bandwidth of hearing (up to c. 300–500 Hz) (Hawkins and Johnstone, 1978). More recently, Harding *et al.* (2016) have tested the hearing sensitivity of Atlantic salmon using Auditory Evoked Potentials (AEPs), a non-invasive electrophysiological measure of the synchronised brain response to auditory stimuli. The experiments focused on three groups: wild post-smolts, captive post-smolts and captive adults, and included measurement of both physiological and behavioural responses to noise. They found evidence of sensitivity to slightly higher frequencies (400-800 Hz), and lower sensitivity at lower frequencies of 100 Hz. Although the experiments were conducted in tanks, compared with open water sea pens used by Hawkins and Johnstone (1978), the method was considered to be robust.
- 12.8.4.65 In a second phase of the study, percussive piling noise was played back to adult Atlantic salmon in a tank to assess behavioural and physiological changes. Changes in metabolic rate was used as a physiological indicator of stress. No significant differences were observed in the distribution of salmon in the tank before and during exposure to percussive piling noise, and there was no

evidence of a startle response. Similarly, there was no evidence of increased oxygen consumption (used as a proxy for metabolic rate), suggesting that fish did not perceive percussive piling noise as a stressor.

- 12.8.4.66 Only one study considered the impact of noise in free ranging, wild individuals in marine environments (Moore and Bendall 2011 in Gillson *et al.*, 2022). The study found that the movement of tagged Atlantic salmon through the River Tyne estuary were similar irrespective of whether they were exposed to percussive piling (according to Gillson *et al.*, 2022). As such, tolerance as been assessed as high.
- 12.8.4.67 In terms of recoverability, although many of the potential behavioural effects are transient and reversible at the individual level, the depleted stocks of many Atlantic salmon populations means that even minor effects on survival, feeding success, or migration, could have consequences at the population level. Recoverability is assessed as low on a precautionary basis. Based on a high tolerance and low recoverability, sensitivity is assessed as low. However, considering the conservation value of Atlantic salmon, the proximity of construction activities to known migratory routes, including those supporting the Langavat SAC population via Loch Roag/Ròg, and the proportion of the population likely to pass through the ensonified zone over the 5 year construction period, the overall sensitivity of Atlantic salmon has been assessed as **Medium** on a precautionary basis.

Sea trout (hearing group 2)

- 12.8.4.68 Like Atlantic salmon, sea trout are only sensitive to particle motion (not sound pressure). Sea trout can however detect a wider band of frequencies from 30-1,000 Hz. Nedwell et al (2003) recorded no observable change in behaviour in sea trout exposed to real percussive piling event (average noise level 134 re 1 μ Pa, peak). As such, tolerance to underwater noise is assessed as high.
- 12.8.4.69 In terms of recoverability, although many of the potential behavioural effects are transient and reversible at the individual level, the depleted stocks of many sea trout populations means that even minor effects on survival, feeding success, or migration, could have consequences at the population level. Recoverability is assessed as low on a precautionary basis.
- 12.8.4.70 Overall, sea trout are considered to have high tolerance and low recovery. Whilst this species is of high value, their overall sensitivity to this pressure is considered to be **Low** based on high tolerance to underwater noise.

European eel (hearing group 3)

- 12.8.4.71 European eel have moderate hearing sensitivity (hearing Group 3). 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 Hz, with greatest sensitivity to 90Hz and are considered to have a relatively high tolerance to underwater

noise. Given poor recruitment in eel throughout Europe reported by ICES (**Appendix 12.1, Volume 2c**; paragraph 4.4.3.2) 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. Their high conservation importance therefore increases their overall sensitivity to **Medium**.

Significance of effect

Marine fish

12.8.4.72 Underwater noise (impulsive) is anticipated to take place during the construction phase of the Offshore Project. Considering the embedded mitigation described in **Table 12-22**, the residual effects of underwater noise (impulsive) on Marine Fish receptors are summarised in **Table 12-39**.

Table 12-34 Significance of effect of underwater noise (impulsive) to Marine Fish during the construction phase

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Significance of Effect	Significance	Commentary
Mortality (including potential mortal injury) and recoverable injury effects						
Marine fish						
Group 1 and 2 (inc. Atlantic mackerel, horse mackerel and ocean sunfish, Atlantic halibut, common sole, lemon sole, European plaice, Anglerfish and the black scabbard fish, Atlantic bluefin tuna and all elasmobranchs (sharks, skates, and rays), including basking shark)	Low	Low	M003 M023	Negligible	Not Significant	<p>Effects are considered spatially limited due to the restricted extent of mortality and recoverable injury effects (mortality may extend up to ~400 m from individual piles, and recoverable injury may extent up to 1,200 m based on cumulative exposure and where the maximum hammer energy is used) assuming no avoidance behaviour.</p> <p>In practice, the implementation of soft starts and ramp-up procedures (embedded mitigation M003) provides fish with the opportunity to move away from the areas of highest noise levels before sound levels become high enough to cause injury. As a result, the actual injury ranges are expected to be smaller than the maximum worst-case distances presented in Table 12-28, with impacts likely to remain highly localised around the percussive piling location.</p> <p>Further, although, sandeels are vulnerable to noise whilst hibernating in the seabed, activities causing impulsive underwater noise will not overlap with the winter period and therefore it is not expected that hibernating sandeels will be impacted.</p>
Group 1 and 2 (inc. sandeels)	Low	Medium		Minor	Not Significant	

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Significance of Effect	Significance	Commentary
Group 3 & 4 species (inc. Atlantic cod, blue whiting, whiting, Norway pout, saithe, blue ling, ling, European hake and roundnose grenadier, Atlantic herring, European sprat and European pilchard)	Low	Medium	M003 M023	Minor	Not Significant	<p>Effects are considered spatially limited due to the restricted extent of mortality and recoverable injury effects (mortality may extend up to ~700 m from individual piles, and recoverable injury may extent up to 1,200 m where the maximum hammer energy is used) assuming no avoidance behaviour.</p> <p>In practice, the implementation of soft starts and ramp-up procedures (embedded mitigation M003) provides fish with the opportunity to move away from the areas of highest noise levels before sound levels become high enough to cause injury. As a result, the actual injury ranges are expected to be considerably smaller than the maximum worst-case distances presented in Table 12-28, with impacts likely to remain highly localised around the percussive piling location. This is particularly relevant to these group 3 & 4 species as they have acute audition and thus might be expected to move away rapidly from an ensonified area.</p>
Group 5 (eggs and larvae)	Low	Low	M003 M023	Negligible	Not Significant	<p>Loss of eggs and larvae may be expected within 600-700 m of percussive piling assuming 5,000 kJ hammer energy and slightly less (600 m) for the 2,500 kJ hammer energy. Spawning grounds are present within the area affected by underwater noise from percussive piling indicating the presence of eggs and larvae. However, these habitats extend over a very wide area across the Marine Fish Study Area and broader region. Given the high fecundity of most marine fish species, the naturally high background mortality characteristic of early life stages, and the small proportional loss relative to the wider egg and larval distribution, such impacts are not expected to influence population recruitment.</p>

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Significance of Effect	Significance	Commentary
TTS Effects						
Marine Fish						
Group 1 and 2 (inc. Atlantic mackerel, horse mackerel and ocean sunfish, Atlantic halibut, common sole, lemon sole, European plaice, Anglerfish and the black scabbard fish, Atlantic bluefin tuna and all elasmobranchs (sharks, skates, and rays), including basking shark)	Low	Low	M003 M023	Negligible	Not Significant	<p>Effects may extend up to ~15 km from individual piles where the maximum hammer energy is used, with the cumulative footprint expected to be broader across the full percussive piling programme, assuming a stationary receptor.</p> <p>Further, although, sandeels are vulnerable to noise whilst hibernating in the seabed, activities causing impulsive underwater noise will not overlap with the winter period and therefore it is not expected that hibernating sandeels will be impacted.</p> <p>While TTS does not constitute physical injury, and affected individuals fully recover, it can reduce the ability to detect biologically relevant cues (e.g., predators, prey, conspecific signals). However, any such effects are expected to be mild, and limited to a small proportion of individuals in proximity to percussive piling. Given the highly mobile nature of most fish, the use of soft-start procedures, and the spatially extensive availability of alternative habitat, population-level consequences are not anticipated.</p>
		Medium		Minor	Not Significant	
Group 3 & 4 species (inc. Atlantic cod, blue whiting, whiting, Norway pout, saithe, blue ling, ling,	Low	Medium	M003 M023	Minor	Not significant	Although hearing specialist species within Groups 3 and 4 are more sensitive to sound, the spatial extent of TTS-level effects does not differ between hearing groups, because the acoustic threshold for TTS (≥ 6 dB temporary, reversible elevation in hearing sensitivity) is applied consistently across all fish groups. As a result, the modelled TTS ranges for Groups 3 and 4 are identical to those presented for

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Significance of Effect	Significance	Commentary
European hake and roundnose grenadier, Atlantic herring, European sprat and European pilchard)						<p>other marine fish (groups 1 and 2) with effects extending up to ~15 km from individual piles where the maximum hammer energy is used, with the cumulative footprint expected to be broader across the full percussive piling programme, assuming a stationary receptor.</p> <p>While TTS does not constitute physical injury, and affected individuals fully recover, it can reduce the ability to detect biologically relevant cues (e.g., predators, prey, conspecific signals). However, any such effects are expected to be mild, and limited to a small proportion of individuals in proximity to percussive piling. Given the highly mobile nature of most fish, the use of soft-start procedures, and the spatially extensive availability of alternative habitat, population-level consequences are not anticipated.</p>
Masking and behavioural effects						
Marine Fish						
Group 1 and 2 (inc. Atlantic mackerel, horse mackerel and ocean sunfish, Atlantic halibut, common sole, lemon sole, European plaice, Anglerfish and the black scabbard fish, Atlantic bluefin tuna and all elasmobranchs)	Low	Low	M003 M023	Negligible	Not Significant	<p>There is potential for behavioural effects for these species – with ‘moderate’ masking effects in the near-field (i.e., 10s off metres of percussive piling) and ‘low’ masking effects for the far-field (i.e., 1,000s of metres of percussive piling). ‘High’ behaviour effects are expected in the near-field (i.e., 10s off metres of percussive piling), and ‘low’ behavioural effects for the far-field (i.e., 1,000s of metres of percussive piling).</p> <p>Further, although, sandeels are vulnerable to noise whilst hibernating in the seabed, activities causing impulsive underwater noise will not overlap with the winter period and therefore it is not expected that hibernating sandeels will be impacted.</p>

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Significance of Effect	Significance	Commentary
(sharks, skates, and rays), including basking shark						Such effects are expected to be short-lived and reversible, with individuals rapidly resuming normal behaviour once noise levels decrease. Given the highly mobile nature of most species in these hearing groups and the large availability of suitable habitat beyond the Zol, it is anticipated that only a small proportion of the wider population would be exposed at levels capable of eliciting these responses at any one time.
Group 1 and 2 (inc. sandeels)	Low	Medium		Minor	Not Significant	
Group 3 & 4 species (inc. Atlantic cod, blue whiting, whiting, Norway pout, saithe, blue ling, ling, European hake and roundnose grenadier, Atlantic herring, European sprat and European pilchard)	Low	Medium	M003 M023	Minor	Not Significant	<p>The risk of behavioural effects in the intermediate and far fields is greater for these species, than Group 1 and 2 species. There is potential for behavioural effects for these species – with ‘high’ behavioural and masking effects expected in the near-field (i.e., 10s off metres of percussive piling) and ‘moderate’ effects for the far-field (i.e., 1,000s of metres).</p> <p>Such effects are expected to be short-lived and reversible, with individuals rapidly resuming normal behaviour once noise levels decrease. Given the highly mobile nature of most species in these hearing groups and the large availability of suitable habitat beyond the Zol, it is anticipated that only a small proportion of the wider population would be exposed at levels capable of eliciting these responses at any one time.</p>
Group 5 (eggs and larvae)	Low	Low	M003 M023	Negligible	Not Significant	<p>There is potential for behavioural effects for these species – with ‘moderate’ masking and behavioural effects in the near-field (i.e., 10s off metres of percussive piling) and ‘low’ masking and behavioural effects for the far-field (i.e., 1,000s of metres of percussive piling).</p> <p>Such effects are expected to be short-lived and reversible, with individuals rapidly resuming normal behaviour once noise levels</p>

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Significance of Effect	Significance	Commentary
						<p>decrease. Given the highly mobile nature of most species in these hearing groups and the large availability of suitable habitat beyond the Zol, it is anticipated that only a small proportion of the wider population would be exposed at levels capable of eliciting these responses at any one time.</p>

Diadromous species

12.8.4.73 Diadromous fish species within close proximity to percussive piling operations may experience injury or mortality. However, the nature of diadromous fish species being highly mobile and tending to pass through the Offshore Project Study Area during migration, it is unlikely to result in significant mortality of diadromous species. The use of soft start percussive piling procedures, allowing individuals in close proximity to percussive piling to flee the ensonified area, further reduces the likelihood of injury and mortality on diadromous species. The maximum distance for mortality of hearing group 2 species such as Atlantic salmon and sea trout, is 400 m, and 1,200 m for recoverable injury (203 dB SEL_{cum}) in the mitigated scenario. The potential for significant effects on salmon and sea trout are discussed below.

Atlantic salmon (hearing group 2)

12.8.4.74 Returning adult Atlantic salmon may approach their spawning rivers from multiple directions using different migratory pathways (Malcolm *et al.* 2010). Fish approaching from northern feeding grounds are considered most likely to follow the coastline north of Loch Roag/Ròg (**Appendix 12.1, Volume 2c**; paragraph 4.4.12.1). In addition to the River Grimersta/Langavat SAC, the rivers north of Loch Roag, including the Bravas, Carloway, Forsa River, and Caslabhat and Tamanabhaigh support populations of salmon which will be migrating through coastal waters during the April to October season in which percussive piling is taking place (paragraph 12.6.1.22).

12.8.4.75 In consultation with NatureScot (see **Appendix 12.2, Volume 2c**) it was agreed that adult salmon are likely to occupy the nearshore coastal zone as they search for their natal rivers and therefore this represents a key pathway. Given that the Turbine Area is located approximately 6,000 m from the shore, and the maximum distance in which recovery injury (203 dB SEL_{cum}) may occur is 1,200 m there would remain a corridor approximately 3,800 m in width outside the recoverable injury impact zone. Adult salmon approaching the River Grimersta via Loch Roag/Ròg from the south and west are less likely to pass through the ensonified zone for TTS (**Figure 12-3, Volume 2b**) since no percussive piling is planned at the southern end of the Array Area, and lower pile energies will be used in these zones (2,500 kJ and 3,500 kJ).

12.8.4.76 Given the **Medium** sensitivity of the local salmon populations, and **Low** magnitude effect of noise that might cause injury, the significance of injury/mortality effects is assessed as **Minor (Not Significant)**.

12.8.4.77 The TTS (186SEL_{cum} stationary) impact zone for 4 of the 6 percussive piling Locations (2, 3, 4, and 5) would intersect with the coast over a distance of approximately 25 km including the mouths of the River Bravas, Blackwater and Carloway, as well as the potential northern migratory route for salmon entering Loch Roag (paragraph 12.8.4.45). Adult fish moving through the coastal area during percussive piling operations have the potential to be impacted, likely through delay to their inward migration, potentially leaving them at greater risk of predation. Depending on the duration, a delay may also reduce the likelihood of successful spawning. Minor reductions in the spawning

success of the populations in a single year has the potential to become significant over the 2 year duration of the percussive piling programme.

- 12.8.4.78 The analysis of rod catch and stock assessment data (Section 12.6.1) aimed to determine the number proportion of the adult salmon populations passing through coastal waters during the percussive piling programme. The highest estimate of returning spawners across all river systems in the Loch Roag salmon fishery district area occurred in July (median = 38.2%), with the second highest in August (median = 22.5%).
- 12.8.4.79 Based on the precautionary assumption that fish will be passing through coastal waters over the month prior to their arrival in the river systems the peak of approximately 38% will occur in June, followed by 22.5% in August (**Plate 12-2**). In total, 80% of the returning adults will pass through coastal waters during May, June and July, and approximately 99% between April - November. Although the stock assessment is likely to underestimate the number of adult fish entering river systems during the closed season for angling, it is likely that at least 90% of the salmon passing through coastal waters north of Loch Roag will pass through the TTS impact zone.
- 12.8.4.80 To assess impacts at a population level it is necessary to consider the seasonal patterns of returns for each age class. Based on the stock assessment data 2SW fish represent the largest proportion between January and May, with 1 SW fish the predominant age class from June to December. Multi-sea-winter fish are most likely to enter rivers between January-March. Given the assumption that fish will be passing through coastal water one month before entering river systems, the greatest impact from the April to October percussive piling programme will be on the 1SW age class. Assuming 2SW fish enter in equal numbers between January and May approximately one fifth of the cohort will pass through the ensonified zone per year. MSW fish, which contribute proportionally more eggs per individual are least likely to be impacted by the April to October percussive piling programme. Similarly, kelts that move out of rivers post spawning during the winter period will avoid impacts from construction noise.
- 12.8.4.81 In relation to post-smolts, there is potential for disruption to the migration routes of out-migrating post-smolts during April/May. Tracking studies suggest that smolts / post-smolts from the River Grimersta either follow northwards route through East Loch Roag/Ròg or take the westward channel towards West Loch Roag/Ròg. Of the tracked 52 smolts / post-smolts that reached the junction of the two migratory paths, 81% (42 individuals) migrated through East Loch Roag/Ròg; and of these 15 entered the Array Area, mostly at the southwest corner. Most post-smolts moved through the Array Area fairly directly, with a median duration of 16 minutes, although some remained for longer periods (up to 27 hours). The majority left the estuary during periods of darkness. Although other studies on diel migration patterns show that downstream migration predominantly occurs at night (Bjerck et al., 2021; Lothian et al., 2018; Haraldstad et al., 2016) in consultation with NatureScot it has been agreed that post-smolts may migrate through coastal waters during the day or night and therefore coincide with percussive piling operations (**Table 12-3**).

- 12.8.4.82 Outward migrating post-smolts following a northward route from the mouth of Loch Roag would pass through the TTS impact contour for percussive piling at Locations 1 and 4 (**Figure 12-4, Volume 2b**). Post-smolts migrating through the TTS zone may respond to percussive piling noise by increasing their swim speed or demonstrating other behavioural responses such as changing course. Although behavioural responses in hearing group 2 species are considered likely to be of low magnitude in the far field (i.e. 1,000's of metres away; **Table 12-33**), there may be marginal increases in predation risk and energy expenditure which could affect survival.
- 12.8.4.83 The magnitude/risk of noise that might lead to TTS has been assessed as **Medium**, thus the significance of potential TTS effects is assessed as **Moderate (Potentially Significant)**. As effects on Atlantic salmon are considered to be potentially significant, effects on the FWPM are likewise considered **Moderate (Potentially Significant)** due to its life stage dependence on these diadromous fish species.
- 12.8.4.84 The wider Scottish salmon populations is considered to be a less sensitive receptor given their wide spatial range and extensive migratory routes outwith the potentially impacted area. The significance of underwater noise effects on the wider populations is therefore assessed as **Minor (Not Significant)**.
- 12.8.4.85 There is potential for behavioural effects for Atlantic salmon – with 'moderate' masking effects in the near-field (i.e., 10s off metres of percussive piling) and 'low' masking effects for the far-field (i.e., 1,000s of metres of percussive piling). 'High' behaviour effects are expected in the near-field (i.e., 10s off metres of percussive piling), and 'low' behavioural effects for the far-field (i.e., 1,000s of metres of percussive piling). Such effects are expected to be short-lived and reversible, with individuals rapidly resuming normal behaviour once noise levels decrease. Given the Medium sensitivity of Atlantic salmon, and Low magnitude effect of noise that might cause behavioural effects, the significance of effect is assessed as **Minor (Not Significant)**.

Sea trout (hearing group 2)

- 12.8.4.86 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 on Scotland/*Alba's* west coast found that only 36% of tagged post-smolts travelled more than 6 km from their release sites within their natal rivers (Middlemas *et al.*, 2009). 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 80 km of their natal rivers, but longer-distance coastal migrations exceeding 500 km have been recorded (Thorstad *et al.*, 2016).
- 12.8.4.87 Given the nearshore location of the Offshore Project and its proximity to estuarine habitats, sea trout post-smolts may pass through or use habitats within the ensonified area during construction. As post-smolts typically remain close to their natal rivers, those near the Offshore Project Boundary

are expected to originate from local populations – specifically, from rivers and estuaries draining to the west of the Isle of Lewis/*Eilean Leòdhais*. 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 Diadromous Fish Study Area could transit or, on occasion, use habitats within the Offshore Project Boundary. It is evident however, considering geographical proximity, that the majority of adult sea trout that may occur within, or within proximity to the Zol for construction noise will be from those rivers draining to the west of the Isle of Lewis/*Eilean Leòdhais*.

- 12.8.4.88 The magnitude/risk of noise that might lead to TTS has been assessed as **Medium**, thus the significance of potential TTS effects is assessed as **Minor (Not Significant)**. The significance of injury/mortality effects on sea trout is assessed as **Negligible**.
- 12.8.4.89 There is potential for behavioural effects for sea trout – with ‘moderate’ masking effects in the near-field (i.e., 10s off metres of percussive piling) and ‘low’ masking effects for the far-field (i.e., 1,000s of metres of percussive piling). ‘High’ behaviour effects are expected in the near-field (i.e., 10s off metres of percussive piling), and ‘low’ behavioural effects for the far-field (i.e., 1,000s of metres of percussive piling). Such effects are expected to be short-lived and reversible, with individuals rapidly resuming normal behaviour once noise levels decrease. Given the Low sensitivity of sea trout, and Low magnitude effect of noise that might cause behavioural effects the significance of effect is assessed a **Negligible (Not Significant)**.

European eel (hearing group 3)

- 12.8.4.90 Little is known about the migratory routes taken by adult European eels migrating towards spawning grounds in the Sargasso Sea. Although, in Scottish waters, evidence from tracking studies undertaken on individuals released from the Swedish and Irish west coasts and Bay of Biscay suggests that they are likely to move westwards and south-westwards to reach routes that converge on the Azores region (Righton *et al.*, 2016). 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. They typically enter coastal waters and rivers during the period from September to November (Tesch, 2003). Given the North Atlantic Drift, Continental Shelf Current, and prevailing southwesterly winds – the west of the British Isles, and especially western Scotland/*Alba*, is likely to be a key region of first landfall for a large proportion of the oceanic migrating eel in most years (Adams *et al.*, 2013).
- 12.8.4.91 Based on these assumption adult eels migrating from the River Grimersta and the rivers to the north including the River Bravas may move through the ensonified zone during their outward migration. As a hearing group 2 species, mortality would be expected to occur within 400 m of the maximum energy percussive piling operation (5,000 kJ), and TTS at between 12 and 15 km for a stationary receptor based on the cumulative SEL metric (for a stationary receptor).

- 12.8.4.92 As with salmonids, there is potential for delay to outward adult eel migrations and returning glass eels during percussive piling operations. The peak of the eel migration, both for adults and elvers takes place in the autumn, although may occur at lower levels throughout the year. Impacts from percussive piling may therefore be partially avoided since the programme will run from April to October.
- 12.8.4.93 Noise impacts leading to mortality and injury are of **low** magnitude, therefore the significance of potential injury/mortality effects on European eel is assessed as **Minor (Not Significant)**. The magnitude of noise impacts that might lead to TTS has been assessed as **medium**, thus the significance to eels is **Moderate**. However, in view of their high degree of mobility and opportunistic wide-ranging foraging behaviour (in contrast to migrating salmon), it is considered that this effect is nonetheless likely to be **Not Significant**.
- 12.8.4.94 There is potential for behavioural effects for European eel – with ‘high’ behavioural and masking effects expected in the near-field (i.e., 10s off metres of percussive piling) and ‘moderate’ effects for the far-field (i.e., 1,000s of metres). Such effects are expected to be short-lived and reversible, with individuals rapidly resuming normal behaviour once noise levels decrease. Given the Medium sensitivity of European eel, and Low magnitude effect of noise that might cause behavioural effects the significance of effect is assessed as **Minor (Not Significant)**.

