Cambois Connection – Marine Scheme

Environmental Statement – Volume 2

ES Chapter 9: Fish and Shellfish Ecology

SSE Renewables

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Contents

Tables

Figures

Acronyms

Acronym	Description
BBWF	Berwick Bank Wind Farm
BBWFL	Berwick Bank Wind Farm Limited
CBD	Convention on Biological Diversity
CIEEM	Chartered Institute for Ecology and Environmental Management
Cefas	Centre for Environment Fisheries & Aquaculture Science
CNS	Central North Sea
DDV	Drop-down video
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
EMF	Electro-magnetic fields
EMP	Environmental Management Plan
EPS	European protected species
ES	Environmental Statement
EU	European Union
EUBS	EU Biodiversity Strategy
FEAST	Feature Activity Sensitivity Tool
FOCI	Features of Conservation Interest
GMF	Geomagnetic field
HDD	Horizontal directional drilling
HRA	Habitats Regulations Assessment / Appraisal
HVDC	High Voltage Direct Current
ICES	International Council for the Exploration of the Sea
iE-field	Induced electric field
IHLS	International Herring Larvae Survey
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
LSE	Likely Significant Effect
MBES	Multi-beam echo sounder
MCAA	Marine and Coastal Access Act

Acronym	Description
MCZ	Marine Conservation Zone
MFE	Mass-flow Excavator
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs
MMO	Marine Management Organisation
MPA	Marine Protected Area
MPS	Marine Policy Statement
MD-LOT	Marine Directorate Licensing Operations Team
ncMPA	Nature Conservation MPA
NPS	National Policy Statement
NSIP	Nationally Significant Infrastructure Project
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
OWF	Offshore Wind Farm
PLGR	Pre-Lay Grapnel Run
PMF	Priority Marine Features
pUXO	Potential unexploded ordnance
PSA	Particle size analysis
RIAA	Report to Inform Appropriate Assessment
ROV	Remotely operated vehicle
RTC	River Tweed Commission
SAC	Special Area of Conservation
SFF	Scottish Fishermen’s Federation
SPA	Special Protection Area
SPL	Sound pressure level
SOPEP	Shipboard Oil Pollution Emergency Plan
SSC	Suspended sediment concentration
SSS	Side Scan Sonar
SSEN	Scottish and Southern Electricity Networks
SSSI	Site of Special Scientific Interest
UK	United Kingdom
UXO	Unexploded ordnance

Units

Unit	Description
cm	Centimetres
dB	Decibel
Hz	Hertz
kJ	Kilojoules
kHz	Kilohertz
km	Kilometre (distance)
km2	Kilometre squared
m	Metres
mg/l	Milligrams per litre
mm	Milimetre
m/s	Metres per second
M2	Metre squared
nm	Nautical mile (distance)
µT	Microtesla
µPa	Micropascal
µV/m	Microvolts per metre
V/m	volts per metre

9. Fish and Shellfish Ecology

9.1. Introduction

2. This chapter presents the assessment of the likely significant effects (as per the "Environmental Impact Assessment (EIA) Regulations"[1]) on the environment arising from the Cambois Connection (hereafter referred to as "the Project") Marine Scheme on fish and shellfish ecology. Specifically, this chapter of the Marine Scheme Environmental Statement (ES) considers the potential impact of the Marine Scheme seaward of Mean High Water Springs (MHWS), during the construction, operation and maintenance, and decommissioning phases.

3. This assessment is informed by the following technical chapters:

- Volume 2, Chapter 3: EIA Methodology;
- Volume 2, Chapter 4: Stakeholder Consultation and Engagement;
- Volume 2, Chapter 5: Project Description;
- Volume 2, Chapter 8: Benthic Subtidal and Intertidal Ecology;
- Volume 2, Chapter 10: Offshore and Intertidal Ornithology; and
- Volume 2, Chapter 11: Marine Mammals.

4. Specifically, this chapter should be read in conjunction with Volume 2, Chapter 8: Benthic Subtidal and Intertidal Ecology, Chapter 10: Offshore and Intertidal Ornithology, and Chapter 11: Marine Mammals due to the predator-prey relationships that exist between fish and shellfish receptors and these groups. The potential impacts on commercial fishery receptors are considered fully in Volume 2, Chapter 12: Commercial Fisheries and are not considered further within this chapter.

9.2. Purpose of this chapter

5. This fish and shellfish chapter:

- Presents the existing environmental baseline established from desk studies and feedback obtained during technical engagement with stakeholders;
- Identifies any assumptions and limitations encountered in compiling the environmental information;
- Presents the potential environmental impacts on fish and shellfish ecology arising from the Marine Scheme, and reaches a conclusion on the likely significant effects on fish and shellfish ecology based on the information gathered and the analysis and assessments undertaken;
- Identifies where impacts are relevant to the Marine Scheme in Scottish waters, the Marine Scheme in English waters, or both. Where there is no separation of assessment of impacts, the assessment for the Marine Scheme (as a whole entity) applies to the Marine Scheme in Scottish waters and English waters separately; and
- Highlights any necessary monitoring and/or mitigation measures recommended to prevent, minimise, reduce or offset the likely significant adverse effects of the Marine Scheme on fish and shellfish ecology.

[1] For the Marine Scheme, this is the Marine Works (Environmental Impact Assessment) Regulations 2007 (as amended).

9.3. Study Area

6. Fish and shellfish are spatially and temporally variable, therefore for the purposes of the fish and shellfish ecology characterisation, two study areas are defined:

- The fish and shellfish ecology study area is defined as a 10 km radius around the Marine Scheme, in order to encompass all likely zones of influence for fish and shellfish receptors associated with the Maximum Design Scenario, (MDS), as detailed in section 9.9; and
- A diadromous fish study area, comprising a 100 km buffer around the Marine Scheme has been used to identify designated sites and salmon rivers which may be indirectly affected through interruptions to diadromous fish migrating through the Marine Scheme.

7. The fish and shellfish ecology study area and buffer are shown in Volume 4, Figure 9.1.

9.4. Policy and Legislative Context

8. A summary of the policy and legislative provisions relevant to fish and shellfish ecology are provided in Table 9.1 and Table 9.2.

9. The Marine Scheme is not located in Scottish inshore (< 12 nm) waters, and therefore legislation only applying to Scottish Inshore Waters is relevant only (1) in respect of the original designation of protected sites and species within the part of the Fish and Shellfish Study Area, which overlaps with Scottish inshore waters; and (2) the general duties of the Scottish Ministers applying as a function of the designation of those sites and species in considering the effects of the Marine Scheme. Legislation relevant to Scottish Inshore Waters is therefore provided for reference below.

Table 9.1 Summary of the legislation relevant to fish and shellfish ecology

Relevant Legislation	Summary of Legislation	How and Where Considered in the ES Report
Scotland and England (UK)		
Marine and Coastal Access Act 2009	The Marine and Coastal Access Act (MCAA) 2009 makes provisions relating to migratory and freshwater fish, access to coastal environments and works which have the potential to result in a detrimental impact to navigational features or assets in both Scottish (>12 nm) and English waters. MPAs existing beyond the 12 nm limit in Scottish Waters and Marine Conservation Zones (MCZs) in English waters are designated under the MCAA 2009. When determining an application, the Regulatory Authority must consider whether developments are capable of affecting protected features of MPAs or MCZs (other than insignificantly).	An assessment of Marine Scheme activities during the construction, operation and maintenance, and decommissioning phases which have the potential to result in an effect on fish and shellfish (and therefore require consideration as part of the Marine Scheme assessment) are considered in section 9.12. As outlined in section 9.7.1, there are no MPAs or MCZs designated for fish and shellfish ecology receptors within the fish and shellfish ecology study area.
The Conservation of Habitats and Species Regulations 2017 (as amended) and the Conservation of Offshore Marine Habitats and Species Regulations 2017 (as amended)	The Conservation of Habitats and Species Regulations 2017 and the Conservation of Offshore Marine Habitats and Species Regulations 2017 are the principal pieces of secondary legislation that transposed the EU Habitats Directive into UK law. The Regulatory Authority must consider the likely significant effects of a development on	All relevant species afforded protection under the Habitats and Species Regulations are considered within section 9.7. All relevant European Sites are listed in section 9.7.1.1. Please refer to the Marine Scheme Report to Inform Appropriate Assessment (RIAA), which

Relevant Legislation	Summary of Legislation	How and Where Considered in the ES Report
	the qualifying features of European Sites, designated under these pieces of legislation.	accompanies this application, and presents detail pertinent to the assessment of impacts on European sites and species under the Habitats Regulations. This follows on from the Cambois Connection: Habitats Regulation Assessment / Appraisal (HRA) Stage 1 Screening Report (see Appendix 1 of the RIAA) assessment carried out by the Applicant which was provided to both Marine Directorate Licensing Operations Team (MD-LOT) and the Marine Management Organisation (MMO) as well as NatureScot and Natural England in March 2023.
The Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019	The Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019 make amendments to the Wildlife and Countryside Act 1981, and the Conservation of Offshore Marine Habitats and Species Regulations 2017 following the UK's exit from the European Union. It is through these regulations that provisions for the UK's National Site Network are outlined.	All relevant European sites are listed in section 9.7.1.1. This legislative framework has been considered in detail as part of the HRA Screening (see Appendix 1 of the RIAA) and RIAA detailed above and subsequently has not been considered further within this chapter of the ES.
Scotland (Territorial waters)		
Marine (Scotland) Act 2010	Scottish Ministers and public authorities must act in the best way to further sustainable development, including the protection and, where appropriate, enhancement of habitat health.	All relevant potential impacts on marine habitats important for fish and shellfish associated with the construction, operation and maintenance and decommissioning of the Marine Scheme have been considered in section 9.12.
	The Marine (Scotland) Act 2010 provides the development of a marine spatial planning system, creating a framework for marine development and the creation of MPAs.	There are no Nature Conservation MPAs (ncMPAs) designated for the conservation of fish and shellfish in proximity to the Marine Scheme, and there are no plausible impacts of the Marine Scheme on any ncMPA designated for fish and shellfish.
The Conservation (Natural Habitats, &c.) Regulations 1994 (as amended)	Commonly referred to as the Habitats Regulations, these regulations transpose Council Directive 92/43/EEC on the conservation of natural habitats and wild flora and fauna into UK (Scots) law. These regulations cover Scottish Territorial Waters < 12 nm	All relevant sites and species afforded protection under this legislative framework are considered as part of section 9.7.
The Conservation (Natural Habitats, &c.) (EU Exit) (Scotland) (Amendment) Regulations 2019	This amends the Conservation (Natural Habitats, &c.) Regulations 1994 following the UK's exit from the European Union.	All relevant sites and species afforded protection under this legislative framework are considered as part of section 9.7.
Nature Conservation (Scotland) Act 2004	This Act places duties on public bodies in relation to the conservation of biodiversity and strengthens wildlife enforcement.	All relevant species afforded protection under this legislative framework are considered as part of section 9.7.1.1.