Summary of significance of effect for diadromous species

- 12.8.4.95 Impulsive underwater noise is anticipated to occur during the construction phase of the Offshore Project. Considering the embedded mitigation described in **Table 12-22**, the effects of impulsive underwater noise diadromous fish receptors are summarised in **Table 12-35**.

Table 12-35 Summary of significance of effect of impulsive noise and vibration for diadromous fish during the construction phase

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Significance of Effect	Significance
Mortality (including potential mortal injury) and recoverable injury effects					
Atlantic salmon (hearing group 2)	Low	Medium	M003	Minor	Not Significant
Sea trout (hearing group 2)	Low	Low	M023	Negligible	Not Significant
European eel (hearing group 3)	Low	Medium		Minor	Not Significant
TSS					
Atlantic salmon (hearing group 2)	Medium	Medium	M003	Moderate	Potentially Significant
Sea trout (hearing group 2)	Medium	Low	M023	Minor	Not Significant
European eel (hearing group 3)	Medium	Medium		Moderate	Not Significant
Masking and behavioural effects					
Atlantic salmon (hearing group 2)	Low	Medium	M003	Minor	Not Significant
Sea trout (hearing group 2)	Low	Low	M023	Negligible	Not Significant
European eel (hearing group 3)	Low	Medium		Negligible	Not Significant



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Further environmental mitigation

12.8.4.96 A **Moderate (Potentially Significant)** effect has been predicted for Atlantic salmon due to TTS and therefore additional secondary mitigation will be implemented. Additional secondary mitigation forms measure A006 - The Piling Strategy. A summary of this additional mitigation and relevance to Atlantic salmon is provided below, and the mitigation strategy is provided in full as **Appendix 12.3, Volume 2c**. This additional mitigation forms Commitment A006 and will be secured in the Marine Licence via the condition for a Piling Strategy to be submitted to MD-LOT for approval.

12.8.4.97 The Fish Ecology secondary mitigation measures are designed to supplement the embedded mitigation already built into the PDE and includes both spatial and temporal mitigation:

- **Spatial mitigation:** Splitting the Percussive Piling Area, in which percussive piling can take place, into 2 zones (refer paragraph 12.8.4.98) with different restrictions associated with each;
- **Temporal mitigation:** Provision of continuous quiet periods (i.e., no percussive piling activity) between percussive piling events and complete percussive piling restriction for 01 April to 25 May, during sensitive migration windows.

12.8.4.98 The Percussive Piling Area, as shown on Plate 3-1 of **Appendix 12.3, Volume 2c**, has been divided into 2 distinct zones based on proximity to the coast of the Isle of Lewis/*Eilean Leòdhais*:

- **Purple Zone:** located closest to the coast;
- **Orange Zone:** located furthest from the coast.

12.8.4.1 The construction sequencing requirements for each zone and the reasoning for this approach is discussed below and summarised in **Table 12-36**.

Purple Zone

12.8.4.2 **Spatial mitigation:** Percussive piling in this zone will be restricted to September and October only (unless otherwise agreed with MD-LOT following the smolt migration study⁹).

12.8.4.3 **Temporal mitigation:** A continuous quiet period will not be required throughout the percussive piling installation within this zone.

12.8.4.4 **Justification:** This timing is intended to avoid the returning adult Atlantic salmon migration periods to the Langavat SAC, North Harris SAC, and populations from other salmon rivers along the coast in May to August. This allows for a coastal migration zone for the returning adults. Further to this, through the Percussive Piling Programme restriction (A006), the Offshore Project will

⁹ Following consultation with NatureScot (**Appendix 12.2, Volume 2c**), the Applicant adopted the smolt migration period identified in Malcolm *et al.* 2015 (13 April–25 May). As this study is over 10 years old, the Applicant will update the evidence base by undertaking a smolt monitoring study prior to construction to refine the migration window for the Langavat SAC. If monitoring indicates a shorter period, the Percussive Piling Programme will be revised accordingly in agreement with MD-LOT.

completely avoid the peak Atlantic salmon smolt migration period during 01 April to 25 May.

Orange zone:

- 12.8.4.5 **Spatial mitigation:** Percussive piling in this zone can be undertaken between late May and October (unless otherwise agreed with MD-LOT following the smolt migration study⁹).
- 12.8.4.6 **Temporal mitigation:** A continuous quiet period (12hrs in length) will be required within the construction sequencing in June to July.
- 12.8.4.7 **Justification:** This timing is intended to minimise disturbance during the peak period of returning adult Atlantic salmon migration periods to the Langavat SAC, North Harris SAC, and populations from other salmon rivers along the coast in June to July. The percussive piling installation works during this peak period will incorporate consistent daily quiet periods allowing fish to migrate through the area with reduced disturbance. Further to this, through the Percussive Piling Programme restriction (A006), the Offshore Project will completely avoid the peak Atlantic salmon smolt migration period during 01 April to 25 May.

Table 12-36 Migration periods and percussive piling installation construction sequencing

	April	May		June	July	August	September	October
		1 st to 25 th	26 th to 31 st					
Atlantic salmon migration								
Kelt Migration (seawards)								
Smolt Migration (seawards)	Peak period	Peak period						
Adult Migration				Peak period	Peak period			
Construction activity								
Orange Zone Piling								
Purple Zone Piling								

Key:

-  Percussive piling installation permitted
-  Percussive piling installation permitted – with continuous quiet period in percussive piling operations
-  Percussive piling installation not permitted
-  Percussive piling installation not permitted unless approved by MD-LOT following further smolt migration study⁹
-  Migration periods



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Significance of residual effect

12.8.4.8 A **Moderate (Potentially Significant)** effect was concluded for adult salmon and smolts due to TTS. With the inclusion of the secondary mitigation measure A006 (**Appendix 12.3, Volume 2c**), namely the sequencing of percussive piling works within the Array Area to avoid TTS impacts within important seasonal migration corridors for adult salmon and post-smolts; and maintaining quiet periods in the percussive piling programme, the significance of the residual effect is considered to be reduced to **Minor** adverse and therefore **Not Significant**.

12.8.5 UNDERWATER NOISE AND VIBRATION (CONTINUOUS NOISE)

12.8.5.1 Continuous underwater noise and vibration will be generated during the construction phase of the Offshore Project. Continuous noise sources include vessel operations, jet trenching for cable installation, and other general construction activities. Generalised noise impacts on fish are described in paragraph 12.8.2.10. The maximum design scenario relating to continuous underwater noise and vibration during the construction phase are presented in **Table 12-21**.

Magnitude

12.8.5.2 Non-piling noise sources including cable laying, dredging, drilling (drill and grout), rock placement, vessel movements, and operational WTG noise other than percussive piling were modelled using background data scaled to an appropriate level for the Offshore Project (refer **Table 12-21**). Impact ranges for recoverable injury (170 dB re 1 μ Pa (48hrs) and TTS (158 dB re 1 μ Pa) were calculated using the hearing group 2 hearing sensitivity as a proxy. For all activities impact ranges were less than 50 m. The ranges are considered to be highly conservative as they assume the receptor remains stationary for the 48 hr period in which the activity is modelled.

12.8.5.3 Overall, underwater noise (continuous) is expected to be adverse, medium-term (over a period of 5 years commencing in 2028 or 2029), but intermittent (restricted to the months of April to October each year except for offshore Landfall construction works located within the HDD Exit Pit Area which may occur all year round). Impacts are likely to occur over a very restricted spatial extent (<50 m from the construction activities detailed in **Table 12-37**).

12.8.5.4 Considering the embedded Offshore Project mitigation measures detailed within **Table 12-22**, specifically M023 (construction timing), the magnitude of this impact is predicted to be **Negligible** for all hearing sensitivity groups.

Table 12-37: Potential risk for the onset of behavioural effects in fish from non-impulsive noise

Activity	Source level (dB re 1 μ Pa @1 m)	Recoverable injury (170 dB re 1 μ Pa (48hrs))	TTS (158 dB re 1 μ Pa)
Cable laying	171	<50 m	<50 m
Dredging (back hoe)	165	<50 m	<50 m
Dredging (suction)	186	<50 m	<50 m

Drilling (drill and grout)	169	<50 m	<50 m
Grinding	183	<50 m	<50 m
Rock placement	172	<50 m	<50 m
Trenching	172	<50 m	<50 m
Vessel noise (large)	168	<50 m	<50 m
Vessel noise (medium)	161	<50 m	<50 m
Water jetting	170	<50 m	<50 m

Sensitivity or value of receptor

12.8.5.5 The sensitivity described for each receptor is based on the criteria provided in **Table 12-12**.

High value receptors

12.8.5.6 The majority of fish receptors are considered of low to medium value. Diadromous fish (Atlantic salmon, sea trout and European eel) and the common skate complex have been assigned a high value. This has been considered when determining the overall sensitivity of the receptors to underwater noise and vibration (continuous) during the construction phase of the Offshore Project. The value and sensitivity is based upon the criteria detailed in Section 12.5.

Marine fish

12.8.5.7 Sensitivity (tolerance and recoverability) of marine fish species to underwater noise has been assessed in Section 12.8.4 for impulsive noise. Sensitivity to continuous noise is considered equivalent because the underlying biological characteristics that determine how fish detect and respond to sound, such as the presence or absence of a swim bladder, auditory specialisations, and hearing bandwidth, do not change with the type of noise source. The Popper *et al.* (2014) (expanded in Popper *et al.*, 2019) guidelines apply the same hearing-group classification (Groups 1–4/5 as defined in **Table 12-26**) when assessing both impulsive and continuous noise, reflecting that sensitivity is defined by species' auditory anatomy and physiology, not by whether the received sound is impulsive or continuous. As such, no further discussion of species-specific sensitivity rankings is provided here. For clarity, sensitivity statements are repeated below.

Hearing group 1 and 2

12.8.5.8 Group 1 and 2 marine fish species with spawning grounds within the (excluding elasmobranchs and sandeels) are considered to have high tolerance and medium recoverability and are of low to medium value. Therefore, group 1 and 2 species (excluding elasmobranchs and sandeels) sensitivity to underwater noise and vibration (impulsive noise) is considered to be **Low**. Sandeel are considered to have medium tolerance and medium recoverability, and are of medium value. As such, sensitivity of sandeel to underwater noise and vibration (impulsive noise) is considered to be **Medium**. Group 1 and 2 marine fish species (elasmobranchs) are considered to have high tolerance and low recoverability and are of low to high value. Therefore, Group 1 and 2 marine fish

species (elasmobranchs) sensitivity to underwater noise and vibration (impulsive noise) is considered to be **Low**.

Hearing group 3 and 4

12.8.5.9 Overall, group 3 and 4 marine fish species of low to medium value, are considered to have medium tolerance and high recovery, and therefore a **Medium** sensitivity overall.

Hearing group 5 (eggs and larvae)

12.8.5.10 Spawning grounds for several fish have been identified within the ZOI for underwater noise as identified in Section 12.6, indicating the presence of eggs and larvae. The Popper *et al.*, (2014) criteria discussed previously are the same for hearing Groups 5 and 2, and are assigned the same overall sensitivity of **Low**.

Diadromous fish

12.8.5.11 Sensitivity (tolerance and recoverability) of diadromous fish species to underwater noise has been assessed in Section 12.8.4 for impulsive noise. Sensitivity to continuous noise is considered equivalent because the underlying biological characteristics that determine how fish detect and respond to sound, such as the presence or absence of a swim bladder, auditory specialisations, and hearing bandwidth, do not change with the type of noise source. The Popper *et al.* (2014) (expanded in Popper *et al.*, 2019) guidelines apply the same hearing-group classification (Groups 1–4/5 as defined in **Table 12-26**) when assessing both impulsive and continuous noise, reflecting that sensitivity is defined by species' auditory anatomy and physiology, not by whether the received sound is impulsive or continuous. As such, no further discussion of species-specific sensitivity rankings is provided here. For clarity, sensitivity statements are repeated below.

Atlantic salmon (hearing group 2)

12.8.5.12 Based on a high tolerance and low recoverability, sensitivity is assessed as low. However, considering the conservation value of Atlantic salmon, the proximity of construction activities to known migratory routes, including those supporting the Langavat SAC population via Loch Roag/Ròg, and the proportion of the population likely to pass through the ensonified zone over the 5 year construction period, the overall sensitivity of Atlantic salmon has been assessed as **Medium** on a precautionary basis.

Sea trout (hearing group 2)

12.8.5.13 Overall, sea trout are considered to have high tolerance and low recovery. Whilst this species is of high value, their overall sensitivity to this pressure is considered to be **Low** based on high tolerance to underwater noise.

European eel (hearing group 3)

12.8.5.14 Given poor recruitment in eel throughout Europe reported by ICES (Section 4.4 of **Appendix 12.1, Volume 2c**) 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. Their high conservation importance therefore increases their overall sensitivity to **Medium**.

Significance of effect

12.8.5.15 Continuous underwater noise is anticipated to occur during the construction phase of the Offshore Project. Considering the embedded mitigation described in **Table 12-22**, the effects of continuous underwater noise on Fish Ecology receptors are summarised in **Table 12-38**.

Table 12-38 Significance of effect of continuous noise and vibration to Fish Ecology during the construction phase

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Significance of Effect	Significance	Commentary
Marine Fish						
Group 1 and 2 (inc. Atlantic mackerel, horse mackerel and ocean sunfish, Atlantic halibut, common sole, lemon sole, European plaice, Anglerfish and the black scabbard fish, Atlantic bluefin tuna and all elasmobranchs (sharks, skates, and rays), including basking shark)	Negligible	Low	M023	Negligible	Not Significant	Recoverable injury and TTS is anticipated to occur within a very small area (less than 50 m from construction activities). Juvenile fish using nursery grounds within the Offshore Project Boundary may be considered a stationary receptor and therefore could experience greater risk of cumulative exposure. There may be some very localised and temporary reduction in the use of nursery habitat by species; however, any effects would be very spatially limited and, given the extensive availability of equivalent nursery habitats across the broader Marine Fish Study Area, such impacts are not expected to influence population-level nursery function.
Group 1 and 2 (inc.sandeels)	Negligible	Medium		Negligible	Not Significant	
Group 3 & 4 (inc. Atlantic cod, blue whiting, whiting, Norway pout, saithe, blue ling, ling, European hake and roundnose grenadier, Atlantic herring,	Negligible	Medium	M023	Negligible	Not Significant	Sandeels are vulnerable to noise whilst hibernating in the seabed. However, construction, where suitable sandeel habitat has been identified (the Array Area), is scheduled to avoid key sensitive periods of sandeel life history, including the spawning season

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Significance of Effect	Significance	Commentary
European sprat and European pilchard						(November–February), demersal egg phase (November–March), and overwintering period (winter). Although offshore Landfall construction works located within the HDD Exit Pit Area may occur during this period, this area is spatially restricted (approximately 1 km ²) and is not considered optimal habitat (refer paragraph 12.8.1.16). As such, the presence of sandeel is expected to be unlikely, or limited to very low, localised densities where small pockets of suitable sediment may occur.
Group 5 (eggs and larvae)	Negligible	Low	M023	Negligible	Not Significant	Spawning grounds are present within the area affected by underwater noise indicating the presence of eggs and larvae. However, these habitats extend over a very wide area across the Marine Fish Study Area and broader region. Given the high fecundity of most marine fish species, the naturally high background mortality characteristic of early life stages, and the small proportional loss (if any) relative to the wider distribution of eggs and larvae, any direct effects on early life stages or short-term behavioural avoidance of spawning habitat within the ensonified area would not be expected to influence population recruitment.
Diadromous fish						

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Significance of Effect	Significance	Commentary
Atlantic salmon (hearing group 2)	Negligible	Medium	M023	Negligible	Not significant	Atlantic salmon (as adults, kelts and post-smolts) and sea trout may pass through the Array Area during migrations to and from natal rivers within the Diadromous Fish Study Area, and whilst foraging in coastal waters. Fish passing through the area affected by continuous underwater noise throughout construction during migrations are unlikely to be present for sufficient time for an impact to occur (between 12 and 48 hours for a stationary receptor). The low likelihood of suitable habitat for sandeel, one of the principal prey species for Atlantic salmon, in all except the south west corner and a small patch in the northern section of the Array Area means that Atlantic salmon are unlikely to forage extensively within the ensonified zone and are therefore at low risk of impacts.
Sea trout (hearing group 2)	Negligible	Low		Negligible	Not significant	
Group 3 – European eel	Negligible	Medium	M023	Negligible	Not Significant	European eel will pass through the Diadromous Fish Study Area as outward migrating adults and as inward migrating glass eels. They are known to remain in coastal waters during their migrations and are therefore at potential risk from noise impacts. Given their relatively low auditory sensitivity, and the short periods of time in which they are likely to be present in the ensonified zone the overall effect is considered to be Negligible.



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Further Environmental Mitigation and Residual Effect

- 12.8.5.16 No additional Fish Ecology mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond the embedded commitments outlined in **Table 12-22**) is **Not Significant** in EIA terms.

12.9 ASSESSMENT OF EFFECTS: OPERATION AND MAINTENANCE

12.9.1 LONG TERM SEABED HABITAT LOSS/CHANGE

- 12.9.1.1 The presence of infrastructure such as WTGs and OSP foundations (where required) along with associated scour and cable protection have the potential to cause subtidal loss/change to fish habitat over the lifetime of the Offshore Project (up to 35 years). Based on the maximum design scenario, long term seabed habitat loss/change associated with scour and cable protection, is assessed on the basis that these materials may remain *in situ*. The maximum design scenario relating to seabed habitat loss/change during the O&M phase is presented in **Table 12-21**.
- 12.9.1.2 Long term seabed loss/change has the potential to degrade, remove or change fish habitats, including foraging, spawning, and nursery areas. 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.

Magnitude

- 12.9.1.3 Long term seabed habitat loss/change will result from the presence of infrastructure within the Offshore Project Boundary, including WTG foundations, associated scour protection, and cable protection along sections of the cable routes. Under the maximum design scenario, a total of 2,411,500m² (2.411km²) of long term seabed habitat loss/change is anticipated. Of this, 661,500 m² (0.6615 km²) of long-term seabed loss/change is anticipated from the WTGs and associated scour protection, and up to 1,750,000 m² (1.75 km²) from cable protection measures along 350 km of Offshore Cables. This equates to approximately 1.16% of the Offshore Project Boundary. Following the operation and maintenance phase, components of the Offshore Project may be left *in-situ* to avoid unnecessarily disturbing the seabed (i.e. where marine habitat has formed). This could include the WTG scour protection, WTG foundations located below seabed level, and the Offshore Cables (including associated scour protection). The potential for infrastructure to remain *in-situ* will be confirmed through consultation on the Decommissioning Programme to ensure the most suitable approach is taken. At this stage it is unconfirmed which components (if any) would remain *in-situ*. As such, under the maximum design scenario of long term seabed habitat loss/change it has been assumed that the WTG scour protection, WTG foundations located below seabed level, and the Offshore Cables (including associated scour protection) will remain in-situ permanently.
- 12.9.1.4 The majority of habitats affected comprise circalittoral rock and other hard substrates, particularly biotopes such as A4.214 Faunal and algal crusts on exposed to moderately wave-exposed

circalittoral rock, which dominate the Array Area and large portions of the OCAS (refer **Chapter 11, Volume 2a**). In these areas, the change represents a shift from natural hard substrate to artificial hard substrate (e.g., concrete or rock scour protection), rather than complete removal. In contrast, limited and localised pockets of A5.14 Circalittoral coarse sediment and A3.21 *Laminaria digitata* on moderately exposed sublittoral fringe rock in the nearshore portions of the OCAS will be permanently lost and replaced with non-natural substrates, resulting in the loss of those soft sediment or mixed habitat features. It should be noted that there is the potential for recolonisation of artificial hard substrates by epifaunal and macroalgae species allowing some re-establishment of habitat over time.

- 12.9.1.5 These areas will be spatially discrete and localised, either in the immediate vicinity of WTG foundations (including scour protection) or along narrow, linear stretches of the cable route. As such, the footprint of seabed habitat loss/change 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 that include prey species for fish. Secondary effects on fish may occur through the localised loss or change of benthic prey species and habitat structure. However, the Benthic and Shellfish Ecology assessment concluded that impacts from this impact-pathway were minor to negligible (Not Significant) for all receptor groups (**Chapter 11, Volume 2a**). As such, any secondary effects on fish via reduced availability of epifaunal or infaunal communities are assumed to be minimal.
- 12.9.1.6 Long-term seabed habitat loss/change will affect only a small proportion of available habitat relative to the wider marine area. In many areas, this involves a change in substrate type rather than complete loss of habitat, with the potential for re-establishment of habitat on hard surfaces over time.
- 12.9.1.7 Based on the maximum design scenario detailed in **Table 12-21** the impacts to fish will be adverse, limited in spatial extent, partially reversible, intermittent in frequency, and long-term duration. Considering embedded mitigation measures detailed within **Table 12-22**, specifically M001 (micrositing), the magnitude of impact from long-term seabed habitat loss/change during the O&M phase is predicted to be **Low**.

Sensitivity or value of receptor

- 12.9.1.8 The sensitivity described for each receptor is based on the criteria provided in **Table 12-12**.

High value receptors

- 12.9.1.9 The majority of fish receptors are considered of low to medium value. Diadromous fish (Atlantic salmon, sea trout and European eel) and the common skate complex have been assigned a high value. This has been considered when determining the overall sensitivity of the receptors to long

term seabed habitat loss/change and/or disturbance during the O&M phase of the Offshore Project. The value and sensitivity is based upon the criteria detailed in Section 12.5.

Marine fish

- 12.9.1.10 Marine fish may be indirectly affected by long-term seabed habitat loss through changes in prey availability or benthic community structure. Many demersal species feed on infaunal and epifaunal invertebrates associated with seabed habitats. However, most fish exhibit generalist feeding strategies and can adapt to localised changes by shifting foraging areas or prey preferences. Therefore, receptor sensitivity to this indirect pathway is considered low and does not materially alter the sensitivity conclusions presented below.
- 12.9.1.11 Species considered most sensitive to this impact are those with strong associations to specific benthic habitats and/or demersal spawning strategies. This includes Atlantic herring, sandeel, and oviparous elasmobranchs (e.g. the common skate complex). These species are considered in more detail below.

Atlantic herring

- 12.9.1.12 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 long term seabed loss. Although the seabed within the Offshore Project Boundary is primarily of either moderate or low potential as spawning habitat, higher potential habitat in the south of the Array Area will be lost or disturbed (5% of Offshore Project Boundary classified as sedimentary habitat that is suitable for Atlantic herring spawning, see **Appendix 12.1, Volume 2c**) resulting in a long-term, albeit limited extent, reduction in the availability of spawning habitat. 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 (Hay *et al.*, 2001; 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 long term seabed loss is considered **Medium**.

Common skate complex and spotted ray

- 12.9.1.13 Oviparous elasmobranchs such as blue skate, flapper skate (the common skate complex), and spotted ray have identified nursery grounds within the Offshore Project Boundary and lay demersal egg cases. Demersal egg-laying behaviour makes these species more vulnerable to long term seabed loss as this may result in the loss of spawning habitats and/or damage to deposited egg cases over several generations. 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 non-motile and are therefore considered more sensitive than their adult counterparts.

- 12.9.1.14 The common skate complex is considered of high value, low tolerance, and low recoverability. Sensitivity is therefore **High**. Spotted ray is considered to have lower conservation concern, a broader habitat range, and greater reproductive plasticity. It is therefore assessed as having low value, medium tolerance, and medium recoverability. Sensitivity is therefore **Medium**.

Sandeel

- 12.9.1.15 Sandeel are highly sensitive to both physical seabed disturbance and substratum change (FeAST, 2025). They rely on specific sediment types for burrowing and overwintering. Long term seabed habitat loss/change may reduce the extent of suitable habitat. While monitoring from other developments (e.g. Horns Rev I, Beatrice Offshore Wind Farm) suggests potential for recovery (van Deurs et al., 2012; BOWL, 2021) is more fragmented, possibly limiting recovery potential from permanent loss of suitable habitats. Sandeel are assessed as having medium value, low tolerance, and low recoverability. Sensitivity is therefore **High**.

All other marine fish species (not discussed individually)

- 12.9.1.16 Other marine fish species not specifically mentioned – including, but not limited to gadoids (e.g. haddock, whiting), , pelagic species (e.g. mackerel), and viviparous elasmobranchs – are considered less sensitive to this impact. These species are typically more generalist and exhibit higher tolerance to habitat change. Many also possess life-history traits (e.g. 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**.

Diadromous species

Atlantic salmon, sea trout and European eel

- 12.9.1.17 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 (e.g., spawning or key foraging areas) within the Offshore Project Boundary, these species have limited direct reliance on benthic habitats affected by long term seabed loss. As such, direct impacts are expected to be negligible.
- 12.9.1.18 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 long term habitat change. 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), persistent localised reductions in prey availability may lead to some energetic or behavioural impacts.
- 12.9.1.19 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 long term seabed habitat loss/change is considered to be **Medium**.

Significance of effect

12.9.1.20 Long term seabed loss is anticipated to take place during the O&M phase of the Offshore Project. Considering the embedded mitigation described in **Table 12-22**, the residual effects of long term seabed habitat loss/change on Fish Ecology receptors are summarised in **Table 12-39**.

Table 12-39 Significance of effect of long term seabed habitat loss/change to Fish Ecology during the O&M phase

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
Marine Fish						
Atlantic herring	Low	Medium	M001	Minor	Not Significant	Effects are considered spatially limited due to the restricted extent of suitable spawning substrate within the area affected by long term seabed habitat loss/change, especially when considering the availability of suitable spawning grounds across the broader Marine Fish Study Area and wider region.
Common skate complex	Low	High		Minor	Not Significant	While common skate complex may utilise the affected area, suitable egg-laying habitats are spatially restricted, being limited to shallow nearshore waters (<20 m depth). These shallow habitats represent only a small proportion of the area subject to long term seabed loss (limited to within the OCAS). As such, the potential impact on key reproductive habitat is limited.
Spotted ray	Low	Medium		Minor	Not Significant	The footprint of seabed habitat loss or change is small in proportion to the extent of similar habitats in the wider region. Potential impact on key reproductive habitat is limited. Spotted ray has lower conservation value and greater reproductive plasticity than the common skate complex.
Sandeel	Low	High		Minor	Not Significant	The footprint of seabed habitat loss or change is small in proportion to the extent of similar habitats in the wider region. Fragmented habitat may possibly limit recovery potential from long-term loss of suitable habitats.

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
All other marine fish species (not discussed individually)	Low	Low		Negligible	Not Significant	The footprint of habitat loss or conversion is small in proportion to the extent of similar habitats in the wider region. These species typically exhibit higher tolerance to habitat change. Many also possess life-history traits (e.g. high fecundity, mobility) that support faster recovery.
Diadromous Fish						
Diadromous fish – Atlantic salmon, sea trout, European eel	Low	Medium	M001	Minor	Not Significant	The footprint of seabed habitat loss or change is small in proportion to the extent of similar habitats in the wider region. Highly mobile and no known critical habitats (e.g., spawning or key foraging areas) within the Offshore Project Boundary. Possible indirect effect through changes to prey (sandeel).

Further Environmental Mitigation and Residual Effect

- 12.9.1.21 No additional Fish Ecology mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond the embedded commitments outlined in **Table 12-22**) is **Not Significant** in EIA terms.

12.9.2 SHORT TERM SEABED HABITAT LOSS AND/OR DISTURBANCE

- 12.9.2.1 Short term seabed loss and/or disturbance may occur intermittently and be repeated during O&M activities, from activities such as repair or replacement of sections of cable and major component replacement of WTGs requiring a jack-up vessel. The maximum design scenario relating to short term seabed habitat loss and/or disturbance during the O&M phase are presented in **Table 12-21**.
- 12.9.2.2 Short term seabed loss and/or disturbance has the potential to degrade or remove 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 short term loss and/or change in benthic habitats that support key prey species or provide ecological functions critical to early life stages.

Magnitude

- 12.9.2.3 Short term seabed loss and/or disturbance will occur during the O&M phase. This may result from episodic activities such as cable repair, or replacement, and the use of jack-up vessels for WTG minor and major component replacement. Under the maximum design scenario, 27,610,800m² (27.610 km²) of short term seabed disturbance may occur over the 35-year operational lifespan. Of this, 11,860,800m² (11.86 km²) may occur within the Array Area associated with major and minor component replacement for WTGs, and 15,750,000 m² (15.75 km²) associated with repair and/or replacement of Offshore Cables. While these activities are short in duration and reversible, they represent repeated disturbance events across the 35-year operational lifespan.
- 12.9.2.4 Short term seabed loss and/or disturbance will affect only a small proportion of available habitat relative to the wider marine area. Short term disturbances during O&M are considered adverse, occurring over the operational lifespan of the Offshore Project, but intermittent, and each incidence is considered short in duration. Short term disturbance is considered to be highly localised and reversible through natural recovery processes. Based on the maximum design scenario detailed in **Table 12-21** the impacts on fish will be adverse, partially reversible, intermittent in frequency, and of long-term duration. Considering embedded mitigation measures detailed in **Table 12-22**, specifically M001 (micrositing), M005 (best practice techniques for seabed excavations), the overall magnitude of impact is assessed as **Low**.

Sensitivity or value of receptor

- 12.9.2.5 The sensitivity described for each receptor is based on the criteria provided in **Table 12-12**.

High value receptor

- 12.9.2.6 The majority of fish receptors are considered of low to medium value. Diadromous fish (Atlantic salmon, sea trout and European eel) and the common skate complex have been assigned a high value. This has been considered when determining the overall sensitivity of the receptors to short term seabed loss and/or disturbance during the O&M phase of the Offshore Project. The value and sensitivity is based upon the criteria detailed in Section 12.5.3 and **Chapter 5, Volume 1a**.

Marine fish

- 12.9.2.7 Sensitivity (tolerance and recoverability) of marine fish species to short term seabed loss and/or disturbance has been assessed for the construction phase in **Section 12.12**. As the impacts during the O&M phase are the same – namely, short term seabed loss and/or disturbance – sensitivity is considered equivalent. No further discussion of species-specific sensitivity rankings is provided in this section. For clarity, sensitivity statements are repeated below.

Atlantic herring

- 12.9.2.8 Atlantic herring are considered to have low tolerance and medium recoverability and to be of medium value. Therefore, Atlantic herring sensitivity to short term seabed loss and/or disturbance is considered to be **Medium**.

The common skate complex and spotted ray

- 12.9.2.9 The common skate complex is considered of high value, medium tolerance and low recoverability. Based on these attributes, sensitivity is assessed as Medium. However, considering the high conservation value of this species, declining population and identified nursery ground within the area affected by this impact, the sensitivity of the common skate complex is considered to be **High**. Spotted ray is considered to have lower conservation concern, a broader habitat range, and greater reproductive plasticity. It is therefore considered to have low tolerance, medium recoverability and to be of low value. Therefore, spotted ray sensitivity to short term seabed loss and/or disturbance is considered to be **Medium**.

Sandeel

- 12.9.2.10 Sandeel are of medium value, and considered to have low tolerance and high recoverability to this impact. Therefore, sandeel sensitivity to short term seabed loss and/or disturbance is considered to be **Medium**.

All other marine fish species (not discussed individually)

- 12.9.2.11 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 species to short term seabed loss and/or disturbance is considered to be **Low**.

Diadromous species

12.9.2.12 Given their ability to avoid disturbed areas, opportunistic feeding behaviour, and the resilience of prey populations, diadromous fish species exhibit high tolerance to short term seabed loss and/or disturbance 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 short term seabed loss and/or disturbance is considered **Low**.

Significance of effect

12.9.2.13 Short term seabed loss and/or disturbance is anticipated to take place during the O&M phase of the Offshore Project. Considering the embedded mitigation described in **Table 12-22**, the residual effects of short term seabed loss and/or disturbance on Fish Ecology receptors are summarised in **Table 12-40**.

Table 12-40 Significance of effect of short term seabed loss and/or disturbance to Fish Ecology during the O&M phase

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
Marine Fish						
Atlantic herring	Low	Medium	M001 M005	Minor	Not Significant	The spatial extent of the impact is limited and the overlap with suitable spawning substrate within the area restricted. Considering the availability of suitable spawning grounds across the broader region, the area of herring spawning ground affected by short term seabed loss and/or disturbance is small. Disturbance is considered reversible, with recovery of spawning habitats and populations expected post-construction.
Common skate complex	Low	High	M001 M005	Minor	Not Significant	Suitable egg-laying habitats for the common skate complex are spatially restricted within the area affected by short term habitat loss and/or disturbance, being limited to shallow nearshore waters (<20 m depth; as discussed in Section 4.3.2 of Appendix 12.1, Volume 2c). As these areas constitute only a small proportion of the area affected by short term seabed loss and/or disturbance, the extent of potential impact on spawning habitats is very limited. Disturbance is considered reversible,

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
						with natural recovery of egg-laying habitats and populations occurring post-construction.
Spotted ray	Low	Medium	M001 M005	Minor	Not Significant	The footprint of seabed habitat loss or change is small in proportion to the extent of similar habitats in the wider region. Potential impact on key reproductive habitat is limited. Spotted ray has lower conservation value and greater reproductive plasticity than the common skate complex.
Sandeel	Low	Medium	M001 M005	Minor	Not Significant	Effects are considered to be spatially limited, as only a small proportion of suitable habitats within the Marine Fish Study Area will be affected, especially when considering the availability of habitats across the broader region. Disturbance is considered reversible, and sandeel populations are expected to recover rapidly.
All other marine fish species (not discussed individually)	Low	Low	M001 M005	Negligible	Not Significant	Due to their limited reliance on specific benthic habitats for key life stages, all other marine fish species are considered to have a lower likelihood of exposure to short term seabed loss and disturbance.
Diadromous Fish						
Atlantic salmon, sea	Low	Low	M001 M005	Negligible	Not Significant	Diadromous species are highly mobile and therefore able to avoid disturbed areas. High tolerance and recoverability to short

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
trout, European eel						term seabed loss and/or disturbance due to opportunistic feeding behaviour, and resilience of prey populations. Impacts are temporary and reversible.



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Further Environmental Mitigation and Residual Effect

- 12.9.2.14 No additional Fish Ecology mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond the embedded commitments outlined in **Table 12-22**) is Not Significant in EIA terms.

12.9.3 INCREASES IN SUSPENDED SEDIMENT CONCENTRATION AND ASSOCIATED SEDIMENT DEPOSITION

- 12.9.3.1 Temporary increases in SSC and subsequent sediment deposition are predicted to occur during the O&M phase, from activities, such as repair, replacement or reburial of cable. 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 avoidance, leading to temporary displacement from affected areas. Increased turbidity associated with SSC also has the potential to reduce foraging efficiency by impairing prey detection in visually hunting species. The maximum design scenario relating to increases in SSC and associated sediment deposition during the O&M phase are presented in **Table 12-21**.
- 12.9.3.2 The resettlement of suspended material (deposition) may result in the smothering of less-mobile species or vulnerable life stages (e.g., 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.

Magnitude

- 12.9.3.3 Increases in suspended sediment concentrations and associated deposition will occur during the O&M phase. This may result from episodic activities such as cable repair, or replacement, and the use of jack-up vessels for WTG minor and major component replacement.
- 12.9.3.4 No modelling has been done for SSC and deposition during the O&M phase, but levels are expected to be equal to or lower than during construction. This is because the 'multiple activities' modelling scenario, during the construction phase, simulated a maximum suspended sediment concentration during drilling of 4 WTG foundations (each with 4 piles), and burial of cables (assuming drilling and cable burial activities happen sequentially) per month. It is not expected that such large-scale works will be undertaken during the O&M phase, and therefore, sediment disturbance will be comparatively lower. It is acknowledged that while these activities are short in duration and reversible, they represent repeated disturbance events across the 35-year operational lifespan.
- 12.9.3.5 Elevated SSCs during the O&M phase are expected to be short-term, intermittent, and spatially limited. Deposition is predicted to be highly localised and naturally reversible through tidal processes. Although O&M activities resulting in increases in SSC and associated deposition may occur more frequently than during construction, each occurrence is expected to be of short

duration. The impact is adverse but temporary, localised, and reversible. Considering the embedded Offshore Project mitigation measures detailed within **Table 12-22**, specifically M005 (best practice techniques for seabed excavations), the magnitude of impact from increases in SSC and associated deposition during the O&M phase is predicted to be **Low**.

Sensitivity or value of receptor

12.9.3.6 The sensitivity described for each receptor is based on the criteria provided in **Table 12-12**.

High value receptors

12.9.3.7 The majority of fish receptors are considered of low to medium value. Diadromous fish (Atlantic salmon, sea trout and European eel) and the common skate complex have been assigned a high value. This has been considered when determining the overall sensitivity of the receptors to increases in SSC and associated sediment deposition during the O&M phase of the Offshore Project. The value and sensitivity is based upon the criteria detailed in **Section 12.5**.

Marine fish

12.9.3.8 Sensitivity (tolerance and recoverability) of fish species to SSC and subsequent deposition has been assessed for seabed preparation, foundation installation, and the laying of Offshore Cables for the construction phase in Section 12.8.1. As the impacts during the O&M phase 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 for each group.

Species with nursery grounds (only) within the area affected by SSC and deposition

12.9.3.9 Atlantic mackerel, blue whiting, anglerfish, European hake, haddock, ling and whiting of medium to low value are considered to have low tolerance and high recoverability. Therefore, sensitivity of these species is considered to be **Medium**. Spurdog, of medium value, is considered to have low tolerance and medium recoverability. Therefore, sensitivity for this species is considered to be **Medium**.

Species with spawning grounds (only) within the area affected by SSC and deposition

12.9.3.10 European sprat are considered to have low tolerance and medium recoverability. Therefore, the overall sensitivity of these species to increases in SSC and deposition is considered to be **Medium**. The common skate complex and spotted ray of high to medium value, have low tolerance and low recoverability. Based on these attributes, sensitivity to increases in SSC and deposition is assessed as **High**.

Species with spawning and nursery grounds, within the area affected by elevated SSC and deposition

12.9.3.11 Atlantic herring, Atlantic cod, lemon sole and Norway pout are considered to have medium tolerance and medium recoverability and are of low to medium value. Therefore, the overall sensitivity of these species to increases in SSC and deposition is considered to be **Medium**.

Sandeel

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

All other marine fish species (not discussed individually)

12.9.3.13 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

12.9.3.14 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 phase in **Section 12.12**. As the impacts during the O&M phase are the same (increases in SSC and subsequent deposition), the sensitivity of the receptors is considered equivalent.

Atlantic salmon, sea trout and European eel

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

Significance of effect

12.9.3.16 Increase in SSC and associated sediment deposition is anticipated to take place during the O&M phase of the Offshore Project. Considering the embedded mitigation described in **Table 12-22**, the residual effects of increase in SSC and associated sediment deposition on Fish Ecology receptors are summarised in **Table 12-41**.

Table 12-41 Significance of effect of increases in suspended sediment concentrations and associated sediment deposition to Fish Ecology during the O&M phase

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
Marine Fish						
Species with nursery grounds (only)(within the area affected by SSC and sediment deposition						
Atlantic mackerel Blue whiting Anglerfish European hake Haddock Ling, Whiting Spurdog	Low	Medium	M005	Minor	Not Significant	Considered to have some tolerance to elevated levels of SSC due to natural high SSC caused by winter storms and tidal currents. Species have broad distribution ranges and high fecundity and therefore high recoverability. Intermittent medium-term impact highly localised and naturally reversible through tidal processes.
Species with spawning grounds (only) within the area affected by SSC and sediment deposition						
European sprat	Low	Medium	M005	Minor	Not Significant	Spawning grounds for this species are known to partially overlap with the Offshore Cable and Array Areas, but are widespread along the west coast of Scotland/Alba. Intermittent medium-term impact highly localised and naturally reversible through tidal processes.
Common skate complex	Low	High		Minor	Not Significant	Suitable egg-laying habitats for the common skate complex are spatially restricted within the area affected by temporary increases in SSC and subsequent deposition, being limited to shallow nearshore waters (<20 m depth; as discussed in Section 12.6.1.9).). As these areas constitute only a small proportion of the area affected by elevated SSC and associated deposition, the extent of potential impact on spawning habitats is very limited.

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
						Disturbance to egg-laying habitats is reversible, with the seabed expected to recover post-construction; any egg cases directly affected would represent a small, localised loss, and given the very limited spatial overlap with suitable habitat, population-level effects are not expected.
Spotted ray	Low	High		Minor	Not Significant	Limited data is available on egg-case distribution for this species, which is used to identify spawning grounds for oviparous species. However, where suitable habitat exists, spawning areas are expected to broadly overlap with nursery grounds (Ellis <i>et al.</i> , 2012). Spawning habitats, as identified in Plate 4-6b of Appendix 12.2, Volume 2c are very spatially restricted within the Marine Fish Study Area, and none lies within the Array Area or OCAS. Disturbance to egg-laying habitats is reversible, with the seabed expected to recover post-construction; any egg cases directly affected would represent a small, localised loss, and given the very limited spatial overlap with suitable habitat, population-level effects are not expected.
Species with spawning and nursery grounds within the area affected by SSC and sediment deposition						
Atlantic herring	Low	Medium	M005	Minor	Not Significant	Substrate suitable for Atlantic herring spawning occurs only in the south west corner of the Array Area. Intermittent medium-term impact highly localised and naturally reversible through tidal processes.

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
Atlantic cod Lemon sole Norway pout	Low	Medium		Minor	Not Significant	Spawning grounds for these species are known to partially overlap with the Offshore Cable and Array Areas, but are widespread along the west coast of Scotland/ <i>Alba</i> . Intermittent medium-term impact highly localised and naturally reversible through tidal processes.
Sandeel						
Sandeel species	Low	Medium	M005	Minor	Not Significant	Sandeel are relatively insensitive to light levels of deposition (≤ 5 cm). Most areas expected to experience less than 2 cm deposition from construction activities. Impacts are of limited spatial extent and short-term.
All other marine fish species (not discussed individually)						
All other marine fish species (not discussed individually)	Low	Low	M005	Negligible	Not Significant	The majority of marine fish species are not particularly sensitive to temporary increases in SSC. Intermittent medium-term impact highly localised and naturally reversible through tidal processes.
Diadromous Fish						

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
Atlantic salmon Sea trout European eel	Low	Low	M005	Negligible	Not Significant	<p>Sensitive life-stages (egg and alevin stages) are not exposed to elevated SSC or deposition associated with offshore construction activities. Adult and juvenile counterparts interacting with the area impacted by elevated SSC and deposition are habituated to estuarine and nearshore coastal habitats where SSC are naturally elevated. Able to avoid areas of maximum disturbance.</p> <p>Intermittent medium-term impact highly localised and naturally reversible through tidal processes.</p>

Further Environmental Mitigation and Residual Effect

- 12.9.3.17 No additional Fish Ecology mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond the embedded commitments outlined in Section 12.8.2 is Not Significant in EIA terms.

12.9.4 UNDERWATER NOISE AND VIBRATION

- 12.9.4.1 Underwater noise and vibration (as a source of noise within the water column) during operation will arise from mechanically generated vibration from the rotating machinery in the WTGs transmitted into the sea through the structure of the WTG tower and foundations (Nedwell *et al.*, 2003; Tougaard *et al.*, 2020). There is potential for impacts on fish ranging from mortality and reversible injury at the highest level, to TTS and behavioural changes at lower noise levels. Generalised noise impacts on fish and quantified thresholds at which impacts may occur are described in Section 12.8.4. The maximum design scenario relating to underwater noise and vibration during the O&M phase are presented in **Table 12-21**.

Magnitude

- 12.9.4.2 In calculating noise and vibration from WTG towers and foundations consideration has been given to the nominal power output of the turbine, with rotor diameter used as a proxy, and expected wind speeds as the primary variables. Based on assumed rotor diameters of between 234 m and 280 m and an assumed average wind speed of 11 ms^{-1} recoverable injury ($170 \text{ dB unweighted } L_p$) may occur at $<50 \text{ m}$ assuming a stationary receptor present within the impacted zone for a period of 48 hours. TTS ($158 \text{ dB unweighted } L_p$) would also be limited to a distance of $<50 \text{ m}$ assuming the receptor remained in the impact zone continuously for 12 hours. A detailed description of the modelling parameters and modelling outputs are provided in **Appendix 13.3, Volume 2c**. The impact is adverse and permanent, and very localised. As such, the magnitude of impact is assessed as **Negligible**.

Sensitivity or value of receptor

- 12.9.4.3 The sensitivity described for each receptor is based on the criteria provided in **Table 12-12**.

High value receptors

- 12.9.4.4 The majority of fish receptors are considered of low to medium value. Diadromous fish (Atlantic salmon, sea trout and European eel) and the common skate complex have been assigned a high value. This has been considered when determining the overall sensitivity of the receptors to underwater noise and vibration (continuous) during the construction phase of the Offshore Project. The value and sensitivity is based upon the criteria detailed in **Section 12.5**.

Marine fish

12.9.4.5 Sensitivity (tolerance and recoverability) of marine fish species to underwater noise has been assessed for the construction phase in Section 12.8.4 for impulsive noise. Sensitivity to operational noise (a continuous noise source) is considered equivalent because the underlying biological characteristics that determine how fish detect and respond to sound, such as the presence or absence of a swim bladder, auditory specialisations, and hearing bandwidth, do not change with the type of noise source. The Popper *et al.* (2014) (expanded in Popper *et al.*, 2019) guidelines apply the same hearing-group classification (Groups 1–4/5 as defined in **Table 12-26**) when assessing both impulsive and continuous noise, reflecting that sensitivity is defined by species' auditory anatomy and physiology, not by whether the received sound is impulsive or continuous. As such, no further discussion of species-specific sensitivity rankings is provided here. For clarity, sensitivity statements are repeated below.

Hearing group 1 and 2

12.9.4.6 Group 1 and 2 marine fish species with spawning grounds within the (excluding elasmobranchs) are considered to have high tolerance and medium recoverability and are of low to medium value. Therefore, group 1 and 2 species (excluding elasmobranchs) sensitivity to underwater noise and vibration (impulsive noise) is considered to be **Low**. Sandeel are considered to have medium tolerance and medium recoverability, and are of medium value. As such, sensitivity of sandeel to underwater noise and vibration (impulsive noise) is considered to be **Medium**. Group 1 and 2 marine fish species (elasmobranchs) are considered to have high tolerance and low recoverability and are of low to high value. Therefore, Group 1 and 2 marine fish species (elasmobranchs) sensitivity to underwater noise and vibration (impulsive noise) is considered to be **Low**.

Hearing group 3 and 4

12.9.4.7 Overall, group 3 and 4 marine fish species of low to medium value, are considered to have medium tolerance and high recovery, and therefore a **Medium** sensitivity overall.

Hearing group 5 (eggs and larvae)

12.9.4.8 Spawning grounds for several fish have been identified within the Zol for underwater noise as identified in Section 12.6.1, indicating the presence of eggs and larvae. The Popper *et al.*, (2014) criteria discussed previously are the same for hearing Groups 5 and 2, and are assigned the same overall sensitivity of **Low**.

Diadromous fish

12.9.4.9 Sensitivity (tolerance and recoverability) of diadromous fish species to underwater noise has been assessed for the construction phase in Section 12.8.4 for impulsive noise. Sensitivity to operational noise (a continuous noise source) is considered equivalent because the underlying biological characteristics that determine how fish detect and respond to sound, such as the presence or absence of a swim bladder, auditory specialisations, and hearing bandwidth, do not change with

the type of noise source. The Popper *et al.* (2014) (expanded in Popper *et al.*, 2019) guidelines apply the same hearing-group classification (Groups 1–4/5 as defined in **Table 12-26**) when assessing both impulsive and continuous noise, reflecting that sensitivity is defined by species' auditory anatomy and physiology, not by whether the received sound is impulsive or continuous. As such, no further discussion of species-specific sensitivity rankings is provided here. For clarity, sensitivity statements are repeated below.