Relevant Legislation	Summary of Legislation	How and Where Considered in the ES Report
England		
Natural Environment and Rural Communities Act 2006	This Act makes provision for the public bodies which are concerned with the natural environment and rural communities. This Act makes provisions in connection with wildlife, sites of special scientific interest (SSSI) and National Parks to provide flexible administrative arrangements for the functions of the environment.	This legislative framework is considered as part of the baseline environment through the identification of designated sites relevant to fish and shellfish ecology (section 9.7).
The Conservation of Habitats and Species Regulations 2017	The Habitats Directive and the Birds Directive are transposed into law. The Conservation of Habitats and Species Regulations 2017, applying to English territorial waters. The Regulatory Authority must consider the likely significant effects of a development on the qualifying features of European Sites, designated under this legislation.	All the relevant European sites have been identified in section 9.7.11, along with their proximity to the Marine Scheme. Details on the potential effects on European sites designated for fish and shellfish features are included within the Cambois connection: Habitats Regulation Assessment / Appraisal (HRA) Stage 1 Screening Report (BBWFL, 2023), provided to both MS-LOT and MMO (as well as NatureScot and Natural England) in March 2023. Please refer to the Marine Scheme RIAA (which accompanies this application) and presents detail pertinent to the assessment of impacts on European sites under the Habitats Regulations.

Table 9.2 Summary of policy relevant to fish and shellfish ecology

Relevant Policy	Summary of Relevant Policy Framework	How and Where Considered in the ES Report
International		
The Convention for the Protection of the Marine Environment of the North East Atlantic ('OSPAR Convention'; 1992)	This legislative agreement regulates international cooperation on environmental protection in the North East Atlantic. The Convention has been ratified by 15 signatory nations. The OSPAR List of Threatened and/or Declining Species and Habitats was developed to identify species and habitats in need of protection.	The OSPAR list of threatened and/or declining species is used to identify relevant fish and shellfish species within the fish and shellfish study area protected by this international policy, as detailed in Table 9.5.
The Convention on the Conservation of European Wildlife and Natural Habitats ('the Bern Convention'; 1979)	The Bonn Convention aims to ensure conservation and protection of wild plant and animal species and their natural habitats (listed in Appendices I and II of the Convention), to increase co-operation between contracting parties, and to regulate the exploitation of migratory species listed in Appendix III.	Table 5 identifies species within the fish and shellfish study area protected by this international policy.
The Convention on the Conservation of Migratory Species of Wild Animals ('the Bonn Convention'; 1979)	The Bonn Convention is an international agreement that aims to conserve migratory species throughout their ranges. Under the Bonn Convention, species are classed under Appendix I – threatened migratory species or Appendix II – migratory species requiring international cooperation.	Table 9.5 identifies species within the fish and shellfish study area protected by this international policy.
Scotland and England (UK)		
UK Marine Policy Statement (2011)	The UK Marine Policy Statement (MPS) is the framework for preparing Marine Plans and taking decisions affecting the marine environment. The MPS aims to "ensure a sustainable marine environment which promotes healthy, functioning marine ecosystems and protects marine habitats, species and our heritage assets."	The assessment of impacts is provided in section 9.12 and considers the magnitude of impact and the sensitivity of fish and shellfish receptors to determine if the impact would result in a significant change from the baseline and if the effect on the relevant feature is likely to be significant.
UK Post-2010 Biodiversity Framework	The UK Post-2010 Biodiversity Framework covers the period from 2011 to 2020, and was developed in response to two main drivers: the Convention on Biological Diversity's (CBD's) Strategic Plan for Biodiversity 2011-2020 and its five strategic goals and 20 'Aichi Biodiversity Targets', published in October 2010; and the EU Biodiversity Strategy (EUBS), released in May 2011.	Species thought to be present in the fish and shellfish ecology study area which are covered by the Framework are listed in section 9.7.1.1. Section 9.12 assesses the significance of the effect of the Marine Scheme on all fish and shellfish receptors where an impact pathway exists.

Relevant Policy	Summary of Relevant Policy Framework	How and Where Considered in the ES Report
	The Framework aims to set out a shared vision across the UK, facilitate cooperation and streamline UK-scale activity.	
Scotland		
Scottish National Marine Plan (2015)	GEN 9 Natural Heritage: Development and use of the marine environment must: comply with legal requirements for protected areas and protected species; not result in significant impact on the national status of Priority Marine Features (PMFs); and protect and, where appropriate, enhance the health of the marine area. GEN 5 Climate Change: Marine planners and decision makers must act in the way best calculated to mitigate, and adapt to, climate change. GEN 13 Noise: Development and use in the marine environment should avoid significant adverse effects of man-made noise and vibration, especially on species sensitive to such effects. WILD FISH 1: The impact of development and use of the marine environment on diadromous fish species should be considered in marine planning and decision making processes. Where evidence of impacts on salmon and other diadromous species is inconclusive, mitigation should be adopted where possible and information on impacts on diadromous species from monitoring of developments should be used to inform subsequent marine decision making. RENEWABLES 6: New and future planned grid connections should align with relevant sectoral and other marine spatial planning processes, where appropriate, to ensure a co-ordinated and strategic approach to grid planning. Cable and network owners and marine users should also take a joined-up approach to development and activity to minimise impacts on the marine historic and natural environment and other users. FISHERIES 2: The following key factors should be taken into account when deciding on uses of the marine environment and the potential impact on fishing: • The cultural and economic importance of fishing, in particular to vulnerable coastal communities. • The potential impact (positive and negative) of marine developments on the sustainability of fish and shellfish stocks and resultant fishing opportunities in any given area.	GEN9 Natural Heritage: Protected species and PMFs are identified in section 9.7.1.1 Section 9.12 presents an assessment of the significance of the effects of the Marine Scheme on fish and shellfish receptors. GEN5 Climate Change: The impact of climate change on the baseline environment and how this may influence the assessment of effects is considered as part of the future baseline in section .7.2.9 GEN13 Noise: The impact of underwater noise on fish and shellfish ecology receptors is assessed in section 9.12.1.3. WILD FISH 1: Section 9.12 presents assessments of the significance of the effects of the development on diadromous fish species. Renewables 6: The maximum design scenario for the Offshore Export Cables is shown in section 9.9.1 and the cumulative effects of these cables along with the cables from other projects in the area is assessed in section 9.14. Further information on the route selection process for the Marine Scheme is presented in Volume 2, Chapter 6: Route Appraisal and Consideration of Alternatives. FISHERIES 2 and FISHERIES 3: Nursery and spawning areas are detailed in section 9.7.1.1 and 9.7.1.2. Section 9.12 presents an assessment of the significance of the effects of the Marine Scheme on

Relevant Policy	Summary of Relevant Policy Framework	How and Where Considered in the ES Report
	• The environmental impact on fishing grounds (such as nursery, spawning areas), commercially fished species, habitats and species more generally. • The potential effect of displacement on: fish stocks; the wider environment; use of fuel; socio-economic costs to fishers and their communities and other marine users.FISHERIES 3: Where existing fishing opportunities or activity cannot be safeguarded, a Fisheries Management and Mitigation Strategy should be prepared by the proposer of development or use, involving full engagement with local fishing interests (and other interests as appropriate) in the development of the Strategy. All efforts should be made to agree the Strategy with those interests. Those interests should also undertake to engage with the proposer and provide transparent and accurate information and data to help complete the Strategy. The Strategy should be drawn up as part of the discharge of conditions of permissions granted. The content of the Strategy should be relevant to the particular circumstances and could include: • Reasonable measures to mitigate any potential impacts on sustainability of fish stocks (e.g. impacts on spawning grounds or areas of fish or shellfish abundance) and any socio-economic impacts.	fish and shellfish receptors, inclusive of consideration of spawning and nursery areas.
Scottish Priority Marine Features (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. Several fish and shellfish species are listed as PMFs.	Species thought to be present in the fish and shellfish ecology study area which are PMFs are listed in section 9.7.1.1. Section 9.12 assesses the significance of the effect of the Marine Scheme on all fish and shellfish receptors, including PMFs, where an impact pathway exists.
Scottish Wild Salmon Strategy (Scottish Government, 2022)	This policy aims to establish a new path of restoration and recovery for salmon in Scotland.	Reference has been made to the Scottish Wild Salmon Strategy (Scottish Government, 2022) and declining populations of salmon (section 9.7.1.4.1) in line with MD-LOT scoping comments.
England		
	There are potential impacts associated with energy emissions into the environment (e.g. noise or EMF), as well as potential interaction with sea bed sediments.	As outlined in section 9.7.1.1, there are no MPAs or MCZs within the fish and shellfish ecology study area designated for fish and shellfish ecology receptors.