Atlantic salmon (hearing group 2)

- 12.9.4.10 Based on a high tolerance and low recoverability, sensitivity is assessed as low. However, considering the conservation value of Atlantic salmon, the proximity of construction activities to known migratory routes, including those supporting the Langavat SAC population via Loch Roag/Ròg, and the proportion of the population likely to pass through the ensonified zone over the 5 year construction period, the overall sensitivity of Atlantic salmon has been assessed as **Medium** on a precautionary basis.

Sea trout (hearing group 2)

- 12.9.4.11 Overall, sea trout are considered to have high tolerance and low recovery. Whilst this species is of high value, their overall sensitivity to this pressure is considered to be **Low** based on high tolerance to underwater noise.

European eel (hearing group 3)

- 12.9.4.12 Given poor recruitment in eel throughout Europe reported by ICES (**Appendix 12.1, Volume 2c**; paragraph 4.4.3.2) 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. Their high conservation importance therefore increases their overall sensitivity to Medium.

Significance of effect

- 12.9.4.13 Underwater noise is anticipated to occur during the O&M phase of the Offshore Project. Considering the embedded mitigation described in **Table 12-22**, the residual effects of underwater noise on Fish Ecology receptors are summarised in **Table 12-42**.

Table 12-42 Significance of effect of increases in underwater noise to Fish Ecology during the O&M phase

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Significance of Effect	Significance	Commentary
Marine Fish						
Group 1 and 2 (inc. Atlantic mackerel, horse mackerel and ocean sunfish, Atlantic halibut, common sole, lemon sole, European plaice, Anglerfish and the black scabbard fish, Atlantic bluefin tuna and all elasmobranchs (sharks, skates, and rays), including basking shark)	Negligible	Low	N/A	Negligible	Not Significant	Recoverable injury and TTS is anticipated to occur within a very small area (less than 50 m from each WTG).
Group 1 and 2 (inc. sandeels)	Negligible	Medium	N/A	Negligible	Not Significant	Juvenile fish using nursery grounds within the Array Area may be considered a stationary receptor and therefore could experience greater risk of cumulative exposure. There may be some very localised and temporary reduction in the use of nursery habitat by species; however, any effects would be very spatially limited and, given the extensive availability of equivalent nursery habitats across the broader Marine Fish Study Area, such impacts are not expected to influence population-level nursery function.
Group 3 & 4 (inc. Atlantic cod, blue whiting, whiting, Norway pout, saithe, blue ling, ling, European hake and roundnose grenadier, Atlantic herring, European sprat and European pilchard)	Negligible	Medium	N/A	Negligible	Not Significant	Sandeels are considered more vulnerable to noise while hibernating within the seabed during the overwintering period. Operation of the WTGs will occur year-round and therefore coincides with this period. However, the spatial extent of continuous noise at levels causing recoverable injury and TSS is
Group 5 (eggs and larvae)	Negligible	Low	N/A	Negligible	Not Significant	

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Significance of Effect	Significance	Commentary
						<p>extremely small (less than 50 m from each WTG), representing a very small proportion of available habitat. As such, any potential effects on sandeel would be highly localised and are not expected to result in population level effects.</p> <p>Spawning grounds are present within the Array Area indicating the presence of eggs and larvae. However, these habitats extend over a very wide area across the Marine Fish Study Area and broader region. Given the high fecundity of most marine fish species, the naturally high background mortality characteristic of early life stages, and the small proportional loss (if any) relative to the wider distribution of eggs and larvae, any direct effects on early life stages or short-term behavioural avoidance of spawning habitat within the ensonified area would not be expected to influence population recruitment.</p> <p>Noise and vibration from WTG foundations may cause a very minor reduction in the availability of spawning habitat within the Array Area.</p>
Diadromous Fish						

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Significance of Effect	Significance	Commentary
Atlantic salmon (hearing group 2)	Negligible	Medium	N/A	Negligible	Not Significant	Atlantic salmon (as adults, kelts and post-smolts) and sea trout may pass through the Array Area during migrations to and from natal rivers within the Diadromous Fish Study Area, and whilst foraging in coastal waters. Fish passing through the Array Area during inward migrations are unlikely to be stationary around a WTG for sufficient time for an impact to occur (between 12 and 48 hours for a stationary receptor; see paragraph 12.9.4.2). The low likelihood of suitable habitat for sandeel, one of the principal prey species for Atlantic salmon, in all except the south west corner and a small patch in the northern section of the Array Area means that Atlantic salmon are unlikely to forage extensively within the ensonified zone and are therefore at low risk of impacts.
sea trout (hearing group 2)	Negligible	Low	N/A	Negligible	Not Significant	
European eel (hearing group 3)	Negligible	Medium	N/A	Negligible	Not Significant	European eel will pass through the Diadromous Fish Study Area as outward migrating adults and as inward migrating glass eels. They are known to remain in coastal waters during their migrations and are therefore at potential risk from noise impacts. Given their relatively low auditory sensitivity, and the short periods of time in which they are likely to be present in the ensonified zone the overall effect is considered to be negligible.



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Further Environmental Mitigation and Residual Effect

12.9.4.14 No additional Fish Ecology mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond the embedded commitments outlined in **Table 12-22**) is Not Significant in EIA terms.

12.9.5 ELECTROMAGNETIC FIELDS

12.9.5.1 The installation of Array Cables to Final WTG and Array Cables to Landfall/Export Cables to Landfall will result in High Voltage Alternating Current (HVAC) under the maximum design scenario **Table 12-21**. EMFs are generated by 2 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. The maximum design scenario relating to EMF during the O&M phase are presented in **Table 12-21**.

12.9.5.2 Magnetic fields generated during energy transmission 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 (magnetosensitive species). 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 (SEER, 2022). 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 species sensitive to electric fields (electrosensitive species). Alternating current (AC) cables have the potential to produce weak induced electric fields in the range of microvolts per metre ($\mu\text{V}/\text{m}$). Background measurements of the magnetic field are approximately $50 \mu\text{T}$ in the North Sea, and the naturally occurring electric field in the North Sea is approximately $25 \mu\text{V}/\text{m}$. The calculated background magnetic field in the Array Area is slightly higher than the world average, approximately $50.74 \mu\text{T}$ (based on the World Magnetic Model¹⁰).

12.9.5.3 As such, the localised EMF (both the induced electric field and the magnetic field) produced by the Offshore Cables (Array Cables and Export Cables) has the potential to disrupt electrosensitive and magneto sensitive fish.

Magnitude

12.9.5.4 The Applicant has modelled the expected EMF levels from the 2 design scenarios that are considered within the project design envelope (Array Cables to Final WTG and Array Cables to Landfall/Export Cables to Landfall, see **Offshore EIAR Chapter 3, Volume 1a**):

- **Scenario 1 – Offshore Substation**

¹⁰ [NCEI Geomagnetic Calculators](#)

- Array Cables (66 kV, 900 A, 300 mm) running from WTGs to an OSP (Array Cables located within the Array Area);
- 2 Export Cables (220 kV, 1,400 A, 400 mm) extending from the OSP to Landfall (Export Cables located in Array Area and OCAS).

- **Scenario 2 – No Offshore Substation:**

- Array Cables (66 kV, 900 A, 300 mm) running from WTGs to the final WTG in the string (Array Cables located within the Array Area);
- 6 Array Cables to Landfall (132 kV, 900 A, 300 mm) running from the final WTG in the string to Landfall (Array Cables to Landfall located in Array Area and OCAS).

12.9.5.5 Additional modelling assumptions have been made to understand the worst-case scenario for the 2 design Scenarios considered:

- Single Array Cable String - due to the >1 km spacing between parallel cable strings within the Array Area, EMF emissions from each cable are not expected to overlap significantly. A 100 m radius around each cable was used to represent its primary EMF Zol;
- Array Cables are comparable between Scenarios 1 and 2 as it is assumed that these cables will be directed to a central location within the Array Area before being connected to shore;
- A central location of 10 Array Cables in parallel has been modelled to simulate the point where multiple strings converge either at the OSP (Scenario 1) or into the Array Cables to Landfall (Scenario 2). A separation distance of 10 m between the Array Cables has been used.
- For Scenario 1, an additional model was undertaken to assess the EMFs associated with the 2 Export Cables extending from the OSP to Landfall. The cables were modelled together with a separation distance of 10 m, representing the dual-circuit export configuration;
- For Scenario 2, an additional model was undertaken to assess the EMFs associated with 6 Array Cables running from the centralise location to Landfall. These cables were modelled together with a consistent 10 m separation between each cable.

12.9.5.6 All cable configurations described above were modelled under the following environmental and installation conditions:

Tidal current scenarios (based on available UK Hydrographic Office data for the Array Area):

- Maximum tidal current: 0.9 knots (kn);
- Minimum tidal current: 0.1 kn;
- Average tidal current: 0.4 kn.

Cable installation scenarios:

- Buried cables at a depth of 0.5 m;
- Surface-laid cables (i.e. no burial).

- 12.9.5.7 For all cable scenarios and conditions described, both magnetic field strength (μT) and electric field strength ($\mu\text{V}/\text{m}$) were modelled in 2 dimensions:
- **Horizontally:** along the seabed from the cable outwards;
 - **Vertically:** from the cable upwards into the water column (and through the surficial sediment if the cable is buried).
- 12.9.5.8 This enabled assessment of both the strength and spatial extent of EMF propagation relevant to ecological (including fish and benthic) receptors. A summary of the electric fields and magnetic fields under maximum tidal current and assuming the cable is surface laid (representing the worst-case in terms of EMF propagation) is provided in the subsequent sections.
- 12.9.5.9 It is important to note that magnetic field is significantly attenuated when cables are buried. While the maximum design scenario modelled here assumes surface-laid cables (to reflect the most conservative case), it is expected that at least some portions of the cable route will be buried (target depth between 0.2 - 0.5 m, with a maximum depth of 2 m). In many cases, cables will be partially or fully buried, which will notably attenuate EMF propagation, particularly magnetic fields. Additionally, where cables are surface-laid and protected with rock armouring, although this material does not provide electromagnetic shielding it does, however, create a physical barrier that increases the distance between the cable and many demersal or benthic marine organisms. This separation results in reduced exposure, particularly for species not in direct contact with the cable surface.
- 12.9.5.10 Overall, both the magnetic and induced electric fields of the Offshore Cables in all scenarios reach background levels less than 1 m from the cable. This means that for buried cables, the fields will not be perceptible at the seabed surface in many cases. An exception is where numerous cables converge in close proximity allowing fields to interact. This may occur where Array Cables converge on the OSP or central location (as outlined in **Chapter 3, Volume 1a**). In this situation, it is predicted that the magnetic field would extend 2.32 m horizontally and 95 cm vertically before attenuating to background levels. At periods of maximum tidal flow, this would result in an induced electrical field extending horizontally for 2.28 m and vertically for 79 cm. The impact is therefore of local spatial extent (i.e. within a few metres of buried cables), long term duration, continuous and not reversible during the O&M phase (impact is reversible upon decommissioning). Considering embedded mitigation measures detailed in **Table 12-22**, specifically M002 (Cable Installation Plan), the overall magnitude of impact is assessed as Low.

Sensitivity or value of receptor

- 12.9.5.11 The sensitivity described for each receptor is based on the criteria provided in **Table 12-12**.

High value receptor

- 12.9.5.12 The majority of fish receptors are considered of low to medium value. Diadromous fish (Atlantic salmon, sea trout and European eel), and the common skate complex have been assigned a high

value. This has been considered when determining the overall sensitivity of the receptors to EMF during the O&M phase of the Offshore Project. The value and sensitivity is based upon the criteria detailed in **Section 12.5**.

Marine fish

12.9.5.13 In the context of the impacts of EMF, it is useful to distinguish groups of marine fish receptors for assessment due to distinct ecological and physiological traits that influence their responses to electromagnetic fields. These groups include elasmobranchs, many of which possess specialised electrosensory apparatus, and other, less sensitive, marine fish species. Sensitivity for these groups are discussed separately below.

Elasmobranchs

- 12.9.5.14 Elasmobranchs are generally considered the most electro and magneto-sensitive species group due to their highly developed electrosensory systems. For this reason, elasmobranchs are discussed separately from other marine fish below in terms of their sensitivity to EMF.
- 12.9.5.15 Elasmobranchs (sharks, skates, and rays) are generally considered to be the most electro-sensitive species group due to their possession of a highly sensitive electrosensory 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.
- 12.9.5.16 Elasmobranchs are capable of detecting electric fields down to as low as 1–5 nV/cm (Normandeau et al., 2011) and magnetic fields within the natural range of the Earth’s geomagnetic field (approximately 25–50 μ T). 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).
- 12.9.5.17 A range of laboratory and mesocosm studies have demonstrated behavioural responses of elasmobranchs to electromagnetic fields produced by subsea cables. **Table 12-43** summarises available evidence for elasmobranch species detected within the baseline marine fish survey area or closely related taxa.

Table 12-43 Elasmobranch species for which information on sensitivity to electric or magnetic fields has been suggested for

Species	Reference(s)	Detection of magnetic and/or electric fields
Family Scyliorhinidae		
Spiny dogfish (spurdog) <i>Squalus acanthias</i>	Gill <i>et al.</i> (2009)	No response observed to exposure to 36 kV AC cables
Small-spotted catshark ¹¹ <i>Scyliorhinus canicula</i>	Gill <i>et al.</i> (2009), Gill & Taylor (2001), others	Behavioural and physiological response observed at electric fields of 0.01-0.1 $\mu\text{V}/\text{cm}$
Family Triakidae		
Smooth dogfish <i>Mustelus asterias</i>	Dawson <i>et al.</i> 1980, Kalmijn 1982	Behavioural response observed at electric fields of 0.005-0.01 $\mu\text{V}/\text{cm}$
Family Carcharhinidae		
Blue shark <i>Prionace glauca</i>	Heyer <i>et al.</i> 1981, Kalmijn 1982, Klimley <i>et al.</i> 2002	Behavioural response observed at electric fields of 0.005 $\mu\text{V}/\text{cm}$
Family Rajidae		
Little skate <i>Leucoraja erinace*</i>	Hutchison <i>et al.</i> , 2020	Behavioural response to 49.7 μT and 52.6 μT electric fields produced from 300 and 500 kv DC cables
Family Platyrhynidae		
Thornback ray <i>Raja clavata</i>	Gill <i>et al.</i> 2009, Kalmijn 1971	Behavioural and physiological response observed at electric field of 0.01 $\mu\text{V}/\text{cm}$, and a magnetic field of 35 μT . Response also observed at an induced field electric field of 160 $\mu\text{V}/\text{cm}$.

- 12.9.5.18 Field studies have shown variable responses among elasmobranchs. For instance, a COWRIE (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 10 $\mu\text{V}/\text{cm}$ (Gill & Taylor, 2001), though this exceeds typical field strengths generated by buried AC cables and exceeds the predicted fields in all areas of the Offshore Project except in the immediate vicinity (within 10s of cm) of unburied cables converging on the OSP as explained in Section 12.9.5.10.
- 12.9.5.19 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. Higher EMF field strengths or proximity to cables could increase the likelihood of impact. In light of the available evidence and the specialised sensory systems of elasmobranchs, these species are assessed to have low tolerance to EMFs 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

¹¹ Also known as lesser spotted dogfish.

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 EMFs generated by subsea cables is assessed as **Medium**.

All other marine fish species (not discussed individually)

- 12.9.5.20 In contrast to elasmobranchs, most teleost (bony) fish lack specialised electroreceptors and their ability to detect and respond to EMFs 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 EMFs generated by subsea cables is inconsistent.
- 12.9.5.21 Field observations from AC power cable installations in California found no evidence of fish being attracted to or repelled by 35 kV cables (Love *et al.*, 2016). Likewise, in controlled laboratory studies, juvenile flounder *Platichthys flesus* exposed to magnetic fields up to 3.7 μT over a 3-month period showed no effect on survival (Bochert and Zettler, 2004). Similarly, exposure of Atlantic halibut *Hippoglossus hippoglossus* to magnetic fields between 1,000–1,200 μT 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 EMFs on larval behaviour or orientation (Cresci *et al.*, 2020; 2022).
- 12.9.5.22 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 50–150 μT . While some larvae exhibited changes in swimming speed, suggesting that magnetic field exposure may elicit selective responses depending on individual behavioural phenotypes (e.g., proactive vs reactive behaviours), these effects were not considered ecologically significant (Cresci *et al.*, 2019).
- 12.9.5.23 Field studies at the Nysted Offshore Wind Farm investigated the potential behavioural effects of EMFs from a high-voltage AC subsea cable buried approximately 1 m beneath the seabed. Although the primary focus was on eel migration, additional assessments were conducted on 5 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 EMFs in this species, although confounding environmental factors could not be entirely ruled out (Hal, Volwater and Neitzel, 2022).

- 12.9.5.24 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).
- 12.9.5.25 The physiological and behavioural sensitivity of most marine teleost fish to EMFs is considered low. While some species may detect weak electromagnetic fields, 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 induced electric fields from operational subsea cables. On this basis, teleost fish are considered to exhibit high tolerance to EMF exposure. Where behavioural responses do occur (e.g. 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 this basis, marine fish (excluding elasmobranchs) of low to high value, exhibit high tolerance, and high recoverability. Therefore, the overall sensitivity is assessed as **Low**.

Diadromous species

Overview

- 12.9.5.26 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 magnetoreception. Research has identified iron-rich particles, such as magnetite, in their tissues – particularly in areas like the lateral line and nervous system – supporting their ability to detect geomagnetic cues. Bellinger *et al.* (2022) found magnetite clusters in olfactory tissues of salmonids. Behavioural studies further confirm this, with both species showing orientation changes in response to magnetic fields. As a result, EMFs generated by subsea cables could potentially interfere with these natural navigation processes during migration.

Atlantic salmon and sea trout

- 12.9.5.27 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 95 μT . Similar research conducted in Sweden on the impact of 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 EMFs 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.

- 12.9.5.28 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 the proximity of the cable route to known migratory routes, including those supporting the Langavat SAC population via Loch Roag/Ròg, the overall sensitivity of Atlantic salmon has been increased to **Medium** on a precautionary basis.

European eel

- 12.9.5.29 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 130 kV 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 7,000 km 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 9.6 μT 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**.

Significance of effect

- 12.9.5.30 Change in EMF is anticipated to take place during the O&M phase of the Offshore Project. Considering the embedded mitigation described in **Table 12-22**, the residual effects of changes to EMF on Fish Ecology receptors are summarised in **Table 12-44**.

Table 12-44 Significance of effect of EMF to Fish Ecology during the O&M phase

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
Marine Fish						
Elasmobranchs	Low	Medium	M002	Minor	Not Significant	Magnetic and induced electric fields reach background levels less than 1 m from the cable in most cases. Where array cables it is predicted that fields would be of local spatial extent (i.e. within a few metres of buried cables) and of long term duration. Demersal species likely to be more exposed. Limited evidence exists of population-level impacts in the field (CSA, 2019; Love <i>et al.</i> , 2016). The most likely behavioural responses include attraction, avoidance, or temporary disorientation. Observed effects are often subtle and species-specific, with some individuals showing little to no behavioural alteration.
All other marine fish species (not discussed individually)	Low	Low		Negligible	Not Significant	Magnetic and induced electric fields reach background levels less than 1 m from the cable in most cases. Where array cables it is predicted that fields would be of local spatial extent (i.e. within a few metres of buried cables) and of long term duration. Most teleosts lack specialised electroreceptors, which reduces their capacity to detect or respond to EMFs from operational subsea cables. While some species may detect weak electromagnetic fields, observed responses are generally inconsistent, short-lived, and often attributable to other environmental factors.
Diadromous Fish						

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
Atlantic salmon Sea trout	Low	Medium		Minor	Not Significant	Magnetic and induced electric fields reach background levels less than 1 m from the cable in most cases. Where array cables converge it is predicted that fields would be of local spatial extent (i.e. within a few metres of buried cables) and of long term duration. Studies indicate that while short-term behavioural changes may occur when Atlantic salmon or sea trout encounter EMFs from subsea cables, there is no evidence that these effects interfere with overall migration success or population viability.
European eel	Low	Medium		Minor	Not Significant	Magnetic and induced electric fields reach background levels less than 1 m from the cable in most cases. Where array cables converge it is predicted that fields would be of local spatial extent (i.e. within a few metres of buried cables) and of long term duration. Eels may intermittently encounter EMFs generated by subsea cables when diving near the seabed. While the species is considered to have moderate tolerance to EMFs, its recoverability is low due to its depleted conservation status. However, the brief and episodic nature of its presence within the Offshore Project Boundary during migration reduces the likelihood of sustained exposure.

Further Environmental Mitigation and Residual Effect

- 12.9.5.31 No additional Fish Ecology mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond the embedded commitments outlined in **Table 12-22**) is **Not Significant** in EIA terms.

12.9.6 FISH AGGREGATION EFFECTS

- 12.9.6.1 Permanent infrastructure introduced as part of the Offshore Project – including WTGs piles and foundations, scour protection, and cable protection (e.g., rock armouring) – will add hard substrate and greater structural complexity to the environment. These features can function as artificial reefs. Fish, particularly pelagic and demersal species, may be directly attracted to certain structures for shelter, feeding, or spawning, potentially altering local fish assemblages in terms of species composition and density (Bicknell *et al.* 2025). The maximum design scenario relating to fish aggregation effects during the O&M phase are presented in **Table 12-21**.
- 12.9.6.2 In addition to direct effects, indirect effects may also occur through ecological changes linked to reef-like functioning of the structures. Colonisation by epifaunal invertebrates (e.g., barnacles, mussels, polychaetes) may modify the benthic prey base, influencing food availability for certain fish species. Further indirect effects may arise from altered predator-prey dynamics, whereby aggregation of fish and/or increased prey availability could attract higher trophic level predators (e.g., piscivorous fish or marine mammals), potentially affecting fish behaviour and survival.

Magnitude

- 12.9.6.3 The magnitude of impact for this effect pathway is considered in relation to the extent and nature of infrastructure introduced to the marine environment, which may result in fish aggregation effects. This includes the maximum volume of hard substrate introduced through the placement of WTG foundations and associated scour protection, as well as cable protection (pre-lay carpet and rock/concrete armouring). The total volume of new hard substrate within the Offshore Project Boundary is estimated to be approximately 10,877,500 m³. Of this, 7,147,500 m³ will be introduced from WTG foundations, shafts and associated scour protection, and approximately 3,730,000 m³ from Offshore Cables and associated cable protection. Following the operation and maintenance phase, components of the Offshore Project may be left *in-situ* to avoid unnecessarily disturbing the seabed (i.e. where marine habitat has formed). This could include the WTG scour protection, all elements of the WTG foundations located below seabed level, and the Offshore Cables (including associated scour protection). The potential for hard infrastructure to remain *in-situ* will be confirmed through consultation on the Decommissioning Programme to ensure the most suitable approach is taken. At this stage it is unconfirmed which components (if any) would remain *in-situ*, however, under the maximum design scenario of fish aggregation effects it has been assumed that the WTG scour protection, all elements of the WTG foundations located below seabed level, and the Offshore Cables (including associated scour protection) will remain *in-situ* permanently.