Relevant Policy	Summary of Relevant Policy Framework	How and Where Considered in the ES Report
National Policy Statement (NPS) for Renewable Energy Infrastructure (EN-3) 2011[2][3]	The applicant should identify fish species that are the most likely receptors of impacts with respect to, for example, protected areas (e.g. HRA sites and MCZs).	Please refer to Marine Scheme RIAA, which accompanies this application, which presents detail pertinent to the assessment of impacts on European sites and species. This follows on from the Cambois Connection: Habitats Regulation Assessment / Appraisal (HRA) Stage 1 Screening Report (Appendix 1 of the Marine Scheme RIAA) assessment carried out by the Applicant which was provided to both MD-LOT and MMO as well as NatureScot and Natural England in March 2023.
	The assessment should also identify potential implications of underwater noise from construction and unexploded ordnance (addressing both sound pressure and particle motion) and EMF on sensitive fish species.	The impact of underwater noise on fish and shellfish receptors is assessed in section 9.12.1.3. As detailed in Volume 2, Chapter 5 – Project Description; UXO clearance is not anticipated, and this activity is not included in the Marine Scheme. As such UXO clearance has not been considered further as part of this ES (please see responses to consultee comments in section 9.5).

[2] Whilst it is acknowledged that neither BBWF nor the Marine Scheme comprise or form part of an NSIP (please see Volume 2: Chapter 2: Policy and Legislative Context) , NPSs are however a statement of government intention relating, in this case, to renewable energy projects, therefore can be taken into consideration during the preparation of the Marine Scheme ES

[3] A suite of draft revised Energy NPSs were published and consulted on by the UK Government in March 2023, and consultation closed on 23rd June. The consultation responses will be subject to consideration and the draft revised NPSs may now be revised before the NPSs are formally adopted. There is currently no date for the next stage of the review process and therefore this ES presents the current adopted NPSs which have been considered during the preparation of this ES. It is however noted by the Applicant that the new draft NPSs state that they may be material considerations in other applications which are not considered under the Planning Act (2008), this includes the Marine Scheme. Further detail on the consideration of the draft NPSs in this ES is provided in Volume 2 Chapter 2 Policy and Legislation.

Relevant Policy	Summary of Relevant Policy Framework	How and Where Considered in the ES Report
North East Inshore and North East Offshore Marine Plan	Per NE-BIO-1, NE-BIO-2, NE-MPA-1, NE_MPA-2 proposals that may have adverse impacts on: • The distribution of priority habitats and priority species; • Native species or habitat adaptation or connectivity, or native species migration; • The objectives of marine protected areas; and • An individual marine protected area's ability to adapt to the effects of climate change, and so reduce the resilience of the marine protected area network, must demonstrate that they will, in order of preference: avoid, minimise or mitigate against adverse impacts. In respect of NE-MPA-1, due regard must be given to statutory advice on an ecologically coherent network. In respect of NE-BIO-1 and NE-BIO-2, adverse impacts must be mitigated so that they are no longer significant. Where significant adverse impacts cannot be mitigated, compensation should be provided.	As outlined in section 9.7.1.1 there are no MPAs or MCZs within the fish and shellfish ecology study area designated for fish and shellfish ecology receptors. Relevant designated sites and species have been identified in section 9.7.1.1. Section 9.12 assesses the significance of the effect of the Marine Scheme on fish and shellfish ecology.
	NE-CE-1: Proposals which may have adverse cumulative effects with other existing, authorised, or reasonably foreseeable proposals must demonstrate that they will, in order of preference: A) Avoid B) Minimise C) Mitigate adverse cumulative and/or in-combination effects so they are no longer significant.	The assessment of cumulative effects is included in section 9.14
	NE-DIST-1: Proposals that may have significant adverse impacts on highly mobile species through disturbance or displacement must demonstrate that they will, in order of preference: a) Avoid b) Minimise c) Mitigate	Migratory fish species are introduced in section 9.7.1.2 and are addressed throughout the impact assessment in section 9.12.

Relevant Policy	Summary of Relevant Policy Framework	How and Where Considered in the ES Report
	adverse impacts so they are no longer significant.	
	NE-UWN-1: Proposals that result in the generation of impulsive sound must contribute data to the UK Marine Noise Registry as per any currently agreed requirements. Public authorities must take account of any currently agreed targets under the Marine Strategy Part One Descriptor 11. NE-UWN-2: Proposals that result in the generation of impulsive or non-impulsive noise must demonstrate that they will, in order of preference: a) Avoid b) Minimise c) Mitigate adverse impacts on highly mobile species so they are no longer significant.	The impact of underwater noise on fish and shellfish ecology receptors is assessed in section 9.12.1.3.
English Features of Conservation Interest (FOCI)	FOCI are marine features that are particularly threatened, rare, or declining species or habitats. FOCI apply to English waters and are used in the process of identifying areas for designation as MCZs.	Species thought to be present in the fish and shellfish ecology study area which are FOCI are listed in section 9.7.1.1. Section 9.12 assesses the significance of the effect of the Marine Scheme on all fish and shellfish receptors, including PMFs, where an impact pathway exists.

9.5. Consultation and Technical Engagement

10. A summary of the key issues raised during consultation and technical engagement activities undertaken to date specific to fish and shellfish ecology is presented in Table 9.3[4], together with how these issues have been considered in the production of this fish and shellfish ecology chapter. Further detail is presented within Volume 2, Chapter 4: Stakeholder Consultation and Engagement.

[4] Where scoping comments from stakeholders and consultees have been restated and/or paraphrased by the regulators within Scoping Opinions, this is only referenced with regards to MD-LOT and MMO Scoping Opinions, for brevity and to reduce duplication.

Table 9.3 Summary of key consultation and technical engagement undertaken for the Marine Scheme relevant to fish and shellfish ecology

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this ES Chapter
Relevant consultation and engagement undertaken to date			
December 2022	MMO: Consultation meeting	Unclear why average monetary value is present in Table 9-1 of Scoping Report and advise abundance is included instead.	Monetary value of fish and shellfish species is considered in Volume 2, Chapter 12: Commercial Fisheries. Species of commercial importance have been assessed in section 9.7.1.3 of this chapter, using ecological parameters and not commercial value.
18 April 2023	MMO: Consultation meeting	The Applicant sought confirmation that UXO investigation or clearance is not within the scope of the Marine Licence applications for the Marine Scheme. The MMO confirmed that the preference is for UXO activities to be covered under a separate Marine Licence(s) and agree it will therefore not be covered within the Marine Scheme EIA or Marine Licence applications.	As detailed in Volume 2, Chapter 5 – Project Description; UXO clearance is not anticipated, and this activity is not included in the Marine Scheme. As such UXO clearance has not been considered further as part of this ES. The rationale for this is included in full within Volume 2, Chapter 5: Project Description; in summary: • The exact locations of potential UXO / UXO are not currently known and will not be known until detailed design, as informed by UXO surveys along the route of the Marine Scheme; • The corridor for the Marine Scheme is approximately 1 km wide. A key reason for adopting this corridor is to provide the construction contractor(s) with flexibility to micro-route around potential UXO / UXO; • If at a later stage UXO clearance is required, it will be subject to a robust assessment at the time based on data regarding UXO to enable a meaningful assessment; and • In the event that such an assessment is required, it will be subject to separate marine licensing

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this ES Chapter
			requirements and European Protected Species licensing requirements.
18 April 2023	MMO: Consultation meeting	The Applicant would like to confirm the intention not to undertake a full herring and sandeel assessment within the ES. The MMO defer to Cefas on this matter. The MMO confirm they will discuss this with Cefas and return to the Applicant with a decision.	A response from the MMO, as informed by Cefas consultation was not received following this consultation meeting. Therefore, a full herring and sandeel assessment has been taken in support of the fish and shellfish impact assessment. The results of this are presented in Volume 3, Appendix 9.1 and summarised in section 9.7.1.2
Consultation on the Marine Scheme: Scoping Opinion			
19 December 2022	NatureScot: Scoping comments	Recommend the inclusion of 'Essential Fish Habitat Maps for Fish and Shellfish Species in Scotland' developed by the Marine Energy Research (ScotMER) programme.	The distribution maps have been referred to throughout the baseline as appropriate to inform which species are likely to use the area (section 9.7.1).
19 December 2022	NatureScot: Scoping comments	In addition to being qualifying features of European sites, Atlantic salmon are PMFs along with European eel and sea trout.	Details on protected species are presented in section 9.7.1.1 (including Atlantic salmon, European eel, and sea trout).
19 December 2022	NatureScot: Scoping comments	Atlantic salmon are undergoing a significant decline across their global range, and numbers in Scotland have declined dramatically since 2010. This has led to the recent publication of a Scottish Wild Salmon Strategy (Scottish Government, 2022), and continuing high levels of mortality at sea is a significant issue. European eel is a conservation priority due to a dramatic decrease in its population size over the last 20 years; it is listed as 'critically endangered' on the global IUCN Red list. However, very little is known about their local migration pathways, either as juveniles or adults. Malcolm *et al.* (2010) contains a review of available data in relation to migration routes and behaviour, and Gill & Bartlett (2010) on effects of noise and electromagnetic fields (EMF) on European eel as well as sea trout. Sea trout support a number of fisheries in Scotland and many of these fisheries have undergone declines in the last 25 years. Note that juvenile Atlantic salmon and trout (including those destined to become sea trout) can also be a host species for freshwater pearl mussel (FWPM).	Reference has been made to the Scottish Wild Salmon Strategy (Scottish Government, 2022) and declining populations of salmon (section 9.7.1.4.1). The Malcolm *et al.* (2010) and Gill and Bartlett (2010) references have been included, as suggested. Details on European eel migration pathways have been addressed in section 9.7.1.1.4. EMF effects have been considered in the impact assessment (section 9.12.2.1) Salmon and trout connectivity with freshwater mussels has been discussed in section 9.7.1.4.1 and section 9.7.1.4.2, respectively.

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this ES Chapter
19 December 2022	NatureScot: Scoping comments	In section 9.5.4, the Scoping Report discusses spawning and nursery grounds. It is advised to include presence/absence of sandeel, as presented in Langton *et al.* 2021.	Spawning and nursery grounds are addressed in section 9.7.1.2 where reference to Langton *et al.* (2021) has been made.
19 December 2022	NatureScot: Scoping comments	Increased suspended sediment concentrations is a key impact pathway captured in Table 9-3 for construction and decommissioning activities.	The assessment on temporary increases in Suspended Sediment Concentration (SSC) and associated sediment deposition and potential release of contaminants has been assessed in section 9.12.1.2. The maximum zone of influence associated with this impact has been informed by the findings within Volume 2, Chapter 7: Offshore Physical Environment and Seabed Conditions.
19 December 2022	NatureScot: Scoping comments	We welcome the inclusion of habitat loss and disturbance (both temporary and long term) from the Cambois Connection on these prey species, which is carried through into the seabird and marine mammals topic.	Noted. Temporary habitat and species disturbance or loss is considered in section 9.12.1.1. Potential connectivity and indirect impacts on ornithological receptors and marine mammals have been assessed in Volume 2, Chapter 10: Offshore and Intertidal Ornithology and Chapter 11: Marine Mammals respectively.
19 December 2022	NatureScot: Scoping comments	Advise that the full range of mitigation techniques and published guidance is considered and discussed in the EIAR.	Guidance used to inform the assessment is presented in section 9.10.1. Mitigation measures relevant to fish and shellfish ecology can be found in 9.11.
December 2022	Scottish Fishermen's Federation (SFF)	SFF question why in 9.5 Baseline Environment for fish and shellfish ecology is being defined by value of landings from ICES squares, each of which is c900sq miles when it belongs in the Commercial Fisheries, whilst habitats and populations should be defined there.	Monetary value of fish and shellfish species is considered in Volume 2, Chapter 12: Commercial Fisheries. Species of commercial importance have been assessed in section 9.7.1.3 of this chapter, using ecological parameters and not commercial value.
09 January 2023	Cefas: Scoping comments	Cefas disagrees with potential impacts to be scoped out such as scoping out the impact of underwater noise on fish. Whilst Cefas are generally in agreement that construction noise arising from the proposed construction works (e.g., seabed preparation, cable laying and vessel noise) is unlikely to generate noise levels that will cause significant physiological effect to fish receptors, there is still potential for behavioural disturbance to fishes, particularly during their spawning periods as a result of underwater noise. This is of particular relevance to herring and cod which have a swim bladder involved in hearing and are vulnerable to noise disturbances (Popper *et al.*, 2014). In addition, herring are benthic	Underwater noise has since been scoped in for assessment. The assessment can be found in section 9.12.1.3.

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this ES Chapter
		spawners that rely on a specific substrate on which to lay their eggs, hence if noise disturbance causes the fish to 'flee' the area, then there may not be suitable alternative spawning grounds nearby. Furthermore, as the cable passes through herring spawning grounds, there is potential for in-combination and cumulative adverse effects to occur as a result of noise disturbance and disturbance to spawning habitat if works are carried out during the herring spawning season. The Banks herring population spawn off the north-east coast of England between August and October (inclusive). For these reasons, Cefas recommend that the effects of underwater noise are scoped into the Applicant's environmental impact assessment (EIA).	
09 January 2023	Cefas: Scoping comments	Accidental release of pollutants was scoped out from the assessment on the basis of the following embedded mitigation and best practice measures proposed, which aim to ensure that the risks of pollutants are minimised; Construction Environmental Management Plan (CEMP), Operations Environmental Management Plan (OEMP), The International Convention for the Prevention of Pollution from Ships (MARPOL) and Shipboard Oil Pollution Emergency Plan (SOPEP). Cefas are content with their scoping out of this impact for fish ecology receptors, however, this has been deferred to the Cefas SEAL team for further comments on the adequacy of these measures in relation to the proposed works.	Noted. An Environmental Management Plan (EMP) for the Marine Scheme will be prepared, an outline EMP is provided in Volume 5, Appendix 5.1.
09 January 2023	Cefas: Scoping comments	Cefas agrees with the decision to scope in EMF effects however, Cefas also suggests the addition of additional papers by Hutchison *et al.* (2020b, 2021) that may also be useful to inform the assessment of EMF. In accordance with the National Policy Statement for Renewable Energy Infrastructure (EN-3) (Dept. of Energy & Climate Change, 2011) Cefas fisheries advisors recommend minimising the potential effects of EMF (and sediment heating) by laying cables to a depth of greater than 1.5m. The effects of EMF on sensitive species e.g., elasmobranchs may be mitigated by adopting this recommendation by increasing the distance between the EMF	Noted. Potential effects of EMF, including consideration of the suggested papers and mitigation measures have been assessed in section 9.12.2.1.

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this ES Chapter
		and the receptor. Cefas recognise that this may be subject to local seabed geology and other receptors in the area.	
09 January 2023	Cefas: Scoping comments	Cefas is content with the embedded mitigation measures described to manage and mitigate potential effects on fish receptors. However, Cefas notes the requirement for any additional fisheries-specific mitigation, such as those for sandeel and herring should be determined on the outcomes of suitable habitat assessments and the EIA.	Noted. Secondary mitigation will be considered where potential significant effects are identified, as per the EIA methodology (Volume 2, Chapter 3: EIA Methodology).
09 January 2023	Cefas: Scoping comments	Cefas note that there is potential for UXO in this project which raises some concerns. In the event that UXO detonation/clearance is required, Cefas would expect underwater noise modelling to be carried out to determine the likely range of impact in relation to fish spawning and nursery grounds. The noise modelling should be presented as supporting evidence to accompany the marine licence for this activity.	Following further consultation and discussions with the MMO, as outlined in the second row of this table UXO clearance is not anticipated, and this activity is not included in the Marine Scheme. As such UXO clearance has not been considered further as part of this ES. The rationale for this is included in full within Volume 2, Chapter 5: Project Description; in summary: • The exact locations of potential UXO / UXO are not currently known and will not be known until detailed design, as informed by UXO surveys along the route of the Marine Scheme; • The corridor for the Marine Scheme is approximately 1 km wide. A key reason for adopting this corridor is to provide the construction contractor(s) with flexibility to micro-route around potential UXO / UXO; • If at a later stage UXO clearance is required, it will be subject to a robust assessment at the time based on data regarding UXO to enable a meaningful assessment; and • In the event that such an assessment is required, it will be subject to separate marine licensing requirements and European Protected Species licensing requirements.

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this ES Chapter
			Underwater noise associated with geophysical activities has been included within section 9.12.1.3
January 2023	River Tweed Commission (RTC): Scoping Comments	RTC point out in reference to the question (Do you agree that the existing desktop data on fish and shellfish resources in the fish and shellfish ecology study area is sufficient to characterise the describe the ecology in the fish and shellfish baseline?), that the run-timing of adult salmon returning to the Tweed SAC has changed very considerably in just the last few years. Instead of September and October being the main months of return, this is now July to August. Published data sources are therefore out of date and misleading. The RTC will be happy to provide more recent, accurate, data.	Migration of Atlantic salmon is addressed in section 9.7.1.4.1 where reference has been made to the RTC regarding run timings based on this comment.
January 2023	RTC: Scoping Comments	RTC point out in reference to the question (do you agree with the stakeholder and consultees identified as part of the proposed EIA methodology?), that RTC should be added to the list.	This is noted, and the Applicant apologises for this omission. RTC have been added to the consultee list.
January 2023	RTC: Scoping Comments	Proposed amendments for salmon and sea trout migration: Salmon and Sea trout smolts will move to the open sea in April and May and may still be migrating through the study area to their feeding grounds in June. Atlantic salmon and Sea trout will migrate back to local rivers throughout the year due to variable run timing, with the peak likely to be from May to July based on evidence from Tweed rod catches and local knowledge.	Noted, Atlantic salmon and sea trout migrations have been considered in sections 9.7.1.4.1 and section 9.7.1.4.2 respectively.
January 2023	RTC: Scoping Comments	Advised there is a need to note when European eel will be in the study area for glass eels and adults.	Information on European eel life stages has been included in the baseline environmental characterisation (section 9.7.1.4.4).
January 2023	RTC: Scoping Comments	RTC point out downstream migration for five species is of relevance migratory periods is April to June (Salmon and Sea Trout smolts), late Spring (Eel), July to September (Sea and River Lamprey). The timings noted for upstream migration are all year, with peaks April to July (Salmon and Sea Trout), January to June (Eel), April to May (River Lamprey), and Winter and Spring (Sea Lamprey).	Migration periods for Atlantic salmon and sea trout smolts are addressed in sections 9.7.1.4.1 and 9.7.1.4.2 respectively. Migration periods for Lamprey and European eel are addressed in Sections 9.7.1.4.3 and 9.7.1.4.4 respectively.
January 2023	RTC: Scoping Comments	Note (for future reference): River SACs are assigned to protect salmon smolt migrations, there are four river SACs which are relevant to the Marine Scheme which include the River Tweed,	The features SACs are considered in section 9.7.1.1. This chapter assesses the effects of the Marine Scheme on the protected features (i.e. Atlantic salmon) of these