- 12.9.6.4 Across the Offshore Project Boundary, a significant proportion of the seabed is already characterised by hard substrate, particularly circalittoral rock biotopes such as A4.214 (Faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock), which dominate the Array Area and large portions of the OCAS (see **Chapter 11, Volume 2a** and discussion in Section 12.9.1.4). Therefore, much of the proposed infrastructure will be placed on habitat that is already structurally hard in nature, limiting the extent of ecological alteration.
- 12.9.6.5 Where hard infrastructure is placed on existing rocky or circalittoral habitats, the resulting ecological change is likely to be modest. Species composition may shift slightly, but overall biodiversity and habitat function may remain similar or even support increased abundance due to structural complexity (Andersson & Öhman, 2010). In contrast, isolated areas of soft sediment within the Cable Corridor may experience a greater degree of change, as colonisation by hard-bottom species replaces the original soft-bottom assemblages (Andersson *et al.*, 2009).
- 12.9.6.6 While the introduction of artificial structures may lead to colonisation by epifaunal invertebrates, which could alter local prey availability for some fish, these changes are expected to be minor. As detailed in **Chapter 11, Volume 2a**, benthic community responses to new hard substrate are anticipated to be spatially limited and Not Significant. Therefore, any indirect changes to fish via prey base alteration are expected to be minimal.
- 12.9.6.7 The change is predicted to be adverse, partially reversible and long term duration. However, considering the relatively small spatial extent of infrastructure introduced to the marine environment, the fact that most installations are located on areas already comprising hard substrate, and the limited ecological change expected in benthic communities and embedded mitigation measure M033 (LMP) (**Table 12-22**) the magnitude of effect from aggregation effects (including potential changes in predator-prey interactions) is assessed as **Low**.

Sensitivity or value of receptor

- 12.9.6.8 The sensitivity described for each receptor is based on the criteria provided in **Table 12-12**.

High value receptors

- 12.9.6.9 The majority of fish receptors are considered of low to medium value. Diadromous fish (Atlantic salmon, sea trout and European eel) and the common skate complex have been assigned a high value. This has been considered when determining the overall sensitivity of the receptors to fish aggregation effects during the O&M phase of the Offshore Project. The value and sensitivity is based upon the criteria detailed in Section 12.5.3 and **Chapter 5, Volume 1a**.

Marine Fish

- 12.9.6.10 In the context of the impacts of fish aggregation affects, it is useful to distinguish groups of marine fish receptors for assessment due to distinct ecological and physiological traits that influence their responses to this impact-pathway. These groups include species with nursery grounds within the

Offshore Project Boundary, demersal species, species vulnerable to predation and open water species. Sensitivity for these groups are discussed separately below.

Species with nursery grounds within the Offshore Project Boundary

12.9.6.11 The aggregation effect pathways described above act differently on different groups of marine fish. It is therefore helpful to consider the sensitivity different receptor groups according to the following:

- predominantly demersal and reef associated species that are attracted to the introduced structures;
- species that may experience increased predation comprising those with nursery grounds within the offshore project boundary and key forage species; and
- open water species that are less likely to be affected.

Demersal fish

12.9.6.12 Numerous studies have demonstrated attraction behaviour in hard-substrate-associated fish species to offshore wind farm infrastructure. For example, species such as Atlantic cod *Gadus morhua* and pouting *Trisopterus luscus* have shown strong site fidelity to WTG foundations and associated scour protection layers (Reubens *et al.*, 2013a). Similarly, species including black sea bass *Centropristis striata*, shorthorn sculpin *Myoxocephalus scorpius*, and goldsinny wrasse *Ctenolabrus rupestris* have also been recorded aggregating around such features (Carey *et al.*, 2020; Bergström *et al.*, 2013). At the Horns Rev and Lillgrund offshore wind farms, post-construction monitoring identified increases in reef-associated species such as goldsinny wrasse, lump sucker *Cyclopterus lumpus*, and eelpout *Zoarces viviparus* (Danish Energy Agency, 2013; Bergström *et al.*, 2013).

12.9.6.13 In addition, recent acoustic telemetry studies near operational wind farms off the Dutch coast have provided fine-scale movement data for Atlantic cod, confirming high site residency and fidelity to artificial reefs around the windfarm. Atlantic cod were frequently observed using the artificial reefs for shelter and protection (e.g., against high current speeds) (Berges *et al.*, 2024). It is important to note, however, that these findings were based on the addition of supplementary artificial structures (e.g. an assembly of hollow pipes combined with rock-based scour protection) beyond what would typically be implemented in standard offshore wind farm design. As such, the magnitude of fish aggregation effects observed in this study is likely to have been enhanced relative to what might be expected under more conventional project infrastructure.

12.9.6.14 In contrast to reef-associated species, sand-dwelling species generally exhibit lower affinity for artificial structures (Lindeboom *et al.*, 2011; Van Deurs *et al.*, 2012; Wilber *et al.*, 2018). However, a study by Buyse *et al.* (2022) documented some attraction of plaice *Pleuronectes platessa*, a soft-bottom species, to sandy patches located within the scour protection layer at a wind farm, suggesting that local habitat features can influence species-specific responses. Additionally, long-term monitoring (over 10 years) at a Belgian wind farm observed slight increases in the densities of

several soft-sediment species (e.g., common dragonet *Callionymus lyra*, solenette *Buglossidium luteum*, lesser weever *Echiichthys vipera*, and plaice) in areas between WTGs. These changes were hypothesised to represent early signs of potential refuge effects, possibly driven by a combination of reduced fishing pressure and enhanced food availability (Annelies *et al.*, 2021). It is important to note, however, that these findings occurred in areas where the original habitat was predominantly soft sediment and subsequently altered by the introduction of hard substrate. In contrast, baseline conditions in the Offshore Project already feature more pronounced hard substrate, with more limited areas of soft sediment (**Chapter 11, Volume 2a**).

- 12.9.6.15 Collectively, the available evidence indicates that the sensitivity of fish to potential aggregation effects is species- and habitat-specific. Reef-associated species, particularly those with strong site fidelity and shelter-seeking behaviour (e.g., Atlantic cod), are more likely to exhibit attraction responses to increased structural complexity. In contrast, sand-dwelling species typically display lower sensitivity to such changes, although context-dependent responses have been observed. The degree of structural modification relative to baseline habitat (e.g., hard vs. soft substrate) is also an important consideration in determining which species are likely to be affected. This consideration is discussed further under the magnitude section (Section 12.9.6.4). Given their low to medium importance and variable responses, demersal fish are considered of **Medium** sensitivity overall.

Species vulnerable to predation

- 12.9.6.16 Increased structural complexity and the resulting fish aggregation effects discussed above may alter predator-prey dynamics. Fish that aggregate around structures may attract higher trophic level species, including piscivorous fish and marine mammals. As discussed in Section 12.9.6.13, the attraction of predatory species such as Atlantic cod to wind farm structures is documented (Berges *et al.*, 2024; Winter *et al.*, 2010). Evidence also exists for the attraction of marine mammals to offshore wind farms for foraging. At the Egmond aan Zee Offshore Wind Farm (sic), increased presence of harbour porpoise during the operational phase was recorded, with higher detection rates within the wind farm than outside (Scheidat *et al.*, 2009). Similarly, telemetry data for grey seals *Halichoerus grypus* and harbour seals *Phoca vitulina* showed foraging behaviour associated with WTG foundations in both UK and Dutch waters (Russel *et al.*, 2014).
- 12.9.6.17 The body of evidence presented above highlights several mechanisms by which fish species may respond to artificial reef effects—most notably through attraction to WTG foundations, and subsequent changes in predator-prey dynamics. From a sensitivity perspective, while attraction to structures may represent a neutral or even beneficial outcome for some reef-associated species, the resulting predator-prey interactions are considered the more ecologically significant pathway for adverse impacts. For example, increased local densities of prey species may lead to greater foraging by predatory fish or marine mammals, potentially affecting early life stages and nursery functions. Accordingly, sensitivity rankings have been primarily informed by the potential for increased predation pressure, rather than attraction behaviours alone. This is discussed further in the following subsections.

- 12.9.6.18 In particular, species with nursery grounds within the Offshore Project Boundary, including Atlantic mackerel, blue whiting, anglerfish, European hake, haddock, ling, and whiting, are likely to be among the most exposed to increased predation pressure due to their use of the area during early, more vulnerable life stages. These species are considered to have medium recovery potential due to relatively high fecundity and broad spatial distribution of nursery grounds. Overall, these species of medium to low value with nursery grounds within the Offshore Project Boundary are considered to have medium tolerance and medium recoverability. Their sensitivity is therefore **Medium**.
- 12.9.6.19 Key prey species occurring within the Marine Fish Study Area, such as sandeel, whiting, Atlantic herring, and sprat, may also be subject to increased predation risk. These species exhibit high fecundity, short generation times, and large population sizes, supporting high recoverability even under increased predation pressure. Key prey species (including sandeel, whiting, Atlantic herring, Atlantic mackerel and sprat) of medium to low value are considered to have low tolerance, and high recoverability. Their sensitivity is therefore **Medium**.

Open water species

- 12.9.6.20 Other marine fish species without spawning or nursery habitat in the vicinity of the Offshore Project Boundary including ocean sunfish, Atlantic bluefin tuna and basking shark are considered less sensitive to this impact. There is no evidence for open ocean solitary species such as ocean sunfish or basking shark congregating around artificial structures, though predatory tuna may be attracted to congregations of prey species. The congregation of tuna around FADs is well documented (Phillips, 2025), with no evidence of any adverse effect of such congregations. These receptors are of low to high value and are considered to have high tolerance and low to moderate recoverability. Their sensitivity is therefore **Low**.

Diadromous species

Atlantic salmon

- 12.9.6.21 Diadromous fish species that may interact with the Offshore Project Boundary are expected to do so primarily during migratory movements to and from freshwater systems. Their presence within the Offshore Project Boundary is therefore expected to be transitory, associated with specific life stages such as the seaward migration of post-smolts, adult return migrations, or glass eel landfall. These species are generally not anticipated to make routine use of hard substrates introduced by wind farm infrastructure for shelter or residency. However, some species – such as sea trout – may exhibit limited foraging behaviour in coastal areas, which could increase their exposure to any changes in predator-prey dynamics associated with WTG foundations and scour protection. As such, the potential for predator aggregation around infrastructure is considered the primary mechanism of concern for aggregation effects on diadromous fish and is assessed further below for each diadromous species.
- 12.9.6.22 Atlantic salmon post-smolts are particularly vulnerable to predation during the early marine phase of their lifecycle. Several studies have identified Atlantic cod and saithe *Pollachius virens* as key

predators of post-smolts in estuarine and coastal waters. For example, Friedland *et al.* (2017) linked reduced post-smolt survival in the Baltic to changes in cod distribution and abundance. Similarly, field studies in Norwegian river systems reported post-smolt mortality rates from predation of up to 24.8%, primarily due to aggregations of Atlantic cod (Hvidsten and Mokkelgjerd, 1988). By contrast, no significant predation effects were reported in the Tana River in northeast Norway, despite the presence of predators. It was hypothesised that the high availability of alternative prey species (particularly lesser sandeel) may have reduced predation pressure on post-smolts (Svenning *et al.*, 2005). In addition to fish predators, marine mammals are known to prey on salmonid species. While post-smolts are most at risk during early marine migration, returning adult salmon may also be vulnerable to seal predation during coastal transit (Butler *et al.*, 2006).

- 12.9.6.23 Atlantic salmon have evolved under naturally high predation pressure during early life-stages. The species produces a large number of offspring relative to expected survival, a reproductive trait that buffers against high early mortality. This provides some compensatory capacity, contributing to resilience at the population level. However, predation on post-smolts during the early marine phase can be substantial and has been increasing in some regions (Doogan *et al.*, 2023). When combined with other pressures such as climate change, fisheries bycatch, and habitat degradation, and considering the depleted stocks of many salmon populations, additional mortality from increased predation may exceed the species' natural compensatory capacity (Thorstad *et al.*, 2012). As such, while the species demonstrates moderate tolerance to this impact, the ability to recover from potentially elevated predation is considered low.
- 12.9.6.24 Atlantic salmon are considered to be of high value, with medium tolerance due to the population's innate ability to withstand some loss of early life-stages and a relatively limited presence within areas where predation risk may be elevated (discussed further in paragraph 12.9.6.28). However, recoverability is considered low due to the depleted status of salmon populations and the potential for additional predation pressure to exceed natural compensatory mechanisms. Based on these attributes, sensitivity is assessed as **Medium**. However, considering the high conservation value of this species, and the proximity of the permanent infrastructure to known migratory routes – including those supporting the Langavat SAC population via Loch Roag/Ròg – the overall sensitivity to this impact is considered to be **High**.

Sea trout

- 12.9.6.25 Like Atlantic salmon, sea trout have evolved under naturally high predation pressure during the post-smolt stage. Their life-history strategy provides some capacity to buffer against natural levels of early marine mortality. This trait suggests a degree of tolerance to predation effects. However, as with Atlantic salmon, there is a risk that additional pressures, such as increased predation, could exceed the species' natural compensatory capacity (as discussed in Section 12.9.6.23). Overall, sea trout are considered to be of medium value. They are assessed as having medium tolerance due to some natural adaptation to high early-stage mortality, but low recoverability due to the potential

for additional pressures to exceed natural compensatory mechanisms. Sensitivity is therefore **Medium**.

European eel

- 12.9.6.26 At sea, European eels are preyed on by a wide range of marine species, including those that may aggregate around wind farm structures. This includes large piscivorous fish such as Atlantic bluefin tuna, and marine mammals (Battaglia *et al.*, 2013; Wahlberg *et al.*, 2014). Glass eels, a particularly vulnerable life stage due to their small size, are known to make landfall along the west coast of Scotland/*Alba* (Adams *et al.*, 2013; refer to Section 12.6). However, glass eels are thought to transit relatively rapidly through coastal waters as they move into estuaries. Adult silver eels adopt various behaviours migrating towards the Azores and the Sargasso Sea, but may travel at speeds between 12 and 50 km/day (Aarestrup *et al.*, 2010).
- 12.9.6.27 European eel is considered to have medium tolerance to changes in predator-prey dynamics that may arise from predator aggregation. However, due to the depleted status of the European eel population, the species recoverability is assessed as low, this combined with the high conservation value of this species, and the proximity of the Offshore Project to potentially key landfall site for glass eels, means their overall sensitivity to this impact is considered **High**.

Significance of effect

- 12.9.6.28 Fish aggregation effects is anticipated to take place during the O&M phase of the Offshore Project. Considering the embedded mitigation described in **Table 12-22**, the residual effects of fish aggregation effects on Fish Ecology receptors are summarised in **Table 12-45**.

Table 12-45 Significance of fish aggregation effects to Fish Ecology during the O&M phase

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
Marine Fish						
Species with nursery grounds within the Offshore Project Boundary (e.g. Atlantic mackerel, blue whiting, anglerfish, European hake, haddock, ling, and whiting)	Low	Medium	M033	Minor	Not Significant	Any aggregation effects and consequent changes in predator-prey dynamics will be spatially limited. Where hard infrastructure is placed on existing hard substrates, the resulting ecological change is likely to be modest. Isolated areas of soft sediment within the Offshore Project Boundary may experience a greater degree of change. Overall, the impact is adverse and permanent but is expected to remain spatially localised. Likely to be among the most exposed to increased predation pressure due to their use of the area during early, more vulnerable life stages
Key prey species, including sandeel, whiting, Atlantic herring, sprat	Low	Medium		Minor	Not Significant	May be subject to increased predation risk. These species exhibit high fecundity, short generation times, and large population sizes, supporting high recoverability even under increased predation pressure.
All other marine fish	Low	Low		Negligible	Not Significant	Less sensitive to impact. Open ocean solitary species are not known to congregate around artificial structures. Predators may be attracted to higher concentrations of prey species though there is no evidence of any adverse effect of congregation around marine structures.

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
Diadromous Fish						
Atlantic salmon	Low	High	M033	Minor	Not Significant	Both post-smolts and returning adults are rapid migrants through coastal waters, spending minimal time in nearshore environments. Tracking studies show that Atlantic salmon move quickly between river mouths and offshore feeding grounds, with limited evidence of foraging or prolonged residency in inshore areas (refer to Section 12.6). These behavioural patterns reduce the likelihood of sustained exposure to elevated predator densities potentially associated with offshore wind infrastructure.
Sea trout	Low	Medium		Minor	Not Significant	This species exhibits behavioural traits – such as nearshore residency and foraging within shallow coastal waters – that may increase its potential to interact with ecological changes around offshore wind farm infrastructure. Specifically, the presence of artificial hard substrate may enhance local prey availability (e.g., epifaunal invertebrates or small fish), which could attract sea trout and potentially bring them into closer proximity to predator aggregations. Despite these behavioural traits, sea trout are considered to have moderate sensitivity to changes in predator-prey dynamics, reflecting their broad distribution, ecological adaptability, and lack of

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
						evidence for population-level effects from similar pressures.
European eel	Low	High		Minor	Not Significant	The duration and frequency of European eel exposure to increased predation risk associated with wind farm infrastructure are influenced by the species' migratory behaviour and habitat use. Glass eels, although vulnerable, typically undertake brief migratory transits through coastal waters before entering estuaries and are not expected to remain within the Offshore Project Boundary for extended periods. Similarly, the transit of silver eels through the area is thought to be relatively quick.



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Further Environmental Mitigation and Residual Effect

- 12.9.6.29 No additional Fish Ecology mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond the embedded commitments outlined in **Table 12-22**) is Not Significant in EIA terms.

12.10 ASSESSMENT OF EFFECTS: DECOMMISSIONING

12.10.1 SHORT TERM SEABED HABITAT LOSS AND/OR DISTURBANCE DURING DECOMMISSIONING ACTIVITIES

- 12.10.1.1 Short term seabed habitat loss and/or disturbance of seabed habitats within the Offshore Project Boundary during the decommissioning phase will occur, including from the use of jack-up vessels, decommissioning of cables and WTGs and anchor placements associated with these activities. The maximum design scenario relating to short term seabed habitat loss and/or disturbance of seabed habitats during the decommissioning phase are presented in **Table 12-21**.
- 12.10.1.2 Such activities have the potential to affect identified fish receptors directly (e.g. removal or injury of individuals) and indirectly (e.g. loss of, or damage to important fish habitats, such as spawning grounds and/or reduction in prey species).

Magnitude of impact

- 12.10.1.3 Decommissioning activities within the Offshore Project Boundary may result in short term seabed habitat loss and disturbance. These activities include the use of jack-up vessels during foundation removal, removal of cables, and associated anchor placements. The magnitude of impact from decommissioning is predicted to be equivalent to or lower than that of the construction phase. This is because, unlike construction, seabed clearance is not expected to be required for foundation installation or along cable routes. Any seabed clearance during decommissioning is likely to be limited to the placement of jack-up vessel legs. Further discussion of these types of impacts and their associated magnitude is provided in Section 12.8.1.
- 12.10.1.4 Components of the Offshore Project may be left *in-situ* to avoid unnecessarily disturbing the seabed (i.e. where marine habitat has formed). This could include the WTG scour protection, all elements of the WTG foundations located *below* seabed level, and the Offshore Cables (including associated scour protection). The potential for infrastructure to remain *in-situ* will be confirmed through consultation on the Decommissioning Programme to ensure the most suitable approach is taken. At this stage it is unconfirmed which components (if any) would remain *in-situ*, however under the maximum design scenario for short term seabed habitat loss and/or disturbance during decommissioning it has been assumed that all infrastructure would be removed.
- 12.10.1.5 Overall, short term seabed habitat loss and/or disturbance during the decommissioning phase is adverse, the impact is expected to be of medium duration (maximum of 5 years) (although only a

small proportion of the total area will be affected at any one time with individual elements of decommissioning having much shorter durations), but intermittent. Short term seabed habitat loss and/or disturbance is predicted to be highly localised and naturally reversible. Considering the embedded Offshore Project mitigation measures detailed within **Table 12-22**, specifically M005 (best practice techniques for seabed excavations) and M020 (Decommissioning Plan) the magnitude of impact from short term seabed loss/disturbance during the decommissioning phase is predicted to be **Low**.

Sensitivity or value of receptor

12.10.1.6 The sensitivity described for each receptor is based on the criteria provided in **Table 12-12**.

High value receptors

12.10.1.7 The majority of fish receptors are considered of low to medium value. Diadromous fish (Atlantic salmon, sea trout and European eel) and the common skate complex have been assigned a high value. This has been considered when determining the overall sensitivity of the receptors to short term seabed habitat loss and/or disturbance during the decommissioning phase of the Offshore Project. The value and sensitivity is based upon the criteria detailed in Section 12.5.

Marine Fish

12.10.1.8 Sensitivity (tolerance and recoverability) of marine fish species to short term seabed habitat loss and/or disturbance has been assessed for seabed preparation, foundation installation, and the laying of cables for the construction phase in Section 12.8.1. As the impacts during the decommissioning phase are the same – namely, short term seabed habitat loss and/or disturbance – sensitivity is considered equivalent. No further discussion of species-specific sensitivity rankings is provided here. For clarity, sensitivity statements are repeated below.

Atlantic herring

12.10.1.9 Atlantic herring are considered to have low tolerance and medium recoverability and to be of medium value. Therefore, sensitivity is considered to be **Medium**.

Common skate complex and spotted ray

12.10.1.10 Overall, the common skate complex is considered of high value, medium tolerance and low recoverability. However, considering its high conservation value, declining population and identified nursery ground within the area affected by this impact, the sensitivity of the common skate complex is considered to be **High**. Spotted ray is considered to have lower conservation concern, a broader habitat range, and greater reproductive plasticity. It is therefore considered to have low tolerance, medium recoverability and to be of low value. Therefore, sensitivity is considered to be **Medium**.

Sandeel

- 12.10.1.11 Sandeel of medium value, are considered to have low tolerance and high recoverability to this impact. Therefore, sensitivity is considered to be **Medium**.

All other marine fish species (not discussed individually)

- 12.10.1.12 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 species is considered to be **Low**.

Diadromous Fish

Atlantic salmon, sea trout and European eel

- 12.10.1.13 As for marine fish, the sensitivity (tolerance and recoverability) of diadromous species to short term seabed habitat loss and/or disturbance has been assessed for seabed preparation, foundation installation, and the laying of cables for the construction phase in Section 12.8.1. As the impacts during the decommissioning phase are the same – namely, short term seabed habitat loss and/or disturbance – sensitivity is considered equivalent. No further discussion of species-specific sensitivity rankings is provided here. For clarity, sensitivity statements are repeated below.

- 12.10.1.14 Given their ability to avoid disturbed areas, opportunistic feeding behaviour, and the resilience of prey populations, diadromous fish species exhibit high tolerance to short term seabed 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**.

Significance of effect

- 12.10.1.15 Short term seabed habitat loss and/or disturbance is anticipated to take place during the decommissioning phase of the Offshore Project. Considering the embedded mitigation described in **Table 12-22**, the residual effects of short term seabed habitat loss and/or disturbance on Fish Ecology receptors are summarised in **Table 12-46**.

Table 12-46 Significance of effect of short term seabed habitat loss and/or disturbance to Fish Ecology during the decommissioning phase

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
Marine Fish						
Atlantic herring	Low	Medium	M005 M020	Minor	Not Significant	Atlantic herring are demersal spawners that may be affected by the short term seabed habitat loss and/or disturbance of local spawning substrates. Effects are, however considered spatially limited due to the restricted extent of suitable spawning substrate within the area affected by short term seabed habitat loss and/or disturbance, especially when considering the availability of suitable spawning grounds across the broader Marine Fish Study Area and wider region.
Common skate complex	Low	High		Minor	Not Significant	Common skate complex is considered to have high sensitivity, owing to its conservation importance and vulnerability to habitat disturbance. Though the species may utilise the affected area, suitable egg-laying habitats are limited to shallow nearshore waters (<20 m depth) which represent only a small proportion of the area subject to short term seabed loss and/or disturbance associated with decommissioning. As such, the potential impact on key reproductive habitat is limited. Disturbance is considered reversible, with natural recovery of egg-laying habitats and populations occurring post-activity.
Spotted ray	Low	Medium		Minor	Not Significant	Spotted ray has lower conservation concern, a broader habitat range, and greater reproductive plasticity. It is thus less sensitive to short term seabed habitat loss and/or disturbance.