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this ES Chapter
		River Teith, River Tay, and River South Esk. Potential impacts from the cable installation activities and operation and maintenance will result in the River Tweed SAC being considered further within the ES and supporting HRA.	designated sites in EIA terms. However, as noted, the potential effects of the Marine Scheme on the designated sites themselves will be considered within the supporting Marine Scheme RIAA (which accompanies this application).
20 January 2023	Environment Agency: Scoping Comments	The Northumberland coast, estuaries and rivers are important sites for the migration of Atlantic salmon (*Salmo salar*), Sea trout (*Salmo trutta*), European eel (*Anguilla anguilla*) and other fish species.	Rivers of importance to salmon and migratory species have been considered in section 9.7.1.4 along with other such designations.
20 January 2023	Environment Agency: Scoping Comments	An assessment is required to understand the impacts of the cable installation and associated works on the behavior of migratory fish species, including, but not limited to; noise, vibration, and sediment disturbance. The assessment needs to consider the inward and coastal migration of adult species as well as the outward migration of smolts (juveniles).	Underwater noise has since been scoped in for assessment (vibration has been considered as part of this assessment). This can be found in section 9.12.1.3. Temporary sediment disturbance has been assessed in section 9.12.1.1
20 January 2023	Natural England: Scoping Comments	Advise that long-term habitat change is also scoped in as the introduction of hard substrate as cable protection may impact the numbers and types of fish and shellfish species present along the cable route and in the vicinity.	Long-term habitat change has been referred to as permanent throughout per consultee request. This impact has been scoped in and is assessed in section 9.12.2.2.
23 February 2023	MD-LOT: Scoping Opinion	The Applicant sets out the study area and baseline data sources used for fish and shellfish ecology at sections 9.3 and 9.4 of the Scoping Report. The Scottish Ministers are broadly content with this approach, however, recommend that the additional datasets and studies highlighted by NatureScot and the RTC are, used to inform the EIA Report.	Noted. The additional datasets and studies have been added as appropriate based on consultee comments.
23 February 2023	MD-LOT: Scoping Opinion	Concerning the baseline characterisation at section 9.5 of the Scoping Report, NatureScot recommends that the EIA Report include the abundance of species as opposed to their monetary value which is a view supported by the Scottish Ministers. The Applicant is also directed to NatureScot representation as regards the omission of the Firth of Forth Banks Complex ncMPA from the list of protected sites. Potential impacts to the designated features of the ncMPA must be assessed in the EIA Report, as detailed in paragraph 5.5.8 below. The Scottish Ministers further direct the Applicant to the NatureScot representation regarding the contextual information on priority marine features and	Monetary value of fish and shellfish species is considered in Volume 2, Chapter 12: Commercial Fisheries. Species of commercial importance have been assessed in section 9.7.1.3 of this chapter, using ecological parameters and not commercial value. The Firth of Forth Banks Complex ncMPA is designated for a number of benthic features. However, none are of specific relevance to fish and shellfish receptors. This designated site has been considered in the context of Chapter 8: Benthic Subtidal and Intertidal Ecology.

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this ES Chapter
		recommendation on the inclusion of the presence/ absence of sandeel which must be fully considered in the EIA Report.	PSA data collected for potential of suitable sandeel habitat in the fish and shellfish ecology study area is discussed in section 9.7.1.2.
23 February 2023	MD-LOT: Scoping Opinion	The Applicant is further directed to representation from the RTC as regards the baseline characterisation and environment to be assessed in the EIA Report. The Scottish Ministers advise that the Applicant address comments on the migratory timings of Atlantic salmon, Sea trout and European eel as highlighted by the RTC.	Noted, Atlantic salmon, Sea trout, and European eel migratory timings have been discussed in sections 9.7.1.4.1, 9.7.1.4.2, and 9.7.1.4.4.
23 February 2023	MD-LOT: Scoping Opinion (*NatureScot*)	Table 9-3 provides a summary of the potential impacts to be scoped in and out of the EIA Report in respect of this receptor. The Scottish Ministers advise that pre-construction seabed preparation works should be included within the assessment of temporary and long term habitat loss/disturbance throughout all phases of the Proposed Works in line with NatureScot representation.	Seabed preparation works are considered temporary therefore have been considered in section 9.12.1.1 as part of the assessment of temporary habitat and species disturbance or loss. Permanent habitat loss during the operational phase resulting from the installation of external protection is assessed in section 9.12.2.2.
23 February 2023	MD-LOT: Scoping Opinion (*NatureScot and SFF*)	In addition, the impact of underwater noise on this receptor should be scoped into the EIA Report for pre-construction activities such as UXO clearance and geophysical activities which emit significant underwater noise, including impacts to diadromous fish features of designated sites. The Applicant is further advised to take implement the NatureScot representation in terms of the need to include further evidence within the EIA Report in relation to the impact pathway of underwater noise on fish species during construction and decommissioning. This view is further supported by the SFF representation.	Following further consultation and discussions with MMO, and MD-LOT, as outlined in the second row of this table, UXO clearance is not anticipated, and this activity is not included in the Marine Scheme. As such UXO clearance has not been considered further as part of this ES. The rationale for this is included in full within Volume 2, Chapter 5: Project Description; in summary: • The exact locations of potential UXO / UXO are not currently known and will not be known until detailed design, as informed by UXO surveys along the route of the Marine Scheme; • The corridor for the Marine Scheme is approximately 1 km wide. A key reason for adopting this corridor is to provide the construction contractor(s) with flexibility to micro-route around potential UXO / UXO;

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this ES Chapter
			• If at a later stage UXO clearance is required, it will be subject to a robust assessment at the time based on data regarding UXO to enable a meaningful assessment; and • In the event that such an assessment is required, it will be subject to separate marine licensing requirements and European Protected Species licensing requirements. Considering this feedback, as well as feedback from other stakeholders, underwater noise is now scoped in for assessment. This impact is addressed within section 9.12.1.3.
23 February 2023	MD-LOT: Scoping Opinion (*NatureScot and SFF*)	The Scottish Ministers advise that the impact pathway of thermal emissions from operational cables should be considered alongside the assessment of EMF and therefore be scoped in to the EIA Report. This corresponds with NatureScot and SFF representation.	Thermal emissions, while an operational impact like EMF, are considered separately owing to the different impact they can have on species. They are considered to represent distinct pathways with differing bodies of supporting literature. For ease of assessment, they have been considered separately. The assessment of thermal emissions can be found in section 9.12.1.3 and EMF is considered in section 9.12.2.1.

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this ES Chapter
23 February 2023	MD-LOT: Scoping Opinion (*NatureScot*)	Given the colonisation of hard structures has been scoped in to the benthic subtidal and intertidal ecology receptor, the Scottish Ministers recommend that the Applicant scope this impact into the fish and shellfish ecology receptor in line with NatureScot advice.	Impacts associated with colonisation of hard structures, such as rock protection, have been considered in Volume 2, Chapter 8: Benthic Subtidal and Intertidal Ecology. There is no documented evidence of marine developments affecting the prey species of benthic receptors, as such no assessment of this impact pathway is proposed. This notwithstanding, were significant effects on benthic receptors to be identified, potential indirect impacts on species which may depend on that receptor as a prey species would be assessed herein. However, as no significant impact was identified in relation to colonisation of hard structures, there is no opportunity for consequent indirect impacts on fish and shellfish ecology receptors. This has therefore not been addressed within this chapter.
23 February 2023	MD-LOT: Scoping Opinion	With regards to the assessment approach, the Scottish Ministers advise that the NatureScot representation on the need to consider ocean quahog aggregations both alone and in-combination as part of the assessment on all three areas comprising the Firth of Forth Bank Complex ncMPA must be fully addressed in the EIA Report. The Scottish Ministers re-emphasise NatureScot comments on the need to include more detailed maps within the EIA Report showing the Proposed Works in relation to neighbouring wind farms and the ncMPA in addition to maps detailing the location of protected features within the MPA itself. The Scottish Ministers are in agreement with this approach.	The Firth of Forth Banks Complex ncMPA is designated for a number of benthic features, including ocean quahog. This site does not contain any features specific to fish and shellfish ecology, consequently is not considered herein. Ocean quahog, as a benthic feature will be considered in Volume 2, Chapter 8: Benthic Subtidal and Intertidal Ecology. Please see the Marine Protected Area and Marine Conservation Zone Assessment in full (provided as a supporting document to the MLA).
23 February 2023	MD-LOT: Scoping Opinion	In terms of mitigation measures outlined at section 9.6 of the Scoping Report, the Scottish Ministers advise that where significant impact pathways have been identified, the full range of mitigation techniques and published guidance is considered and discussed in the EIA Report.	Noted. Mitigation will be considered where potential significant effects are identified, as per the EIA methodology (Volume 2, Chapter 3: EIA Methodology).
23 February 2023	MD-LOT: Scoping Opinion (*NatureScot*)	With regard to the cumulative impacts on fish and shellfish ecology considered by the Applicant at section 9.8, the Scottish Ministers advise that the assessment must consider cumulative impacts in combination with the proposed Berwick Bank wind farm	The Firth of Forth Banks Complex ncMPA is designated for a number of benthic features, including ocean quahog. This site does not contain any features specific to fish and shellfish ecology, consequently the site is

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this ES Chapter
		and neighbouring (consented) wind farms in the Forth and Tay area, with their associated export cables, especially in relation to impacts to the ncMPA. The Scottish Ministers direct the Applicant to the NatureScot representation for further advice on the presentation of information which should be implemented within the EIA Report.	instead considered in Volume 2, Chapter 8: Benthic Subtidal and Intertidal Ecology. Independent of the ncMPA, the CEA addresses cumulative impacts relevant to fish and shellfish receptors in full in section 9.14. Justification for the shortlist of third party developments which were considered cumulatively is also provided in section 9.14.
February 2023	MD-LOT Scoping Opinion	The Scottish Ministers agree with the Applicant that transboundary impacts on fish and shellfish ecology can be scoped out of the EIA Report as outlined at Table 16-1 of the Scoping Report.	Noted.
14 March 2023	MMO: Scoping Opinion	Appropriate data sources have been used to inform the fish ecology baseline, as indicated in section 9.4 of the report, You have identified the key marine and migratory fish receptors of commercial and ecological importance within the vicinity of the works and identified relevant species that may be vulnerable to the impacts arising from the proposed works.	Noted.
14 March 2023	MMO: Scoping Opinion (*Cefas*)	The scoping report has identified that the cable route overlaps sandeel (Ammodytidae) habitat and Atlantic herring (Clupea harengus) spawning grounds (as per Coull *et al.*, 1998) and Ellis *et al.*, 2012) Therefore, in addition to the data sources outlined in Section 9.4, I recommend that you follow the methodology described in MarineSpace (2013a and 2013b) to determine potential spawning habitat suitability for sandeel and herring respectively. The MarineSpace method assigns confidence levels to a suite of data to provide 'heat maps' indicating suitable spawning grounds and habitat. I note that particle size analysis (PSA) data acquired during benthic surveys of the cable route will be used to inform the herring and sandeel habitat assessments. The PSA data should be included for use when following the MarineSpace methodologies. For the assessment of potential herring spawning habitat, you should use the latest 10 years of International Herring Larvae Survey (IHLS) data. IHLS data is available to download from the International Council for the Exploration of the Sea (ICES) website; Eggs and larvae (ices.dk)	In line with this comment also received from Cefas, the suggested methodologies have been used to determine habitat spawning suitability as suggested. The herring spawning assessment is presented in Volume 3, Appendix 9.1 and summarised in section 9.6 and 9.7.1.2. PSA has since been undertaken on samples obtained during a benthic survey of the Marine Scheme Export Cable Corridor (see section 9.6.2). International Herring Larvae Survey data was also used to identify potential herring spawning grounds located within the fish and shellfish ecology study area, presented in Volume 3, Appendix 9.1 and summarised in section 9.7.1.2.

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this ES Chapter
14 March 2023	MMO: Scoping Opinion	The MMO are satisfied that all impacts that have potential to cause adverse effects to fish receptors as a result of the proposed works have been identified. Impacts are as follows: • Temporary habitat and species disturbance or loss. • Temporary increases in suspended sediment concentrations (SSC) and associated sediment deposition and potential release of contaminants. • Underwater noise. • Accidental release of pollutants. • Pre-installation surveys including - Geophysical/ Geotechnical/ Archaeological surveys. • EMF effects. • Long-term habitat loss and disturbance. • Thermal emissions from operational cables. • Accidental release of pollutants.	The Applicant notes that the MMO are content that all relevant impacts were identified and assessed by the Scoping Report. Responses to the Scoping Opinion are provided below.
14 March 2023	MMO: Scoping Opinion	You have scoped out the impacts of underwater noise on fish however, there is still potential for behavioural disturbance to fishes, particularly during their spawning periods as a result of underwater noise. This is of particular relevance to herring and cod which have a swim bladder involved in hearing and are vulnerable to noise disturbances (Popper *et al.*, 2014). In addition, herring are benthic spawners that rely on a specific substrate on which to lay their eggs, hence if noise disturbance causes the fish to 'flee' the area, then there may not be suitable alternative spawning grounds nearby. Furthermore, as the cable passes through herring spawning grounds, there is potential for in-combination and cumulative adverse effects to occur as a result of noise disturbance and disturbance to spawning habitat if works are carried out during the herring spawning season. The Banks1 herring population spawn off the north-east coast of England between August and October (inclusive). For these reasons, the MMO recommend that the effects of underwater noise are scoped into the EIA.	Underwater noise has since been scoped in for assessment. The assessment can be found in section 9.12.1.3.

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this ES Chapter
14 March 2023	MMO: Scoping Opinion (*Cefas*)	There is potential for unexploded ordnance (UXO) (Section 3.4 & 14.5; point 5) to be present along the cable route. Therefore, there is a potential for significant adverse impacts to occur to fish should UXO clearance / detonation be required. The MMO recognise that UXO clearance works will fall under a separate marine licence and do not form part of this consultation. In the event that UXO clearance works are required along the cable route the MMO advise that Cefas fisheries advisors are consulted through the MMO. Detailed UXO surveying results should also be provided as part of the initial UXO licence application documentation.	Following further consultation and discussions with MMO, as outlined in the second row of this table, UXO clearance is not anticipated, and this activity is not included in the Marine Scheme. As such UXO clearance has not been considered further as part of this ES. The rationale for this is included in full within Volume 2, Chapter 5: Project Description; in summary: • The exact locations of potential UXO / UXO are not currently known and will not be known until detailed design, as informed by UXO surveys along the route of the Marine Scheme; • The corridor for the Marine Scheme is approximately 1 km wide. A key reason for adopting this corridor is to provide the construction contractor(s) with flexibility to micro-route around potential UXO / UXO; • If at a later stage UXO clearance is required, it will be subject to a robust assessment at the time based on data regarding UXO to enable a meaningful assessment; and In the event that such an assessment is required, it will be subject to separate marine licensing requirements and European Protected Species licensing requirements. Underwater noise associated with geophysical activities has been included within section 9.12.1.3.
14 March 2023	MMO: Scoping Opinion	You have has scoped out pre-installation surveys (geophysical/geotechnical) from your impact assessment. Some of the surveys you are expected to carry out include; multi-beam echo sounder (MBES), side-scan sonar, drop-down video (DDV), remotely operated vehicle (ROV)/diver based surveys, magnetometer surveys, grab sampling and core surveys. Given the short duration and limited scale of impact for these activities, the MMO agree that pre-installation surveys can be scoped out.	Noted, however underwater noise impacts on fish and shellfish receptors have been scoped in to address stakeholder comments from NatureScot, MD-LOT, Cefas, and MMO.

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this ES Chapter
14 March 2023	MMO: Scoping Opinion (*Cefas*)	You have scoped out thermal emissions from operational cables from the impact assessment. You acknowledge that buried cables can increase sediment temperatures by 2.5°C but concludes that significant impacts to fish are unlikely to occur. The MMO recommend that thermal emissions from operational cables are scoped into the assessment for herring and sandeel specifically. Herring are benthic spawners that lay their eggs on gravel substrate. The newly hatched larvae also remain close to the seabed during their yolk absorption period. The duration of egg development and yolk absorption in herring is temperature dependant (see Tables 1 and 2), therefore changes in sediment temperature have the potential to affect egg and larval development. Sandeels spawn, burrow and hibernate in the sandy sediments. They hibernate during winter months and spawn on the sediment between November to February (inclusive). Sandeel productivity is understood to be affected by temperature in multiple life stages including during their reproductive cycle (Wright *et al.*, 2017a, 2017b) and during their egg development (Regnier *et al.*, 2018). Accordingly, if seabed sediment temperatures alter beyond natural levels, the environmental conditions that herring and sandeel rely upon for their natural ecology (synchronised spawning/feeding/burrowing behaviour) may also be altered, with potential to cause adverse effects to individuals located above or near to export cables.	Thermal emissions have since been scoped in for assessment. This can be found in section 9.12.2.3.
14 March 2023	MMO: Scoping Opinion	You have scoped in 'temporary habitat and species disturbance or loss' into the assessment which is appropriate. You have stated that PSA data acquired during benthic surveys of the cable route will be used to inform the herring spawning habitat and sandeel habitat assessments. These assessments will be integral in identifying any overlaps of the cable route with herring spawning habitat and sandeel habitat, as well as any overlaps in the timing of seabed preparation and cable installation activities with herring and sandeel spawning and hibernation periods.	PSA has since been undertaken on samples obtained during a survey of the Marine Scheme Export Cable Corridor. The findings contributed to the determination of habitat suitability for herring and sandeel spawning (following the method in section 9.6). As requested by the MMO and Cefas, a herring spawning and sandeel habitat assessment has been undertaken, presented in Volume 3, Appendix 9.1 and summarised in section 9.6 and 9.7.1.2.
14 March 2023	MMO: Scoping Opinion	You have stated that "Given the limited potential for significant fish spawning grounds along the offshore export cable route and the	PSA was conducted for samples taken within the Marine Scheme Offshore Export Cable Corridor. These results

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this ES Chapter
	(*Cefas*)	localised nature and small scale of direct seabed disturbance the potential for significant impacts to occur is unlikely." However, at this stage it is premature to make this assumption as an appropriate assessment to determine the extent and intensity of herring spawning habitat and sandeel habitat has not yet been undertaken. Nor has the timing of seabed preparation and cable installation activities been considered in relation to herring and sandeel spawning and hibernation periods. The likelihood of significant impacts occurring should be determined on the outcomes of the EIA.	were applied to herring and sandeel spawning grounds in sections 9.7.1.2.1 and 9.7.1.2.2 respectively. Demersal spawners have been considered separately within the assessment on temporary habitat and species disturbance or loss (section 9.12.1.1) and within the assessment on permanent habitat loss and associated temporary disturbance (section 9.12.1.2).
14 March 2023	MMO: Scoping Opinion	You have scoped in the effects of electro-magnetic fields (EMF) as a potential impact to electro-sensitive fish receptors, which the MMO agree is appropriate. You have cited a recent paper by Hutchison *et al.* (2020a) which considers the effects of EMF on benthic dwelling marine species. The MMO direct you to additional papers by Hutchison *et al.* (2020b, 2021) that may also be useful to inform the assessment of EMF. In accordance with the National Policy Statement for Renewable Energy Infrastructure (EN-3) (Dept. of Energy & Climate Change, 2011) Cefas fisheries advisors recommend minimising the potential effects of EMF (and sediment heating) by laying cables to a depth of greater than 1.5 m. The effects of EMF on sensitive species e.g., elasmobranchs may be mitigated by adopting this recommendation by increasing the distance between the EMF and the receptor. We recognise that this may be subject to local seabed geology and other receptors in the area	Noted. The suggested papers have been referenced in section 9.12.2.1.
14 March 2023	MMO: Scoping Opinion (*Cefas*)	You have scoped in long-term habitat loss and disturbances into the assessment. This potential impact should be scoped in, however, unless you are confident that you will remove all cable protection materials (e.g., rock berms, mattresses etc) after the projects lifetime then you should assess this habitat loss as permanent, rather than long-term	This has now been referred to as permanent throughout. This impact is assessed in section 9.12.2.2.

9.6. Methodology to Inform Baseline

9.6.1. Desktop Study

11. Information on fish and shellfish ecology within the fish and shellfish ecology study areas was collected through a detailed desktop review of existing studies and datasets. These are summarised in Table 9.4. below.