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
Sandeel	Low	Medium		Minor	Not Significant	For sandeel, effects are spatially limited. Only a small proportion of suitable habitats will be affected, relative to available habitats across the wider Marine Fish Study Area.
All other marine fish species (not discussed individually)	Low	Low		Negligible	Not Significant	Due to their limited reliance on specific benthic habitats for key life stages, all other marine fish species are considered to have a lower likelihood of exposure to short term seabed habitat loss and/or disturbance.
Diadromous Fish						
Diadromous fish	Low	Low	M005 M020	Negligible	Not Significant	Diadromous species are highly mobile and therefore able to avoid disturbed areas. High tolerance and recoverability to short term seabed habitat loss and/or disturbance due to opportunistic feeding behaviour, and resilience of prey populations. Impacts are temporary and reversible.

Further Environmental Mitigation and Residual Effect

- 12.10.1.16 No additional Fish Ecology mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond the embedded commitments outlined in **Table 12-22**) is Not Significant in EIA terms.

12.10.2 INCREASES IN SUSPENDED SEDIMENT CONCENTRATION AND ASSOCIATED SEDIMENT DEPOSITION

- 12.10.2.1 Temporary increases in SSC and subsequent sediment deposition are predicted to occur during the decommissioning phase, from activities, such as cable removal. 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 avoidance, leading to temporary displacement from affected areas. Increased turbidity associated with SSC also has the potential to reduce foraging efficiency by impairing prey detection in visually hunting species. The maximum design scenario relating to increase in SSC and associated sediment deposition during the decommissioning phase are presented in **Table 12-21**.
- 12.10.2.2 The resettlement of suspended material (deposition) may result in the smothering of less-mobile species or vulnerable life stages (e.g., 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.

Magnitude of impact

- 12.10.2.3 Temporary increases in SSC and subsequent sediment deposition are predicted to occur during the decommissioning phase, from activities, such as removal of cables, and use of jack-up vessels. The magnitude of impact from decommissioning is predicted to be equivalent to or lower than that of the construction phase. This is because, unlike construction, seabed clearance is not expected to be required for foundation installation or along cable routes. Any seabed clearance during decommissioning is likely to be limited to the placement of jack-up vessel legs. Further discussion of these types of impacts and their associated magnitude is provided in Section 12.8.1.
- 12.10.2.4 Following the operation and maintenance phase, components of the Offshore Project may be left *in-situ* to avoid unnecessarily disturbing the seabed (i.e. where marine habitat has formed). This could include the WTG scour protection, all elements of the WTG foundations located below seabed level, and the Offshore Cables (including associated scour protection). The potential for infrastructure to remain *in-situ* will be confirmed through consultation on the Decommissioning Programme to ensure the most suitable approach is taken. At this stage it is unconfirmed which components (if any) would remain *in-situ*, however, under the maximum design scenario for increases in SSC and associated deposition during decommissioning it has been assumed that all infrastructure would be removed.

12.10.2.5 Overall, elevated SSC and subsequent deposition during the decommissioning phase, is expected to be of medium duration (maximum of 5 years) (although only a small proportion of the total area will be affected at any one time with individual elements of decommissioning having much shorter durations, typically ranging from several weeks to a few months), but intermittent. Elevated SSC and subsequent deposition are predicted to be highly localised and naturally reversible. Considering the embedded Offshore Project mitigation measures detailed within **Table 12-22**, specifically M005 (best practice techniques for seabed excavations) and M020 (Decommissioning Plan) the magnitude of impact from increases in SSC and associated deposition during the decommissioning phase is predicted to be **Low**.

Sensitivity or value of receptor

12.10.2.6 The sensitivity described for each receptor is based on the criteria provided in **Table 12-12**.

High value receptors

12.10.2.7 The majority of fish receptors are considered of low to medium value. Diadromous fish (Atlantic salmon, sea trout and European eel) and the common skate complex have been assigned a high value. This has been considered when determining the overall sensitivity of the receptors to increases in SSC and associated sediment deposition during the decommissioning phase of the Offshore Project. The value and sensitivity is based upon the criteria detailed in Section 12.5.

Marine Fish

12.10.2.8 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 Offshore Cables for the construction phase in Section 12.8.1. As the impacts during the decommissioning phase 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.

Species with nursery grounds (only) within the area affected by SSC and deposition

12.10.2.9 Atlantic mackerel, blue whiting, anglerfish, European hake, haddock, ling and whiting of medium to low value are considered to have low tolerance and high recoverability. Therefore, sensitivity of these species is considered to be **Medium**. Spurdog, of medium value, is considered to have low tolerance and medium recoverability. Therefore, sensitivity for this species is considered to be **Medium**.

Species with spawning grounds (only) within the area affected by SSC and deposition

12.10.2.10 European sprat are considered to have low tolerance and medium recoverability. Therefore, the overall sensitivity of these species to increases in SSC and deposition is considered to be **Medium**. The common skate complex and spotted ray of high to medium value, have low tolerance and low

recoverability. Based on these attributes, sensitivity to increases in SSC and deposition is assessed as **High**.

Species with spawning and nursery grounds, within the area affected by elevated SSC and deposition

12.10.2.11 Atlantic herring, Atlantic cod, lemon sole and Norway pout are considered to have medium tolerance and medium recoverability and are of low to medium value. Therefore, the overall sensitivity of these species to increases in SSC and deposition is considered to be **Medium**.

Sandeel

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

All other marine fish species (not discussed individually)

12.10.2.13 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

12.10.2.14 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 phase in Section 12.12. As the impacts during the O&M phase are the same (increases in SSC and subsequent deposition), the sensitivity of the receptors is considered equivalent.

Atlantic salmon, sea trout and European eel

12.10.2.15 Given their ability to avoid disturbed areas, opportunistic feeding behaviour, and the resilience of prey populations, diadromous fish species exhibit high tolerance to temporary increases in SSC and deposition. Furthermore, sensitive life-stages will not be exposed to elevated SSC from the Offshore Project. Whilst these species are of high value, their overall sensitivity to this pressure is considered **Low**.

Significance of effect

12.10.2.16 Increase in SSC and associated sediment deposition is anticipated to take place during the O&M phase of the Offshore Project. Considering the embedded mitigation described in **Table 12-22**, the residual effects of increase in SSC and associated sediment deposition on Fish Ecology receptors are summarised in **Table 12-47**.

Table 12-47 Significance of effect of increases in suspended sediment concentration and associated sediment deposition to Fish Ecology during the decommissioning phase

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
Marine Fish						
Species with nursery grounds (only)(within the area affected by SSC and sediment deposition						
Atlantic mackerel Blue whiting Anglerfish European hake Haddock Ling, Whiting Spurdog	Low	Medium	M005 M020	Minor	Not Significant	Considered to have some tolerance to elevated levels of SSC due to natural high SSC caused by winter storms and tidal currents. Species have broad distribution ranges and high fecundity and therefore high recoverability. Intermittent medium-term impact highly localised and naturally reversible through tidal processes.
Species with spawning grounds (only) within the area affected by SSC and sediment deposition						
European sprat	Low	Medium	M005 M020	Minor	Not Significant	Spawning grounds for this species are known to partially overlap with the Offshore Cable and Array Areas, but are widespread along the west coast of Scotland/Alba. Intermittent medium-term impact highly localised and naturally reversible through tidal processes.
Common skate complex	Low	High		Minor	Not Significant	Suitable egg-laying habitats for the common skate complex are spatially restricted within the area affected by temporary increases in SSC and subsequent deposition, being limited to shallow nearshore waters (<20 m depth; as discussed in Section 12.6.1.9).). As these areas constitute only a small proportion of the area affected by elevated SSC and associated deposition, the extent of potential impact on spawning habitats is very limited.

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
						Disturbance to egg-laying habitats is reversible, with the seabed expected to recover post-construction; any egg cases directly affected would represent a small, localised loss, and given the very limited spatial overlap with suitable habitat, population-level effects are not expected.
Spotted ray	Low	High		Minor	Not Significant	Limited data is available on egg-case distribution for this species, which is used to identify spawning grounds for oviparous species. However, where suitable habitat exists, spawning areas are expected to broadly overlap with nursery grounds (Ellis <i>et al.</i> , 2012). Spawning habitats, as identified in Plate 4-6b of Appendix 12.2, Volume 2c are very spatially restricted within the Marine Fish Study Area, and none lies within the Array Area or OCAS. Disturbance to egg-laying habitats is reversible, with the seabed expected to recover post-construction; any egg cases directly affected would represent a small, localised loss, and given the very limited spatial overlap with suitable habitat, population-level effects are not expected.
Species with spawning and nursery grounds within the area affected by SSC and sediment deposition						
Atlantic herring	Low	Medium	M005 M020	Minor	Not Significant	Substrate suitable for Atlantic herring spawning occurs only in the south west corner of the Array Area. Intermittent medium-term impact highly localised and naturally reversible through tidal processes.

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
Atlantic cod Lemon sole Norway pout	Low	Medium		Minor	Not Significant	Spawning grounds for these species are known to partially overlap with the Offshore Cable and Array Areas, but are widespread along the west coast of Scotland/ <i>Alba</i> . Intermittent medium-term impact highly localised and naturally reversible through tidal processes.
Sandeel						
Sandeel species	Low	Medium	M005 M020	Minor	Not Significant	Sandeel are relatively insensitive to light levels of deposition (≤ 5 cm). Most areas expected to experience less than 2 cm deposition from construction activities. Impacts are of limited spatial extent and short-term.
All other marine fish species (not discussed individually)						
All other marine fish species (not discussed individually)	Low	Low	M005 M020	Negligible	Not Significant	The majority of marine fish species are not particularly sensitive to temporary increases in SSC. Intermittent medium-term impact highly localised and naturally reversible through tidal processes.
Diadromous Fish						
Atlantic salmon Sea trout European eel	Low	Low	M005 M020	Negligible	Not Significant	Sensitive life-stages (egg and alevin stages) are not exposed to elevated SSC or deposition associated with offshore construction activities. Adult and juvenile counterparts interacting with the area impacted by elevated SSC and deposition are habituated to estuarine and nearshore coastal habitats where SSC are naturally elevated. Able to avoid areas of maximum disturbance.

Receptor	Magnitude	Sensitivity	Embedded mitigation measures	Effect	Significance	Commentary
						Intermittent medium-term impact highly localised and naturally reversible through tidal processes.

Further Environmental Mitigation and Residual Effect

- 12.10.2.17 No additional Fish Ecology mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond the embedded commitments outlined in **Table 12-22**) is Not Significant in EIA terms.

12.11 ASSESSMENT OF COMBINED EFFECTS

12.11.1 APPROACH

- 12.11.1.1 The combined effects assessment considers likely significant effects from multiple impacts and activities from the construction, O&M, and decommissioning phases of the Offshore Project on the same receptor, or group of receptors. The overall method following in identifying and assessing potential Combined Effects in relation to the offshore environment is set out in **Chapter 5, Volume 1a**.
- 12.11.1.2 Combined effects could potentially arise in one of two ways. The first type of combined effect is a Project lifetime effect, where multiple phases of the Project (construction, O&M, and decommissioning) interact to create a potentially more significant effect on a receptor than in one phase alone.
- 12.11.1.3 The second type of combined effect is receptor-led effects. Receptor-led effects are where effects from different environmental aspects combine spatially and temporally on a receptor. These effects may be short-term, temporary, transient, or longer-term.
- 12.11.1.4 Receptor-led effects have been considered, where relevant, in this chapter for potential interactions between Fish Ecology and the following environmental aspects:
- **Offshore EIAR Chapter 9: Physical and Coastal Processes, Volume 2a;**
 - **Offshore EIAR Chapter 10: Marine Sediment and Water Quality, Volume 2a;**
 - **Offshore EIAR Chapter 11: Benthic and Intertidal Ecology, Volume 2a.**
- 12.11.1.5 Full results of the Project lifetime effects and receptor-led effects assessment can be found in **Chapter 23, Volume 2a**.

12.12 CONSIDERATION OF ONSHORE TRANSMISSION WORKS PROJECT

- 12.12.1.1 A separate application for the Project's onshore elements (the OTW Project) that includes all infrastructure landwards of Mean Low Water Springs (MLWS) within the Onshore Transmission Works Boundary will be made, under the Town and Country Planning (Scotland) Act 1997 to Comhairle nan Eilean Siar (CnES). The OTW Project EIAR will provide a full description of the

onshore elements of the Project landward of MLWS, and include an assessment of the associated likely significant effects.

- 12.12.1.2 This EIAR has considered the additive interactions between the Offshore Project and OTW Project to understand if there is the potential for any change to the assessment outcomes as a result of both elements of the Project. The approach to identify and consider potential interactions between the Offshore Project and OTW Project is set out in **Chapter 5, Volume 1a** and key design parameters associated with the OTW Project are summarised in **Chapter 3, Volume 1a**.
- 12.12.1.3 The potential for effects identified in **Table 12-50** to interact with effects associated with the OTW Project on a common receptor has been considered. It has been assumed that there will be negligible impact to onshore rivers/water bodies due to the OTW Project following the incorporation of mitigation measures. For example, this could include the use of HDD techniques for installation of the Onshore Cable through a watercourse. Following consideration of the OTW Project and likely ZOI and influence on common receptors, there are no pathways that have the potential to effect Fish Ecology receptors. As a result of this, there is no impact pathway that could result in additional interactions to receptors considered within the Fish Ecology assessment and therefore this is not considered further.

12.13 ASSESSMENT OF CUMULATIVE EFFECTS

12.13.1 APPROACH

- 12.13.1.1 A cumulative effects assessment (CEA) examines the potential for impacts of the Offshore Project in addition with 'Other Developments' (including the OTW Project) on the same single receptor or resource and the contribution of the Offshore Project to those impacts. The overall method following in identifying and assessing potential cumulative effects in relation to the offshore environment is set out in **Chapter 5, Volume 1a**.
- 12.13.1.2 The offshore screening approach is based on the Planning Inspectorate's Advice Note Nine (Planning Inspectorate, 2018) and Advice Note Seventeen (Planning Inspectorate, 2024), with relevant components of the RenewableUK accepted guidance (RenewableUK, 2013), which includes aspects specific to the marine elements of an offshore wind farm, addressing the need to consider mobile wide-ranging species (foraging species, migratory routes etc).
- 12.13.1.3 The conclusions of the assessment of the Offshore Project and any additional effect arising from the OTW Project as identified in this chapter have been considered in this CEA. However, given the assumed mitigation and conclusion drawn within Section 12.12 there are no material additional impacts resulting from the OTW Project.

12.13.2 CUMULATIVE EFFECTS ASSESSMENT

- 12.13.2.1 For Fish Ecology, a Zone of Influence (ZOI) of 113 km has been applied to ensure direct and indirect cumulative effects can be appropriately identified and assessed. These include disturbance or injury resulting from underwater noise from percussive piling, short term seabed habitat loss and/or disturbance and increased SSC and associated deposition. The ZOI also accounts for fish mobility and their spawning / nursery grounds, along with capturing coastal waters to accommodate diadromous fish and their movements (as discussed in Section 12.4.2). This precautionary ZOI also ensures cumulative impacts associated with UWN originating from other projects in the vicinity are captured. The Fish Ecology ZOI is shown in **Figure 12-2, Volume 2c**.
- 12.13.2.2 A short list of Other Developments that may interact with the Project ZOIs during their construction, operation, or decommissioning is presented in **Appendix 5.3: Cumulative effects assessment shortlisted developments, Volume 1c**. This list has been generated applying criteria set out in **Chapter 5, Volume 1a** and has been collated up to the finalisation of the EIA through desk study, consultation, and engagement.
- 12.13.2.3 Only those Other Developments in the short list that fall within the Fish Ecology ZOI have the potential to result in cumulative effects with the Project. A screening exercise was undertaken, excluding developments that fall outside the Fish Ecology ZOI, that do not overlap temporally with the Offshore Project or where no physical pathway for impact has been identified. These developments have therefore been excluded from further assessment.
- 12.13.2.4 On the basis of the above, the Other Developments that are scoped into the Fish Ecology CEA are outlined in **Table 12-48**. It should be noted that Other Developments which are proposed or under construction at the time of writing this chapter, are included in the table below with the information available.

Table 12-48 Other Developments considered as part of the Fish Ecology CEA

ID	Development type	Application reference	Description of development	Status	Timescale ¹²	Confidence in assessments	Tier ¹³	Distance to the Array Area	Distance to the OCAS
1	Cable	ENG-029	Western Isles Connection Project - HVDC Link	In Planning - Application Submitted	Construction is anticipated to begin in 2028 and become operational in 2030.	Medium	1	31 km south east	23 km south east
2	Disposal	AGG-001	Stornoway Marine Disposal	Operational	Operational since 2020.	High	1	31 km south	23 km south
3	Offshore Wind Farm	OWF-024	Talisk Offshore Wind Project	In Planning - scoping report submitted	Construction is anticipated to begin in 2029, become operational in 2032 and decommissioned in 2077.	Medium	2	28 km north east	32 km north east
4	Offshore Wind Farm	OWF-026	Havbredey Offshore Wind Project	In Planning - scoping report submitted	Construction is anticipated to begin in 2030, become operational in 2035 and decommissioned in 2060.	Medium	2	55 km north east	55 km north east

¹² The Planning Inspectorate Advice Note 17 states 'Where other developments are expected to be completed before construction of the proposed Major Infrastructure Project and the effects of those projects are fully determined, effects arising from them should be considered as part of the baseline and may be considered as part of both the construction and operational assessment.'

¹³ Chapter 5 sets out the full definitions of the tiers. Tier 1: high level of certainty or information availability (including under construction or where a planning application has been approved or is awaiting decision). Tier 2: medium level of certainty or information (such as developments where a Scoping Report has been submitted). Tier 3: low level of certainty or information available (no planning applications submitted or identified for potential future development only).



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12.13.3 IMPACT PATHWAYS SCOPED INTO THE CUMULATIVE ASSESSMENT

12.13.3.1 Certain impacts that are scoped into the assessment alone are not considered in the cumulative assessment, due to the following reasons:

- highly localised nature of the impacts;
- unlikely to have an effect in the CEA due to mitigation measures put in place; and/or
- where the potential significance of the impact from the project alone has been assessed as negligible.

12.13.3.2 **Table 12-49** sets out the impacts that are not considered within the CEA, and the reasons for their exclusion.

Table 12-49 Impacts excluded from the CEA

Impact	Phase	Justification
Short term seabed habitat loss and/or disturbance	Construction, and Decommissioning	Any effects from short term seabed habitat loss and/or disturbance are expected to be short-term and highly localised. The potential for significant cumulative effects is minimal and therefore this impact is not considered within the CEA assessment.
Release of drilling muds during trenchless construction	Construction	Any increase in suspended sediment or change in water quality from release of drilling muds is expected to be highly localised, short-term and mitigated through the embedded mitigation described in Table 12-22 . The potential for significant cumulative effects is minimal and therefore this impact is not considered within the CEA assessment.
Fish aggregation effects	O&M	Any aggregation effects and consequent changes in predator-prey dynamics will be spatially limited. Where hard infrastructure is placed on existing hard substrates, the resulting ecological change is likely to be modest. The potential for significant cumulative effects is minimal and therefore this impact is not considered within the CEA assessment.
Underwater Noise and Vibration	O&M	Effects from disturbance from other operational noise is expected to be highly localised and is not predicted to have significant effects on fish. The potential for significant cumulative effects is minimal and therefore this impact is not considered within the CEA assessment.
EMF effects	O&M	The Offshore Project does not overlap with any other projects cable routes or is within a close enough distance to result in a

Impact	Phase	Justification
		cumulative effect. Therefore this impact is not considered within the CEA assessment.

12.13.3.3 However, certain impacts have the potential to affect the Fish Ecology over a larger area, and therefore have the potential to result in cumulative effects. For this reason, the following cumulative impacts on Fish Ecology receptors have been considered in the CEA:

- cumulative mortality, injury and behavioural changes resulting from UWN;
- cumulative temporary increases in SSC and deposition;
- cumulative long-term habitat loss/change from operation.

12.13.3.4 These impacts are discussed below and the full CEA is presented in **Table 12-50**.

Cumulative mortality, injury and behavioural changes resulting from UWN;

12.13.3.5 There is a potential for cumulative mortality, injury and behavioural changes resulting from UWN caused by noise generated during the construction phase of the Offshore Project and other nearby projects (see **Table 12-48**). An overlap in construction of these developments could lead to cumulative UWN impacts from percussive piling for foundations.

12.13.3.6 Although decommissioning activities may overlap with the Offshore Project's decommissioning phase, and the projects listed in **Table 12-37**, the timing and nature of these activities are uncertain. It is assumed that noise levels during decommissioning will be comparable to, or lower than, those experienced during construction, given that percussive piling is not required outside the construction phase. The only potential for cumulative impact would arise if the Offshore Project's decommissioning overlapped with the construction or decommissioning of another nearby project. On this basis, cumulative effects from UWN during decommissioning is scoped out.

Cumulative temporary increases in SSC and deposition.

12.13.3.7 There is a potential for cumulative temporary increases in SSC and deposition during the construction phase of the Offshore Project and other nearby projects (see **Table 12-48**). If construction activities within the transport distance of suspended sediments overlap temporally with either the construction or maintenance of the Offshore Project, there is potential for cumulative SSC and sediment deposition to occur within the plume footprints.

Cumulative long-term habitat loss/change from operation.

12.13.3.8 There is potential for cumulative long-term habitat loss/change as a result of the operational presence of the Offshore Project infrastructure interaction with other projects listed in **Table 12-48**.

12.13.3.9 The presence of infrastructure in the Offshore Project Boundary, including turbine foundations, OSP, scour protection and cable protection will cause long-term changes to the extent and distribution of benthic habitats. Similar impacts from other projects may cumulatively affect the

distribution and abundance of sensitive fish receptors that depend on the seabed for part of, or all of their life cycle, either directly or indirectly.

12.13.3.10 A description of the significance of cumulative effects upon Fish Ecology receptors arising from each identified impact is given below. The cumulative effects assessment has been based on information publicly available in the planning application documents for the Other Developments. It is noted that the maximum assessment assumptions quoted within these planning applications (EIARs / ESs) are often refined during the determination period and in the post-consent phase such that the final scheme's build out may have a reduced impact when compared to what has previously been assessed.

12.13.3.11 The full CEA for Fish Ecology is set out in **Table 12-50**.

Table 12-50 Cumulative effects assessment for Fish Ecology

ID	Development title	Application reference	Assessment discussion	Mitigation	Residual cumulative effect
1	Western Isles Connection Project - HVDC Link	ENG-029	<p>The Western Isles Connection Project is a major infrastructure initiative led by SSEN Transmission to connect the Isle of Lewis to the Scottish mainland via a High Voltage Direct Current (HVDC) link.</p> <p>Construction is anticipated to begin in 2028 and become operational in 2030, which will overlap with the Offshore Project's construction phase (anticipated from 2028 – 2033). This introduces potential cumulative impacts from simultaneous construction activities such as cumulative mortality, injury and behavioural changes resulting from UWN and temporary increases in SSC and deposition. The cable is located outside of the Offshore Project's Array and OCAS and is at a distance (24 km) beyond which cumulative impacts during construction (with the exception of underwater noise) are likely. During operation, there is the potential for cumulative habitat loss as both cables are proposing cable protection methods.</p> <p>Cumulative mortality, injury and behavioural changes resulting from UWN</p> <p>As there is overlap in the construction of the HVDC link and the Offshore Project, there is potential for a cumulative impact. Should construction work overlap temporarily, there is the likelihood that cumulative behavioural (TTS) impacts will be</p>	M003 M023	In consideration of the proposed embedded environmental measures listed, which for noise impacts minimise cumulative impacts, no residual significant adverse effect is anticipated on fish receptors.