Table 9.4 Summary of key desktop studies & datasets

Title	Source	Year	Author
Berwick Bank Wind Farm Environmental Impact Assessment Report: Volume 2, Chapter 9: Fish and Shellfish Ecology and associated Appendix 9.1: Fish and Shellfish Ecology Technical Report	https://marine.gov.scot/node/23315	2022	BBWFL
Seagreen Phase 1 (Seagreen Alpha and Seagreen Bravo) Environmental Statement Natural Fish and Shellfish Resource	https://marine.gov.scot/data/environmental-statement-volume-1-main-text-seagreen-alpha-and-bravo-offshore-wind-farms	2012	Seagreen
Blyth Offshore Demonstration Project Environmental Statement: Supplementary Environmental Information	https://marinelicensing.marinemanagement.org.uk/mmofox5/fox/live/	2020	Narec
Scotland England Green Link 1 / Eastern Link 1 - Marine Scheme. Environmental Appraisal Report	https://marine.gov.scot/data/marine-licence-application-segl-eastern-link-1-hvdc-cable-and-cable-protection-torness-hawthorn	2022	National Grid and Scottish Power
Eastern Green Link 2 Environmental Appraisal Report Volume 2 Chapter 9 - Fish and Shellfish Ecology.	https://marine.gov.scot/ml/marine-licence-eastern-green-link-2-egl2-hvdc-cables-and-cable-protection-peterhead-drax-00009943	2022	National Grid and SSEN
Developing Essential Fish Habitat maps for fish and shellfish species in Scotland Report	https://www.gov.scot/binaries/content/documents/govscot/publications/research-and-analysis/2023/05/developing-essential-fish-habitat-maps-fish-shellfish-species-scotland-report/documents/developing-essential-fish-habitat-maps-fish-shellfish-species-scotland-report/developing-essential-fish-habitat-maps-fish-shellfish-species-scotland-report/govscot%3Adocument/developing-essential-fish-habitat-maps-fish-shellfish-species-scotland-report.pdf	2022	Franco, Smyth and Thomson
Fisheries sensitivity maps in British Waters.	https://www.cefas.co.uk/media/o0fgfobd/sensi_maps.pdf	1998	Coull *et al.*
A verified distribution model for the lesser sandeel (*Ammodytes marinus*)	https://marine.gov.scot/maps/1899	2021	Langton *et al.*
Mapping the spawning and nursery grounds of selected fish for spatial planning.	https://www.cefas.co.uk/publications/techrep/TechRep147.pdf	2012	Ellis *et al.*
International Herring Larvae Survey data	https://www.ices.dk/data/dataset-collections/Pages/default.aspx	2007-2017	ICES
Review of migratory routes and behaviour of Atlantic salmon, sea trout and European eel in Scotland's coastal environment: implications for the development of marine renewables.	https://data.marine.gov.scot/dataset/review-migratory-routes-and-behaviour-atlantic-salmon-sea-trout-and-european-eel-scotland%E2%80%99s	2010	Malcolm *et al.*
UK protected sites	https://jncc.gov.uk/our-work/uk-protected-areas/	2022	JNCC

Title	Source	Year	Author
The Marine Life Information Network	https://www.marlin.ac.uk/	Various	MarLIN
Fishbase	https://www.fishbase.org.au/v4	2023	Fishbase
Key to the marine and freshwater fishes of Britain and Ireland	https://cieem.net/resource/key-to-the-marine-and-freshwater-fishes-of-britain-and-ireland/		Maitland and Herdson (2009)

9.6.2. Site-specific Surveys

12. A benthic subtidal survey was completed in 2020 in the BBWF array area and Offshore Export Cable Corridor into Branxton, East Lothian. This included grab samples, Drop Down Video (DDV) sampling and epibenthic trawls. Data collected as part of this survey has been used to inform the fish and shellfish ecology baseline for the Marine Scheme. No further site-specific surveys have been undertaken to inform the EIA for fish and shellfish ecology as agreed through scoping.

13. Where appropriate, information from the benthic survey undertaken in 2022 along the Offshore Export Cable Corridor, has been used to inform the assessment of fish and shellfish ecology associated with the Marine Scheme. Further information is provided in section 8.6.2 of Volume 2, Chapter 8: Benthic Subtidal and Intertidal Ecology. Benthic sediment samples were taken during the survey which enabled PSA to be undertaken. PSA data have been reviewed to determine the suitability of the seabed across the Marine Scheme as a spawning habitat for sandeel and herring. Benthic samples were obtained at 58 stations along the Offshore Export Cable Corridor.

9.7. Baseline Environment

9.7.1. Overview of Baseline Environment

14. This section outlines the current baseline for fish and shellfish ecology within the fish and shellfish ecology study area, including diadromous fish rivers and designated sites within the 100 km diadromous fish study area, as outlined in Figure 9.1. The characterisation of the current baseline environment has been informed by a combination of site-specific and desk-based sources and has been augmented through consultation with key stakeholders.

9.7.1.1. DESIGNATED SITES AND PROTECTED SPECIES

9.7.1.1.1. FISH AND SHELLFISH SPECIES OF CONSERVATION IMPORTANCE

15. There are several fish and shellfish species known to be present in the fish and shellfish ecology study area which are protected under international and national conservation legislation or policy. These species are listed in Table 9.5 below. All species listed in Table 9.5 can be found in both Scottish and English waters.

16. Table 9.5 outlines species thought to be present in the fish and shellfish ecology study area which fall under the following protections:

- Habitats Directive Annex II and Annex IV Species;
- OSPAR list of threatened and/or declining species;
- Bonn Convention Appendix I and II species;
- Bern Convention Appendix II and III species;
- Wildlife and Countryside Act 1981;
- UK Post-2010 Biodiversity Framework;
- English Features of Conservation Interest (FOCI);

- IUCN Red List; and
- Scottish Priority Marine Features (PMF).

Table 9.5 Summary of relevant fish and shellfish species protected by national and international policy or legislation

Common Name	Latin Name	Habitats Directive Annex II and Annex IV Species	OSPAR list of threatened and/ or declining species	Bonn Convention Appendix I and II species	Bern Convention Appendix II and III species	Wildlife and Countryside Act 1981	UK Post-2010 Biodiversity Framework	English FOCI	IUCN Red List[5]*	Scottish PMF*
Atlantic salmon	*Salmo salar*	✓	✓				✓	✓	LC (-)	✓+
Sea trout	*Salmo trutta*						✓		LC (?)	✓+
Sea lamprey	*Petromyzon marinus*	✓	✓		✓		✓	✓	LC (↔)	✓+
River lamprey	*Lampetra fluviatilis*	✓					✓	✓	LC (?)	
European eel	*Anguila anguila*		✓	✓			✓	✓	CR (↓)	✓+
Herring	*Clupea harengus*						✓	✓	LC (↑)	
Mackerel	*Scomber scrombus*						✓	✓	LC (↓)	
Haddock	*Melanogrammus aeglefinus*								VU (-)	

[5] IUCN Red List defined as 'CR'= Critically Endangered, 'EN' = Endangered, 'VU' = Vulnerable, 'NT' = Near Threatened, 'DD' = Data Deficient, and 'LC' = Least Concern. Population trends are defined in brackets as '↑' = increasing, '↓' = decreasing, '↔' = stable, '-' = unspecified, '?' = unknown.

✓- = Offshore waters; ✓+ = Territorial waters; and ✓± = Both

Common Name	Latin Name	Habitats Directive Annex II and Annex IV Species	OSPAR list of threatened and/ or declining species	Bonn Convention Appendix I and II species	Bern Convention Appendix II and III species	Wildlife and Countryside Act 1981	UK Post-2010 Biodiversity Framework	English FOCI	IUCN Red List[5]*	Scottish PMF*
Cod	*Gadus morhua*		✓				✓	✓	VU (-)	✓±
Whiting	*Merlangius merlangus*						✓	✓	LC (?)	✓±
Plaice	*Pleuronectes platessa*						✓	✓	LC (↑)	
Sandeel	*Ammodytidae*						✓	✓	LC (?)	✓±
Spotted ray	*Raja montagui*		✓						LC(↔)	
Thornback ray	*Raja clavata*		✓						LC (↓)	
Spurdog	*Squalus acanthias*		✓				✓		EN (↓)	✓+
Sprat	*Sprattus sprattus*								LC (?)	
Tope shark	*Galeorhinus galeus*						✓		CR (↓)	✓+
Common blue skate	*Dipturus batis*		✓			✓	✓		CR (↓)	✓±
Freshwater pearl mussel	*Margaritifera margaritifera*	✓			✓				EN (↓)	

9.7.1.1.2. DESIGNATED SITES

17. The 10 km fish and shellfish ecology study area overlaps with three designated sites: the Firth of Forth Banks Complex Nature Conservation Marine Protected Area (ncMPA), the Farnes East MCZ, Berwick to St Mary's MCZ and the Coquet to St Mary's MCZ. The Berwick to St Mary's MCZ is designated for common eider and the remaining sites are designated for a number of seabed habitats. However, these features are not linked to the conservation status of the fish and shellfish qualifying features, and therefore they are not considered further within this assessment.

18. The Farnes East MCZ and Forth Banks Complex MPA are additionally designated for ocean quahog. This species is assessed within Volume 2, Chapter 8: Benthic Subtidal and Intertidal Ecology. Therefore, ocean quahog are not considered within this assessment.

19. There are several Special Areas of Conservations (SACs) located within the wider 100 km diadromous fish study area, including the River Tweed SAC, River Teith SAC, River Tay SAC, and River South Esk SAC. Therefore, it is likely diadromous species will cross the fish and shellfish ecology study area when migrating to/from these SACs. Table 9.6 provides detail on these designated sites and the primary and non-primary qualifying features in relation to fish and shellfish ecology.