ID	Development title	Application reference	Assessment discussion	Mitigation	Residual cumulative effect
			<p>experienced by mobile fish. These effects would be short-lived and recoverable in the short term, with mobile fish tending to move away from noise. Although only 24 km away, the Western Isles Connection Project is situated on the opposite side of the Isle of Lewis, and therefore there is no physical pathway of effect. Therefore, the cumulative effect of underwater noise is considered to be Not Significant.</p> <p>Cumulative long-term habitat loss from operation: The Western Isles Connection Project - HVDC Link has the potential to impact the same habitat types (including spawning and nursery grounds of similar species, for example, Atlantic herring and sandeel) as the Offshore Project. Though this impact represents a long-term loss of habitat, the extent is highly localised and represents a negligible proportion of the wider availability of habitats around the Offshore Project. The cable is also located on the other side of the Isle of Lewis, within deeper waters compared to the Offshore Project, so it is unlikely that both projects interact with the same habitat types or support the same species spawning or nursery grounds. Therefore, the cumulative effect of long-term habitat loss or disturbance is considered to be Not Significant.</p>		
2	Stornoway Marine Disposal	AGG-001	The Stornoway Marine Disposal Site is a designated dredge spoil deposit site located off the coast of Stornoway.	NA	No residual significant adverse effect is anticipated on fish receptors.

ID	Development title	Application reference	Assessment discussion	Mitigation	Residual cumulative effect
			<p>Cumulative impacts may arise during construction, O&M, and decommissioning with this disposal site due to the potential cumulative temporary increases in SSC and deposition.</p> <p>Cumulative temporary increases in SSC and deposition A cumulative impact may occur due to the potential overlap between sediment plumes or zones of re-deposition from the disposal site activities and the construction phase of the Offshore Project. Due to the location of the site however (located offshore of Stornoway on the other side of the island), its localised effects are unlikely to result in any significant cumulative impacts from increases in SSC and deposition. Therefore, the cumulative effect of SSC and deposition is considered to be Not Significant.</p>		
3	Talisk Offshore Wind Project	OWF-024	<p>The Talisk offshore wind project’s construction works (anticipated from 2028 – 2030) will overlap with the Offshore Project (anticipated from 2028 – 2033), and will also be operating simultaneously. Talisk offshore wind project scoped in the following impacts on fish receptors:</p> <ul style="list-style-type: none"> • Mortality, injury, behavioural impacts and auditory masking arising from noise and vibration. • Temporary increases in SSCs and deposition. • Direct and indirect seabed disturbance leading to release of sediment contaminants • Temporary habitat disturbance. 	M001 M002 M033 M031 M003 M038 M021 M023 M005 M004 M019	<p>In consideration of the proposed embedded environmental measures listed, no residual significant adverse effect is anticipated on fish receptors.</p>

ID	Development title	Application reference	Assessment discussion	Mitigation	Residual cumulative effect
			<ul style="list-style-type: none"> • Increased risk of introduction and/or spread of Invasive Non-Native Species (INNS). • Long-term habitat loss. • Colonisation of hard substrates. • Electromagnetic Field (EMF) effects arising from cables. <p>Cumulative mortality, injury and behavioural changes resulting from UWN</p> <p>Construction of the Talisk offshore wind project can lead to impacts to fish receptors from changes in underwater noise and vibration. Talisk offshore wind project is a tier 2 development and there is limited information regarding the potential impacts on fish receptors. Underwater noise has been included in the Scoping Report, however there are no details in the public domain to the extent of this impact. Consequently, it is not possible to undertake detailed assessments of the significance of effect. However, it is based on floating WTGs and therefore is likely to require less impulsive percussive piling during installation and likely has a limited scope to generate loud impulsive underwater noise. Should anchor piling at Talisk occur at the same time as construction of the Offshore Project, there is the possibility that cumulative behavioural (TTS) impacts will be experienced by mobile fish. Furthermore, it is not in close proximity to the entrance of waters important to diadromous species. The general mobility of marine fish and their ability to flee an ensonified area (particularly given soft start procedures)</p>		

ID	Development title	Application reference	Assessment discussion	Mitigation	Residual cumulative effect
			<p>means that the effect is likely to be Not Significant. Therefore, the cumulative effect of underwater noise is considered to be Not Significant.</p> <p>Cumulative temporary increases in SSC and deposition The Talisk offshore wind project includes similar infrastructure as the Offshore Project's therefore the construction activities that could lead to increases in SSC and deposition are likely to be the similar (and potentially occur simultaneously given the construction programme overlap). The Talisk offshore wind project is located outside of the Offshore Project's Array Area and OCAS and is at a distance (40 km) beyond which cumulative impacts from SSC and deposition are likely. Therefore the cumulative effect of increased SSC and deposition is considered to be Not Significant.</p> <p>Cumulative long-term habitat loss from operation As the operational phases of the Talisk offshore wind farm and the Offshore Project will overlap, there is potential for cumulative long-term habitat loss from operation. The Talisk offshore wind farm has the potential to impact some of the same habitat types (including spawning and nursery grounds of similar species, for example, Atlantic herring and sandeel) as the Offshore Project. However, Talisk is situated within deeper waters compared to the Offshore Project, so it is unlikely that both projects will interact with entirely the same habitat types or</p>		

ID	Development title	Application reference	Assessment discussion	Mitigation	Residual cumulative effect
			<p>support the same species spawning or nursery grounds. Though this impact represents a long-term loss of habitat, the extent is highly localised and represents a negligible proportion of the wider availability of habitats around the Offshore Project. The proportions of habitat with the potential to be impact by the current Offshore Project is also considered to be a small amount and has been assessed as Not Significant for all fish receptor groups. Therefore, the cumulative effect of long-term habitat loss or disturbance is considered to be Not Significant.</p>		
4	Havbredey Offshore Wind Project	OWF-026	<p>The Havbredey offshore wind project’s construction works (anticipated from 2030 - 2035) will overlap with the Offshore Project (anticipated from 2028 – 2033), and also be operating simultaneously. Havbredey offshore wind project scoped in the following impacts on fish receptors:</p> <ul style="list-style-type: none"> • Temporary seabed habitat loss and/or disturbance • Increases in SSC • Reduction in water quality due to the release of contaminants from seabed sediment disturbance • Underwater noise and vibration • Accidental release of contaminants through sediment disturbance • Permanent seabed habitat loss/disturbance • EMF effects and heat emissions from subsea electrical cables 	<p>M001 M002 M033 M003 M038 M021 M023 M005 M004 M019 M031</p>	<p>In consideration of the proposed embedded environmental measures listed, no residual significant adverse effect is anticipated on fish receptors.</p>

ID	Development title	Application reference	Assessment discussion	Mitigation	Residual cumulative effect
			<ul style="list-style-type: none"> • Fish and shellfish aggregation effects due to the presence of infrastructure in the water column and on the seabed • Ghost fishing due to the presence of lost fishing gear entangled/snagged by infrastructure causing secondary entanglement <p>Cumulative mortality, injury and behavioural changes resulting from UWN</p> <p>Havbredy offshore wind project is a tier 2 development and there is limited information regarding the potential impacts on fish receptors. Underwater noise has been included in the Scoping Report, however there are no details in the public domain to the extent of this impact. Consequently, it is not possible to undertake detailed assessments of the significance of effect. However, it is based on floating WTGs and therefore is likely to require less impulsive percussive piling during installation and likely has a limited scope to generate loud impulsive underwater noise. Should anchor piling occur at the same time as construction of the Offshore Project, there is the possibility that cumulative behavioural (TTS) impacts will be experienced by mobile fish. Mobility of marine fish and their ability to flee an ensonified area (particularly given soft start procedures) means that the effect is likely to be Not Significant. Therefore, the cumulative effect of underwater noise is considered to be Not Significant.</p>		

ID	Development title	Application reference	Assessment discussion	Mitigation	Residual cumulative effect
			<p>Cumulative temporary increases in SSC and deposition The Havbredey offshore wind farm includes similar infrastructure as the Offshore Project's therefore the activities that can lead to increases in SSC and deposition are likely to be similar (and potentially occur simultaneously given the construction programme overlap). The Havbredey offshore wind farm project is located outside the Offshore Project's Array Area and OCAS and is at a distance (66 km) beyond which cumulative activities are likely to result in significant impacts. Therefore, the cumulative effect of increased SSC and deposition is considered to be Not Significant.</p> <p>Cumulative long-term habitat loss from operation The Havbredey offshore wind farm has the potential to impact some of the same habitat types (including spawning and nursery grounds of similar species, for example, Atlantic herring and sandeel) as the Offshore Project. However, Havbredey is situated within deeper waters compared to the Offshore Project, so it is unlikely that both projects will interact with entirely the same habitat types or support the same species spawning or nursery grounds. Though this impact represents a long-term loss of habitat, the extent is highly localised and represents a negligible proportion of the wider availability of habitats around the Offshore Project. The proportions of habitat with the potential to be impacted by the current Offshore Project is also considered to</p>		

ID	Development title	Application reference	Assessment discussion	Mitigation	Residual cumulative effect
			<p>be a small amount and has been assessed as Not Significant for all fish receptor groups. Therefore, the cumulative effect of long-term habitat loss or disturbance is considered to be Not Significant.</p>		



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12.14 TRANSBOUNDARY EFFECTS

12.14.1.1 Transboundary effects occur when a development in one European Economic Area (EEA) State impacts the environment of another EEA State(s). A screening of potential transboundary effects was undertaken within the Scoping Report. Taking onboard feedback received from stakeholders (**Table 12-2**), the Fish Ecology assessment includes consideration of potential transboundary impacts on migratory fish. The migratory fish considered include marine and diadromous fish. The closest European Economic Zones to the Offshore Project are Ireland (256.9 km south) and Norway (469.8 km east).

Marine Fish

Basking shark

12.14.1.2 Basking sharks have a global distribution and are the largest cartilaginous fish present in Scottish waters (Dolton *et al.*, 2020). Basking sharks are present in UK coastal waters primarily in the summer months, between May and October. In the Sea of the Hebrides MPA, peak sightings occur between the months of June and October (Witt *et al.*, 2012). During the winter months, basking sharks typically move further offshore to deeper shelf waters (HWDT, 2018; Johnston *et al.*, 2019; Sims *et al.*, 2022). Their distribution is linked to oceanographic features such as thermal fronts and productive chlorophyll patches which aggregate their plankton prey. The coastal waters of Ireland and the UK have been identified as a North Atlantic hotspot, with individuals frequently observed in coastal Hebridean waters (HWDT, 2018). Therefore, there is the potential for transboundary effects on basking shark into other EEAs (Ireland).

Ocean sunfish

12.14.1.3 Ocean sunfish have been recorded in low numbers off Scottish and Irish coasts, the south and west coasts of England, and into the Baltic Sea (Bleach, 2002; Hinrichsen *et al.*, 2022). While their frequency in northern climates appears to be increasing, they are not frequent visitors to UK waters and occur seasonally in low numbers, due to winter temperatures falling below their thermal tolerance (Rogan and Mackey, 2007). Range expansion of ocean sunfish has been suggested based on an increase in sightings in Irish waters (Lyashevskaya *et al.*, 2022). Therefore, there is the potential for transboundary effects on Ocean sunfish into other EEAs (Ireland).

Bluefin tuna

12.14.1.4 Bluefin tuna have increasingly been observed off the west coast of Scotland/*Alba*. They are relatively rare but there has been an increase in sightings in the Hebrides/*Innse Gall* over the last 5 years and some very large fish have been landed commercially west of Harris/*Na Hearadh*¹⁴. There are suggestions that their seasonal abundance in Scottish waters is increasing due to a

¹⁴ *Harris skipper's 353kg bluefin highlights Scottish tuna potential* - Fishing News. October 2025

combination of stock recovery and increasing sea temperature. Tuna are endothermic and it is possible that temperature has less of a restricting effect on their range than on species such as ocean sunfish. This is supported by that fact that in the first half of the 20th century there was an active recreational fishery for bluefin in the Irish Sea. Therefore, there is the potential for transboundary effects on bluefin tuna into other EEAs (Ireland).

Diadromous Fish

Atlantic salmon

- 12.14.1.5 A recent large-scale tracking study found that Atlantic salmon post-smolts from rivers in Scotland, England, Northern Ireland, and Ireland generally migrate northwards (Rodger *et al.*, 2024). Many move through the Irish Sea, while others from Ireland's west coast move northwards past the Hebrides, indicating a broadly northerly migration route for these fish (see **Appendix 12.1: Fish Ecology Baseline, Volume 1c**). Tracking and netting studies indicate that most salmon post-smolts from rivers around Loch Linnhe and Mull migrate westwards, avoiding the Minch, and instead use the continental shelf edge west of the UK and Ireland as their main migration route to feeding grounds in the Norwegian Sea.
- 12.14.1.6 Although most post-smolts from rivers in mainland Scotland, the wider UK, and Ireland are unlikely to pass through the Offshore Project Boundary, there is notable variability in migration routes. Some uncertainty remains due to the larger number of rivers supporting Atlantic salmon than those previously studied. Post-smolts from rivers draining to the west of the Isle of Lewis/Eilean Leòdhais are most likely to transit near or through the Offshore Project Boundary. It is thought that they move rapidly towards the European continental shelf, as an evolutionary adaptation to minimise predation, but some may linger in the area before continuing their migration northwards. The following section provides details on these rivers and their population trends (see **Appendix 12.1: Fish Ecology Baseline, Volume 1c**). Therefore, there is the potential for transboundary effects on Atlantic salmon into other EEAs (Ireland, Norway).

Sea trout

- 12.14.1.7 Sea trout are likely to pass through or use habitats within the Offshore Project Boundary due to its proximity to estuarine environments. These fish typically remain close to shore and estuaries, with post-smolts migrating to sea lochs and nearshore areas in spring and early summer. Adults may travel further but generally stay within 80 km of their natal rivers. Population assessments show the highest numbers in the Caslabhat and Tamanabhaigh area, followed by the Langavat SAC/River Grimersta (see **Appendix 12.1: Fish Ecology Baseline, Volume 1c**). As adults generally stay within 80 km of their natal rivers, it is unlikely that there will be any potential transboundary effects due to the distance from the nearest EEA state and so are not considered further.

European eel

- 12.14.1.8 European eel undertake long distance migrations with adults moving out of European rivers in the autumn to cross the Atlantic to spawn in the Sargasso Sea (Miller *et al.*, 2019).
- 12.14.1.9 Very little is known about the migration route of adult European eels traveling to spawning grounds from the west coast of Scotland/*Alba*. 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). Considering the migration route taken by the Scandinavian populations and Irish populations (see **Appendix 12.1: Fish Ecology Baseline, Volume 1c**), eel populations along the west coast of Scotland/*Alba*, including the Hebrides/*Innse Gall*, may head directly west or southwest towards the Azores (Righton *et al.*, 2016).
- 12.14.1.10 Juvenile eel return to their natal rivers in autumn. Western Scotland/*Alba* is likely to be a key region of first landfall for a proportion of inward migrating juvenile eels.
- 12.14.1.11 Given the variability in migratory patterns exhibited by European eels it is considered likely that European eels may pass through the Offshore Project Boundary during migration, both as adults and as juveniles (see **Appendix 12.1: Fish Ecology Baseline, Volume 1c**). Therefore, there is the potential for transboundary effects on European eels into other EEAs (Ireland, Norway).
- 12.14.1.12 The potential transboundary impacts screened into the assessment for fish ecology were:
- direct effects as a result of underwater noise exposure to fish during construction;
 - indirect effects may occur in relation to spawning and nursery grounds arising from habitat disturbance / loss during all project phases.
- 12.14.1.13 Underwater noise levels expected to elicit behavioural responses in certain migratory fish are predicted to extend to several tens of kilometres beyond the Offshore Project Boundary and therefore have the potential to affect fish that migrate to another EEA state during the construction phase. These impacts were predicted to be short term and intermittent, with recovery of fish populations to affected areas following completion of all percussive piling activities during construction. Following the implementation of mitigation (including sequencing of percussive piling to avoid sensitive migratory period) the significance of effect for potential injury/mortality effects and TTS has been assessed as **Negligible to Minor (Not Significant)** for both marine and diadromous fish receptors.
- 12.14.1.14 Effects of habitat disturbance/loss are predicted to be limited in extent to within a number of kilometres of the Offshore Project and are therefore not predicted to extend into the waters of other EEA states. However, there is potential for impacts to fish receptors that migrate to other EEA states. The assessment on habitat disturbance/loss throughout the project lifecycle has been assessed as **Negligible to Minor (Not Significant)** for both marine and diadromous fish receptors.

12.14.1.15 Overall, the Offshore Project is a significant distance from the nearest EEA states, and due to the relatively limited scale of effects and/or temporary nature of the impacts on migratory fish which would not result in effects occurring in other countries.

12.15 SUMMARY OF RESIDUAL EFFECTS

12.15.1.1 **Table 12-51** presents a summary of the assessment of significant impacts, any relevant mitigation measures, and residual effects on Fish Ecology receptors.

Table 12-51 Summary of residual effects

Activity and impact	Receptor	Magnitude of impact	Receptor sensitivity or value	Embedded mitigation measures	Significance of effect (significance)	Further environmental mitigation	Significance of residual effect (significance)
Construction							
Short term habitat loss and/or disturbance	Marine Fish						
	Atlantic herring	Low	Medium	M001 M019	Minor (Not Significant)	N/A	Minor (Not Significant)
	Common skate complex	Low	High	M023	Minor (Not Significant)	N/A	Minor (Not Significant)
	Sandeel	Low	Medium		Minor (Not Significant)	N/A	Minor (Not Significant)
	Atlantic cod	Low	Medium		Minor (Not Significant)	N/A	Minor (Not Significant)
	All other marine fish species (not discussed individually)	Low	Low		Negligible (Not Significant)	N/A	Negligible (Not Significant)
	Diadromous Fish						
Atlantic salmon, sea trout, European eel	Low	Low	M001 M023 M019	Negligible (Not Significant)	N/A	Negligible (Not Significant)	
Increases in SSC and associated sediment deposition	Marine Fish						
	Species with nursery grounds within the area affected by SSC and sediment deposition (Atlantic mackerel, Blue whiting, Anglerfish, European hake, Haddock, Ling, Whiting, Spurdog)	Low	Medium	M001 M002 M005 M023	Minor (Not Significant)	N/A	Minor (Not Significant)
	Species with spawning grounds (only) within the area affected by SSC and sediment deposition (European sprat)	Low	Medium		Minor (Not Significant)	N/A	Minor (Not Significant)
	Species with spawning grounds (only) within the area affected by SSC and sediment deposition (Common skate and spotted ray)	Low	High		Minor (Not Significant)	N/A	Minor (Not Significant)
	Species with spawning and nursery grounds within the area affected by SSC and sediment deposition (Atlantic herring, Atlantic cod, lemon sole, Norway pout)	Low	Medium		Minor (Not Significant)	N/A	Minor (Not Significant)
	Sandeel	Low	Medium	M001 M002	Minor (Not Significant)	N/A	Minor (Not Significant)
	All other marine fish species (not discussed individually)	Low	Low	M005 M023	Negligible (Not Significant)	N/A	Negligible (Not Significant)
Diadromous Fish							
Atlantic salmon Sea trout European eel	Low	Low	M001 M002 M005 M023	Negligible (Not Significant)	N/A	Negligible (Not Significant)	
Mortality (including potential mortal injury) and recoverable injury							

Activity and impact	Receptor	Magnitude of impact	Receptor sensitivity or value	Embedded mitigation measures	Significance of effect (significance)	Further environmental mitigation	Significance of residual effect (significance)
Underwater noise and vibration (impulsive)	Marine fish						
	Hearing group 1 & 2 (excluding sandeel)	Low	Low	M003 M023	Negligible (Not Significant)	N/A	Negligible (Not Significant)
	Hearing group 1 & 2 (sandeel)	Low	Medium		Minor (Not Significant)	N/A	Minor (Not Significant)
	Hearing group 3 & 4	Low	Medium		Minor (Not Significant)	N/A	Minor (Not Significant)
	Hearing group 5	Low	Low		Negligible (Not Significant)	N/A	Negligible (Not Significant)
	Diadromous species						
	Atlantic salmon (hearing group 2)	Low	Medium	M003 M023	Minor (Not Significant)	N/A	Minor (Not Significant)
	Sea trout (hearing group 2)	Low	Low		Negligible (Not Significant)	N/A	Negligible (Not Significant)
	European eel (hearing group 3)	Low	Medium		Minor (Not Significant)	N/A	Minor (Not Significant)
	TSS						
	Marine Fish						
	Hearing group 1 & 2 (excluding sandeel)	Low	Low	M003 M023	Negligible (Not Significant)	N/A	Negligible (Not Significant)
	Hearing group 1 & 2 (sandeel)	Low	Medium		Minor (Not Significant)	N/A	Minor (Not Significant)
	Hearing group 3 & 4	Low	Medium		Minor (Not Significant)	N/A	Minor (Not Significant)
	Diadromous species						
	Atlantic salmon (hearing group 2)	Medium	Medium	M003 M023	Moderate (Potentially Significant)	A006	Minor (Not Significant)
	Sea trout (hearing group 2)	Medium	Low		Minor (Not Significant)	N/A	Minor (Not Significant)
	European eel (hearing group 3)	Medium	Medium		Moderate (Not Significant)	N/A	Moderate (Not Significant)
	Masking and behavioural effects						
	Marine Fish						
Hearing group 1 and 2 (excluding sandeel)	Low	Low	M003 M023	Negligible (Not Significant)	N/A	Negligible (Not Significant)	
Hearing group 1 and 2 (sandeel)	Low	Medium		Minor (Not Significant)	N/A	Minor (Not Significant)	
Hearing group 3 & 4 species	Low	Medium		Minor (Not Significant)	N/A	Minor (Not Significant)	
Hearing group 5	Low	Low		Negligible (Not Significant)	N/A	Negligible (Not Significant)	

Activity and impact	Receptor	Magnitude of impact	Receptor sensitivity or value	Embedded mitigation measures	Significance of effect (significance)	Further environmental mitigation	Significance of residual effect (significance)
	Diadromous species						
	Atlantic salmon (hearing group 2)	Low	Medium	M003 M023	Minor (Not Significant)	N/A	Minor (Not Significant)
	Sea trout (hearing group 2)	Low	Low		Negligible (Not Significant)	N/A	Negligible (Not Significant)
	European eel (hearing group 3)	Low	Medium		Negligible (Not Significant)	N/A	Negligible (Not Significant)
Release Of Drilling Fluids During Trenchless Construction and Construction of HDD Exit Pits	Marine Fish						
	Species with nursery grounds (only) within the area affected by SSC and sediment deposition						
	Atlantic mackerel; Blue whiting; Anglerfish; European hake; Haddock; Ling; Whiting; Spurdog	Low	Medium	M001 M002 M005	Minor (Not Significant)	N/A	Minor (Not Significant)
	Species with spawning grounds (only) within the area affected by SSC and sediment deposition						
	European sprat	Low	Medium	M001 M002	Minor (Not Significant)	N/A	Minor (Not Significant)
	Common skate complex	Low	High	M005	Minor (Not Significant)	N/A	Minor (Not Significant)
	Spotted ray	Low	High		Minor (Not Significant)	N/A	Minor (Not Significant)
	Species with spawning and nursery grounds within the area affected by SSC and sediment deposition						
	Atlantic herring	Low	Medium	M001 M002	Minor (Not Significant)	N/A	Minor (Not Significant)
	Atlantic cod Lemon sole Norway pout	Low	Medium	M005	Minor (Not Significant)	N/A	Minor (Not Significant)
	Sandeel						
	Sandeel species	Low	Medium	M001 M002 M005	Minor (Not Significant)	N/A	Minor (Not Significant)
	All other marine fish species (not discussed individually)						
	All other marine fish species (not discussed individually)	Low	Low	M001 M002 M005	Negligible (Not Significant)	N/A	Negligible (Not Significant)
Diadromous Fish							
Atlantic salmon Sea trout European eel	Low	Low	M001 M002 M005	Negligible (Not Significant)	N/A	Negligible (Not Significant)	
	Marine fish						

Activity and impact	Receptor	Magnitude of impact	Receptor sensitivity or value	Embedded mitigation measures	Significance of effect (significance)	Further environmental mitigation	Significance of residual effect (significance)	
Underwater noise and vibration (continuous)	Group 1 and 2 (excluding sandeel)	Negligible	Low	M023	Negligible (Not Significant)	N/A	Negligible (Not Significant)	
	Group 1 and 2 (sandeel)	Negligible	Medium		Negligible (Not Significant)	N/A	Negligible (Not Significant)	
	Group 3 & 4	Negligible	Medium		Negligible (Not Significant)	N/A	Negligible (Not Significant)	
	Group 5 (eggs and larvae)	Negligible	Low		Negligible (Not Significant)	N/A	Negligible (Not Significant)	
	Diadromous fish							
	Atlantic salmon (hearing group 2)	Negligible	Medium	M023	Negligible (Not Significant)	N/A	Negligible (Not Significant)	
	Sea trout (hearing group 2)	Negligible	Low		Negligible (Not Significant)	N/A	Negligible (Not Significant)	
Group 3 – European eel	Negligible	Medium	Negligible (Not Significant)		N/A	Negligible (Not Significant)		
Operation and maintenance								
Long term seabed habitat loss/change	Marine fish							
	Atlantic herring	Low	Medium	M001	Minor (Not Significant)	N/A	Minor (Not Significant)	
	Common skate complex	Low	High		Minor (Not Significant)	N/A	Minor (Not Significant)	
	Spotted ray	Low	Medium		Minor (Not Significant)	N/A	Minor (Not Significant)	
	Sandeel	Low	High		Minor (Not Significant)	N/A	Minor (Not Significant)	
	All other marine fish species (not discussed individually)All other marine fish receptors	Low	Low		Negligible (Not Significant)	N/A	Negligible (Not Significant)	
	Diadromous Fish							
Atlantic salmon Sea trout European eel	Low	Medium	M001	Minor (Not Significant)	N/A	Minor (Not Significant)		
Short term seabed habitat loss/change	Marine fish							
	Atlantic herring	Low	Medium	M001 M005	Minor (Not Significant)	N/A	Minor (Not Significant)	
	Common skate complex	Low	High		Minor (Not Significant)	N/A	Minor (Not Significant)	
	Spotted ray	Low	Medium		Minor (Not Significant)	N/A	Minor (Not Significant)	
Sandeel	Low	Medium	Minor (Not Significant)		N/A	Minor (Not Significant)		

Activity and impact	Receptor	Magnitude of impact	Receptor sensitivity or value	Embedded mitigation measures	Significance of effect (significance)	Further environmental mitigation	Significance of residual effect (significance)
	All other marine fish species (not discussed individually)All other marine fish receptors	Low	Low		Negligible (Not Significant)	N/A	Negligible (Not Significant)
	Diadromous Fish						
	Atlantic salmon Sea trout European eel	Low	Low	M001 M005	Negligible (Not Significant)	N/A	Negligible (Not Significant)
Increases in suspended sediment concentrations and associated sediment deposition	Marine fish						
	Species with nursery grounds (only) within the area affected by SSC and sediment deposition						
	Atlantic mackerel Blue whiting Anglerfish European hake Haddock Ling, Whiting Spurdog	Low	Medium	M005	Minor (Not Significant)	N/A	Minor (Not Significant)
	Species with spawning grounds (only) within the area affected by SSC and sediment deposition						
	European sprat	Low	Medium	M005	Minor (Not Significant)	N/A	Minor (Not Significant)
	Common skate complex Spotted ray	Low	High		Minor (Not Significant)	N/A	Minor (Not Significant)
	Species with spawning and nursery grounds within the area affected by SSC and sediment deposition						
	Atlantic herring Atlantic cod Lemon sole Norway pout	Low	Medium	M005	Minor (Not Significant)	N/A	Minor (Not Significant)
	Sandeel						
	Sandeel species	Low	Medium	M005	Minor (Not Significant)	N/A	Minor (Not Significant)
	All other marine fish species (not discussed individually)						
	All other marine fish species (not discussed individually)	Low	Low	M005	Negligible (Not Significant)	N/A	Negligible (Not Significant)
	Diadromous Fish						
Atlantic salmon Sea trout European eel	Low	Low	M005	Negligible (Not Significant)	N/A	Negligible (Not Significant)	
Underwater noise and vibration	Marine Fish						
	Hearing group 1 and 2 (excluding sandeel)	Negligible	Low	N/A	Negligible (Not Significant)	N/A	Negligible (Not Significant)
	Hearing group 1 and 2 (sandeel)	Negligible	Medium		Negligible (Not Significant)	N/A	Negligible (Not Significant)

Activity and impact	Receptor	Magnitude of impact	Receptor sensitivity or value	Embedded mitigation measures	Significance of effect (significance)	Further environmental mitigation	Significance of residual effect (significance)	
	Hearing group 3 & 4	Negligible	Medium		Negligible (Not Significant)	N/A	Negligible (Not Significant)	
	Hearing group 5	Negligible	Low		Negligible (Not Significant)	N/A	Negligible (Not Significant)	
	Diadromous Fish							
	Atlantic salmon (hearing group 2)	Negligible	Medium	N/A	Negligible (Not Significant)	N/A	Negligible (Not Significant)	
	Sea trout (hearing group 2)	Negligible	Low		Negligible (Not Significant)	N/A	Negligible (Not Significant)	
	European eel (hearing group 3)	Negligible	Medium		Negligible (Not Significant)	N/A	Negligible (Not Significant)	
Electromagnetic Fields	Marine Fish							
	Elasmobranchs	Low	Medium	M002	Minor (Not Significant)	N/A	Minor (Not Significant)	
	All other marine fish species (not discussed individually)	Low	Low		Negligible (Not Significant)	N/A	Negligible (Not Significant)	
	Diadromous Fish							
	Atlantic salmon Sea trout	Low	Medium	M002	Minor (Not Significant)	N/A	Minor (Not Significant)	
	European eel	Low	Medium		Minor (Not Significant)	N/A	Minor (Not Significant)	
Fish aggregation effects	Marine Fish							
	Species with nursery grounds within the Offshore Project Boundary	Low	Medium	M033	Minor (Not Significant)	N/A	Minor (Not Significant)	
	Key prey species	Low	Medium		Minor (Not Significant)	N/A	Minor (Not Significant)	
	All other marine fish	Low	Low		Negligible (Not Significant)	N/A	Negligible (Not Significant)	
	Diadromous Fish							
	Atlantic salmon	Low	High	M033	Minor (Not Significant)	N/A	Minor (Not Significant)	
	Sea trout	Low	Medium		Minor (Not Significant)	N/A	Minor (Not Significant)	
European eel	Low	High	Minor (Not Significant)		N/A	Minor (Not Significant)		

Activity and impact	Receptor	Magnitude of impact	Receptor sensitivity or value	Embedded mitigation measures	Significance of effect (significance)	Further environmental mitigation	Significance of residual effect (significance)
Decommissioning							
Short term seabed habitat loss and/or disturbance during decommissioning activities	Marine Fish						
	Atlantic herring	Low	Medium	M005 M020	Minor (Not Significant)	N/A	Minor (Not Significant)
	Common skate complex	Low	High		Minor (Not Significant)	N/A	Minor (Not Significant)
	Spotted ray	Low	Medium		Minor (Not Significant)	N/A	Minor (Not Significant)
	Sandeel	Low	Medium		Minor (Not Significant)	N/A	Minor (Not Significant)
	All other marine fish species (not discussed individually)	Low	Low		Negligible (Not Significant)	N/A	Negligible (Not Significant)
	Diadromous Fish						
Diadromous fish	Low	Low	M005 M020	Negligible (Not Significant)	N/A	Negligible (Not Significant)	
Increases in suspended sediment concentration and associated sediment deposition	Marine Fish						
	Species with nursery grounds (only) within the area affected by SSC and sediment deposition						
	Atlantic mackerel Blue whiting Anglerfish European hake Haddock Ling, Whiting Spurdog	Low	Medium	M005 M020	Minor (Not Significant)	N/A	Minor (Not Significant)
	Species with spawning grounds (only) within the area affected by SSC and sediment deposition						
	European sprat	Low	Medium	M005 M020	Minor (Not Significant)	N/A	Minor (Not Significant)
	Common skate complex Spotted ray	Low	High		Minor (Not Significant)	N/A	Minor (Not Significant)
	Species with spawning and nursery grounds within the area affected by SSC and sediment deposition						
	Atlantic herring Atlantic cod Lemon sole Norway pout	Low	Medium	M005 M020	Minor (Not Significant)	N/A	Minor (Not Significant)
	Sandeel						
	Sandeel species	Low	Medium	M005 M020	Minor (Not Significant)	N/A	Minor (Not Significant)
All other marine fish species (not discussed individually)							

Activity and impact	Receptor	Magnitude of impact	Receptor sensitivity or value	Embedded mitigation measures	Significance of effect (significance)	Further environmental mitigation	Significance of residual effect (significance)
	All other marine fish species (not discussed individually)	Low	Low	M005 M020	Negligible (Not Significant)	N/A	Negligible (Not Significant)
	Diadromous Fish Atlantic salmon Sea trout European eel	Low	Low	M005 M020	Negligible (Not Significant)	N/A	Negligible (Not Significant)

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12.16 GLOSSARY OF TERMS AND ABBREVIATIONS

12.16.1.1 A list of key terms and acronyms used in this chapter are provided in **Table 12-52** and **Table 12-53**.

Table 12-52 Acronyms and abbreviations

Term	Definition
AC	Alternating current
CBRA	Cable Burial Risk Assessment
CEA	Cumulative effects assessment
CIEEM	Chartered Institute of Ecology and Environmental Management
COWRIE	Collaborative Offshore Wind Research into the Environment
dB	Decibels
dB Peak	Peak Sound Pressure Level
EMF	Electromagnetic Field
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
FeAST	Feature Activity Sensitivity Tool
FWPM	Freshwater Pearl Mussel
HDD	Horizontal Directional Drilling
HRA	Habitat Regulations Appraisal
HVAC	High Voltage Alternating Current
INNS	Invasive Non-native Species
JUV	Jack-up vessel
kJ	Kilojoules
kn	knots
MD-LOT	Marine Directorate Licensing Operations Team
MD-SEDD	Marine Directorate – Science, Evidence, Data and Digital
MarESA	Marine Evidence based Sensitivity Assessment
MarLIN	Marine Life Information Network
MMMP	Marine Mammal Mitigation Protocol
MPA	Marine Protected Areas
m/hour	Meter per hour
NSN	National Site Network
O&M	Operation and Maintenance
OHFT	Outer Hebrides Fisheries Trust
OHIFG	Outer Hebrides Inshore Fisheries Group
ONS	Onshore Substation
OSP	Offshore Substation Platform
PAC	Preliminary Application Consultation
PMFs	Priority Marine Features
SAC	Special Area of Conservation

Term	Definition
SEL	Sound Exposure Level
SEL _{cum}	Cumulative Sound Exposure Level
SSC	Suspended Sediment Concentration
TTS	Temporary Threshold Shift
WTG	Wind Turbine Generator
WIFA	Western Isles Fisherman's Association
ZOI	Zone of Influence
μPa	MicroPascal
μPa ² s	MicroPascal squared second
μT	Microtesla
μV/m	Microvolts per metre
nV/cm	Nanovolts per centimetre

Table 12-53 Glossary

Term	Meaning
Annex I habitats	A natural habitat type of community interest, defined in Annex I of the Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora (Habitats Directive). The designation of Special Areas of Conservation (SAC) is required in the United Kingdom (UK) to ensure the conservation of these habitats. The protection afforded to sites designated prior to European Union (EU) Exit persists in UK law.
Annex II species	Animal or plant species of community interest, defined in Annex II of the Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora (Habitats Directive). The designation of Special Areas of Conservation (SAC) is required in the UK to ensure the conservation of these species. The protection afforded to sites designated prior to EU Exit persists in UK law.
Array Area	The offshore area within which the offshore wind turbine generators (WTGs), associated foundations, Offshore Cables, and Offshore Substation Platform (OSP) (if required), will be located. This area encompasses the Turbine Area that will contain all above water surface infrastructure (WTGs / OSP) and an additional area within which further below water infrastructure (foundations and cables) may also be located.
Array Cables	The offshore electrical and communication cables that connect infrastructure located within the Array Area, for: <ul style="list-style-type: none"> Scenario 1: Array Cables will used to connect Wind Turbine Generators (WTGs) to each other, and to connect WTGs to the OSP. Scenario 2: Array Cables will used to connect WTGs to each other.
Basking Shark and Ocean Sunfish Study Area	Study area for basking sharks and ocean sunfish and includes a 100 km buffer around the Project Area.
Demersal species	Fish that live on or near the seabed.

DAS Study Area	Includes the Array Area and a 10 km buffer, and represents the area surveyed via aerial surveys.
Diadromous species	Fish that spend part of their life in both freshwater and sea water and migrate between the two.
Diadromous Fish Study Area	Study area for salmonid species (Atlantic salmon and sea trout), European eel and Arctic char, and includes all waters located within the northwest anadromous fish region boundary.
Elasmobranchs	A cartilaginous subclass of fish that includes sharks, rays, and skates.
Electrosensitive species	Species sensitive to electric fields.
Electromagnetic field (EMF)	An electric and magnetic force field that surrounds a moving electrical charge.
Electrosensitive species	Species sensitive to electric fields.
Embedded or 'Designed-in' Mitigation	Mitigation measures to avoid or reduce environmental effects that are directly incorporated into the preferred design for the Project. This can include standard practice in accordance with or without guidance. Embedded Mitigation is considered as part of the impact assessment, before effect significance is identified.
Environmental Impact Assessment (EIA)	The process of evaluating the likely significant environmental effects of a proposed project or development over and above the existing circumstances (or 'baseline').
Environmental Impact Assessment Report (EIAR)	The Environmental Impact Assessment Report (EIAR) prepared to assess the likely significant effects of the Project on the environment.
Export Cable	The offshore electrical and communication cables located in the Array Area and Offshore Cables Area of Search that connect the Offshore Substation Platform (OSP) (if required) to Landfall for Scenario 1.
Fish Ecology Study Area	Region encompassing the Marine Fish Study Area, Diadromous Fish Study Area and the Basking Shark and Ocean Sunfish Study Area.
Future Baseline	Refers to the situation in future years without the Offshore Project.
Grilse	A one-sea-winter (1SW) salmon that returns to freshwater to spawn after spending one year in the ocean.
Horizontal Directional Drilling (HDD)	A trenchless crossing engineering technique using a drill steered underground without the requirement for open trenches. This method is able to carry out the underground installation of pipes and cables with minimal surface disruption.
Horizontal Directional Drill (HDD) Exit Pit	Represents one exit pit that will be located within the Landfall Exit Pit Area.
ICES rectangles	ICES statistical rectangles provide a grid covering the area between 36°N and 85°30'N and 44°W and 68°30'E. Fisheries data collected by the ICES is recorded and collated according to these statistical rectangles.
Impact	Change that is caused by an action; for example, foundation installation (action) during construction which results in habitat loss (impact).

Impact pathway	<p>The EIA for the Offshore Project utilises the 'source-pathway-receptor' model to identify relevant receptors, where applicable. This model highlights potential impacts of the Offshore Project on environmental receptors, establishing a clear link between impact sources and receptor.</p> <p>The impact pathway is the route through which the potential impacts (as a result of an effect of an activity) could reach a receptor.</p>
Jack-up vessel	A jack-up vessel is a barge with legs that can be raised and lowered to install offshore wind farm components and foundations.
Kelts	Salmon that have spawned in the previous autumn and subsequently return to the marine environment.
Landfall	This consists of works from offshore Horizontal Directional Drill (HDD) exit pits (located below MLWS) to onshore at the Transition Joint Bays (TJB) (located above MHWS). The infrastructure and installation methods associated with the Landfall involves both onshore and offshore components.
Landfall Exit Pit Area	The offshore area in which all HDD Exit Pits will be located within.
Landfall Substation	The optional onshore substation located on the west side of the Isle of Lewis/ <i>Eilean Leòdhais</i> . Includes the platform, buildings and associated components which allows the voltage to be increased to meet onward transmission requirements.
Likely Significant Effects	With respect to the Electricity Works (EIA (Scotland) Regulations 2017 and The Marine Works (EIA) Regulations 2017, a significant effect that may reasonably be predicted as a consequence of a plan or project, on the receiving environment.
Magnetosensitive species	Species that are sensitive to magnetic fields
Marine Fish Study Area	Study area for all fish species excluding diadromous species, basking shark and ocean sunfish, and has been taken to be the modelled extent an unmitigated, single-strike sound pressure level of 150 dB re 1 μ Pa (RMS).
Maximum Design Scenario	The scenario within the Project Design Envelope with the potential to result in the greatest impact on a particular topic receptor, and therefore the one that should be assessed for that topic receptor. See Chapter 3: Project Description, Volume 1a for detailed description.
Mitigation	Term used to indicate avoidance, remediation or alleviation of adverse impacts.
Offshore	Pertaining to seaward of Mean High Water Springs (MHWS).
Offshore Application	The application for a marine licence under the Marine (Scotland) Act 2010 (between 0 and 12nm) and a Section 36 consent under the Electricity Act 1989.
Offshore Cables	Electrical and communication cables located within the Array Area and Offshore Cable Area of Search. The Offshore Cables consist of Array Cables, Array Cables to Landfall, and Export Cables.
Offshore Cable Area of Search (OCAS)	The area within which the offshore cable infrastructure between the Array Area and Landfall up to Mean High Water Springs (MHWS) will be located.

Offshore Landfall Area	The area seaward of Mean High Water Springs (MHWS) within the Offshore Cable Area of Search (OCAS) that includes works associated with the Horizontal Directional Drill (HDD) installation, including HDD exit pit(s) (located below MLWS) and offshore cable connection to the onshore (TJB) (located above MHWS).
Offshore Project	The offshore components of the Spiorad na Mara offshore wind farm (the Project) located seaward of Mean High Water Springs (MHWS).
Offshore Project Boundary	The 'red line boundary' encompassing the Offshore Project.
Offshore Substation Platform (OSP)	The optional offshore substation located within the Turbine Area. Includes the platform and associated components which allows the voltage to be increased to meet onward transmission requirements.
Offshore Windfarm (OWF)	A group of WTGs located offshore.
Onshore	Pertaining to landward of MLWS.
Onshore Substation (ONS)	A compound housing electrical equipment enabling connection to the grid. The onshore substation also contains equipment to help maintain stable grid voltage. <i>Arnish/Àirinis, an ONS, known as the 'Grid Substation', which is east of Creed Industrial Park, will be situated close to the Scottish and Southern Electricity Networks (SSEN) converter & substation, the 'Lewis Hub.' Here, the electricity will be converted to high-voltage direct current (HVDC) before being transmitted across the Minch/A' Mhaoil to mainland Scotland/Alba.</i>
Onshore Transmission Works (OTW) / Onshore Project	The onshore components of the Spiorad na Mara offshore wind farm (the Project) located landward of Mean Low Water Springs (MLWS). The Applicant will seek consent for the OTW Project through a separate application and so does not form part of this application.
Onshore Transmission Works Boundary / Onshore Project Boundary	The 'red line boundary' encompassing all temporary and permanent works associated with the OTW/Onshore Project.
Pelagic fish	Species that are found predominantly in the mid- and upper water layers of the water column.
Percussive Piling	A method of installing piles and pile casings into the seabed using an impact hammer. This form of piling can be solely used if ground conditions are suitable. If pile depth cannot be achieved through percussive piling alone, a pile-drill-pile technique can be used to reach desired depths. The percussive piling technique can be used for the installation of the Wind Turbine Generators (WTGs) and the Offshore Substation Platform (OSP) (if required) located within the Percussive Piling Area.
Percussive Piling Area	The area within the Turbine Area where both percussive piling, and drill and grout or vibratory piling construction methods can be used for the installation of the

	wind turbine generators (WTGs) and the Offshore Substation Platform (OSP) (if required) fixed foundations.
Percussive Piling Exclusion Area	An area in the southwest of the Turbine Area where there will be no percussive piling. Other methods including drill and grout methods can be used in this area.
Permanent Threshold Shift (PTS)	Permanent hearing damage; auditory injury.
Project	The Sporad na Mara offshore wind farm development. This term describes the whole development, including all offshore and onshore components.
Project Boundary	The 'red line boundary' encompassing all offshore and onshore components of the Project.
Project Design Envelope (PDE)	A description of the range of possible components that make up the Project design options under consideration when the exact engineering parameters are not yet known.
Project-Lifetime Effects	Assessment of the scope for combined effects that occur throughout more than one phase of the project (i.e. construction, operation and maintenance, decommissioning), to interact to potentially create an effect of greater significance than if assessed just within individual/isolated project phases.
Receptor	Any physical, biological or anthropogenic element of the environment that may be affected or impacted by the Project. Receptors can include natural features such as the seabed and wildlife habitats as well as man-made features like fishing vessels and cultural heritage sites.
Scoping Opinion	A report presenting the written opinion of the Scottish Ministers, with input from Comhairle nan Eilean Siar (CnES) for the OTW, as to the scope and level of detail of information to be provided in the Environmental Impact Assessment (EIA) for the Project.
Scoping Report	A document submitted by a developer that outlines the potential environmental issues and effects of a proposed project to determine which topics, methods, and level of detail should be included in the full Environmental Impact Assessment (EIA).
Scour protection	The protection of sediment against localised erosion e.g. by placing rock.
Sediment dispersion	The dilution and settling of sediment as it travels from a source.
Sediment disturbance	Disturbing/displacing sediment (contaminated or uncontaminated).
Sensitivity	A term applied to specific receptors, combining judgements of the susceptibility of the receptor to the specific type of change or development proposed and the value associated to that receptor.
Significance	A measure of the importance of the environmental effect, defined by criteria specific to the environmental aspect.
Significant effect	It is a requirement of the EIA Regulations 2017 to determine the likely significant effects of the development on the environment, which should relate to the level of an effect and the type of effect. Where possible significant effects should be mitigated.

	<p>The significance of an effect gives an indication as to the degree of importance (based on the magnitude of the effect and the sensitivity of the receptor) that should be attached to the impact described.</p> <p>Whether or not an effect should be considered significant is not absolute and requires the application of professional judgement.</p> <p>Significant – ‘noteworthy, of considerable amount or effect or importance, not insignificant or negligible’ (The Concise Oxford Dictionary).</p> <p>Those levels and types of landscape and visual effect likely to have a major or important / noteworthy or special effect of which a decision maker should take particular note.</p>
Sound Exposure Level (SEL or $L_{E,p}$)	The constant sound level acting for 1 second, which has the same amount of acoustic energy, as indicated by the square of the sound pressure, as the original sound. It is the time-integrated, sound-pressure-squared level. SEL is typically used to compare transient sound events having different time durations, pressure levels, and temporal characteristics.
Sound Exposure Level, cumulative (SEL _{cum} or $L_{E,p,t}$)	Single value for the collected, combined total of sound exposure over a specified time or multiple instances of a noise source.
Sound Exposure Level, single strike (SEL _{ss})	Calculation of the sound exposure level representative of a single noise impulse, typically a pile strike.
Sound Pressure Level (SPL or L_p)	The sound pressure level is an expression of sound pressure using the decibel (dB) scale; the standard frequency pressures of which are 1 μ Pa for water and 20 μ Pa for air.
Spawning	The act of releasing or depositing eggs (fish).
Spawning bed	A discrete patch of seabed where eggs are deposited.
Spawning ground	A larger geographic area than a spawning bed, encompassing one or more spawning beds and all the adjoining potential spawning habitat.
Stock assessment	An assessment of the biological stock of a species and its status in relation to defined references points for biomass and fishing mortality.
Suspended sediment concentration	The mass concentration (mass/volume) of sediment in suspension.
the Project	Spiorad na Mara Offshore Windfarm.
Temporary Threshold Shift (TTS)	Reversible and temporary hearing loss.
Transboundary effects	Assessment of changes to the environment caused by the combined effect of past, present and future human activities and natural processes on other European Economic Area Member States.
Turbine Area	A reduced area within the Array Area where above water surface infrastructure would be located i.e. wind turbine generators (WTG) or Offshore Substation Platform (OSP) (if required). This area has been developed and refined through stakeholder consultation and environmental assessment.

Wind Turbine Generator (WTG)	The wind turbines that generate electricity consisting of tubular towers and blades attached to a nacelle housing mechanical and electrical generating equipment.
0 group fish	Fish within their first year of their lives.

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