Table 9.6 Summary of designated sites designated for diadromous fish within the diadromous fish study area

Site Name	Scotland / England	Distance from Marine Scheme (km) (by sea)[6]	Primary Designation	Qualifying Features	Comments
River Tweed SAC	England	34	Atlantic Salmon	River lamprey, sea lamprey, and brook lamprey	The River Tweed is also a designated Special Site of Scientific Interest (SSSI) (JNCC, 2017; SNH, 2017). It is likely that these species will cross over the fish and shellfish ecology study area.
Tweed Estuary SAC	England	40	Estuaries, Mudflats and sandflats not covered by seawater at low tide	River lamprey, and sea lamprey	The estuary of the River Tweed is designated for habitats which support species including migratory Atlantic salmon, and occasional records of river lamprey and sea lamprey. It is likely that these species will cross over the fish and shellfish ecology study area therefore this SAC has been considered.
River Dee SAC	Scotland	71	Freshwater pearl mussel (*Margaritifera margaritifera*), Atlantic salmon, and Otter (*Lutra lutra*)	N/A	The River Dee has been considered due to it being used by migratory species, and it is likely that the species will cross over the fish and shellfish ecology study area.
River Teith SAC	Scotland	100	River lamprey, sea lamprey, and brook lamprey	Atlantic salmon	The River Teith has been considered due to the Firth of Forth being used by migratory species, and it is likely that the species will cross over the fish and shellfish ecology study area.

[6] This distance is to the closest point of the Marine Scheme.

Site Name	Scotland / England	Distance from Marine Scheme (km) (by sea)[6]	Primary Designation	Qualifying Features	Comments
River Tay SAC	Scotland	90	Atlantic salmon	River lamprey, sea lamprey, and brook lamprey	The River Tay has been considered due to the Firth of Tay being used by migratory species, and it is likely that the species will cross over the fish and shellfish ecology study area.
River South Esk SAC	Scotland	62	Atlantic salmon and freshwater pearl mussel	N/A	The River South Esk has been considered due to the channel to the river mouth being used by migratory species, and it is likely that the species will cross over the fish and shellfish ecology study area.

9.7.1.2. SPAWNING AND NURSERY AREAS

20. Fisheries sensitivity maps (Coull et al., 1998; Ellis et al., 2012) indicate that the Marine Scheme overlaps with spawning grounds for cod, herring, lemon sole, Nephrops, plaice, sandeel, sprat, and whiting. The Marine Scheme overlaps with the nursery grounds of anglerfish, blue whiting, cod, common skate, European hake, haddock, herring, lemon sole, ling, mackerel, Nephrops, plaice, saithe, sandeel, spotted ray, sprat, spurdog, and tope shark. The species which use the fish and shellfish ecology study area as spawning and nursing grounds are listed in Table 9.7. The spatial extent of these spawning and nursery grounds are shown in Volume 4, Figure 9.2, Figure 9.3 and Figure 9.4.

21. Demersal spawners, which burrow their eggs into the seabed or in nests along the bottom of the ocean, are sensitive to seabed disturbance. Demersal spawners include herring and sandeel – both of which are thought to utilise the fish and shellfish ecology study area, (Table 9.7). The suitability of the seabed for herring and sandeel spawning is considered in section 9.7.1.2.1 and section 9.7.1.2.2 respectively. Owing to their increased sensitivity, demersal spawners have been considered in the EIA separately.

22. Pelagic spawners release their eggs into the water column where they drift with the ocean currents. Of the species which have spawning or nursery grounds within the fish and shellfish ecology study area, as listed in Table 9.7, the majority are pelagic spawners (with the exception of herring and sandeel, as described above). Due to their low sensitivity to seabed disturbance, potential impacts on pelagic spawners are not considered further in the context of this assessment.

23. Of the remaining species listed in Table 9.7, common skate, spotted ray and spurdog are oviparous meaning they lay eggs on the seabed in the form of egg cases. The number of eggs laid is significantly less than those released by other demersal spawning species. Tope shark are ovoviviparous, meaning they carry eggs within the body of the parent. These eggs hatch internally.

Table 9.7 Summary of spawning and nursery grounds within the fish and shellfish ecology study area

Species	Reproductive strategy[7]	Spawning		Nursery	
		Ellis *et al.* (2012)	Coull *et al.* (1998)	Ellis *et al.* (2012)	Coull *et al.* (1998)
Anglerfish	Pelagic spawner	-	-	✓	-
Blue whiting	Pelagic spawner	-	-	✓	-
Cod	Pelagic spawner	✓	✓	✓	✓
Common skate	Oviparous	-	-	✓	-
European hake	Pelagic spawner	-	-	✓	-
Haddock	Pelagic spawner	-	-	-	✓
Herring	Demersal spawner	-	✓	✓	✓

[7] Demersal spawners lay eggs on the seabed. In comparison, pelagic spawners release eggs into the water column. Oviparous species reproduce by carrying eggs within their bodies which hatch within the parent.

Species	Reproductive strategy[7]	Spawning		Nursery	
		Ellis *et al.* (2012)	Coull *et al.* (1998)	Ellis *et al.* (2012)	Coull *et al.* (1998)
Lemon sole	Pelagic spawner	-	✓	-	✓
Ling	Pelagic spawner	-	-	✓	-
Mackerel	Pelagic spawner	-	-	✓	-
Nephrops	Pelagic spawner	-	✓	-	✓
Plaice	Pelagic spawner	✓	✓	✓	✓
Saithe	Pelagic spawner	-	-	-	✓
Sandeel	Demersal spawner	✓	✓	✓	✓
Spotted ray	Oviparous	-	-	✓	-
Sprat	Pelagic spawner	-	✓	-	✓
Spurdog	Oviparous	-	-	✓	-
Tope shark	Ovoviviparous	-	-	✓	-
Whiting	Pelagic spawner	✓	✓	✓	✓

9.7.1.2.1. HERRING SPAWNING GROUNDS

24. Herring are pelagic fish which are dependent on specific seabed habitats for spawning. As demersal spawners, they congregate together in shoals to lay dense sticky 'egg carpets' where they remain on the seabed. Eggs are typically laid on gravel and other coarse sediments (Ellis et al., 2012). Due to their dependence on substrate type for spawning behaviour, herring are considered to be sensitive to habitat disturbance and changes to substrate type.

25. As stated above, the fish and shellfish ecology study area overlaps with identified spawning grounds for herring according to Coull et al. (1998). Spawning of indeterminate intensity occurs within the Marine Scheme area, largely beyond 12 nm. Several spawning stocks exist within UK waters. The fish and shellfish ecology study area overlaps with the spawning grounds likely associated with the Banks or Dogger herring stock, which spawn in the Central North Sea (CNS) and off the English coast from August until October, or the Buchan herring stock which spawns further north in Scottish waters in August and September (Coull *et al.*, 1998; Ellis *et al.*, 2012). Habitat maps prepared under the ScotMER programme indicate that the majority of the seabed within the Marine Scheme is not suitable for herring spawning with the exception of isolated areas of suitable habitat within the south of the Marine Scheme in English waters (Franco, Smyth and Thomson, 2022).

26. The potential for herring spawning has been further examined using site-specific PSA data to understand if the preferred spawning habitat for herring is present in the fish and shellfish ecology study area. This was undertaken using the methodology devised by Reach *et al*. (2013), in MarineSpace Ltd (2013b). Using this method, locations were classified as "preferred", "marginal" and "unsuitable" habitat for herring spawning based on sediment composition, as shown in Table 9.8able 9.8.

27. The suitability of the sediments in the fish and shellfish ecology study area for herring spawning habitat is shown in Volume 4, Figure 9.5.

Table 9.8 Herring potential spawning habitat (Reach et al., 2013)

% Particle Contribution (muds = <63 µm, sands = 63-2000 µm)	Habitat Sediment Preference	Folk Classification	Habitat Sediment Classification
<5% mud, >50% gravel	Prime	Gravel and part sandy; Gravel	Preferred
<5% mud, >25% gravel	Sub-prime	Part sandy gravel and part gravelly Sand	Preferred
<5% mud, >10% gravel	Suitable	Part gravelly Sand	Marginal
>5% mud, <10% gravel	Unsuitable	Everything excluding Gravel, part sandy Gravel and part gravelly Sand	Unsuitable

28. Ultimately, the PSA recorded high levels of muds (>5% of the sediment composition) and low proportions of gravels (<10%) across the majority of samples within the Marine Scheme. The proportion of muds ranged from 4.23% to 58.52% (average 21.05%). Gravels ranged from 0% to 52.29% (average 5.99%). Consequently, most sample locations were classified as muddy Sand under the Folk classification system (Natural Power, 2023). Overall, conditions were considered to be 'unsuitable' for herring spawning at all but one sample location, which alone was considered to be 'prime (preferred)' habitat. This site was the only one classified as sandy Gravel by the PSA (Natural Power, 2023).

29. Otter trawl and gill net surveys undertaken in support of the Blyth Demonstrator Offshore Wind Farm development, and subsequent additional phases, recorded only three herring during the peak spawning period (Narec, 2020). The Blyth Demonstrator Offshore Wind Farm and corresponding export cable infrastructure are located approximately 1 km from the Marine Scheme as it approaches landfall. Consequently, the development is located within an area of seabed which is common to the Marine Scheme. Despite limitations to the survey, the low numbers of herring recorded in the catch suggested that the area surveyed did not represent an important spawning ground for the Banks herring population (Narec, 2020).

30. Additionally, based on site-specific characterisation of the seabed within the Blyth Demonstrator Offshore Wind Farm development area, combined with findings of the IHLS survey, as analysed within the Narec (2020) documentation, herring present within the vicinity of the development are likely to be transiting to and from feeding and spawning grounds located to the north of the development location, as opposed to utilising resources in the area (Narec, 2020).

31. PSA data gathered for BBWF in Scottish waters showed that the majority of the BBWF array area was also unsuitable sediment for herring spawning. Only a small patch of suitable (marginal to sub-prime) habitat was identified in the northwest section of the BBWF array area (BBWFL, 2022). On the whole, these BBWF survey findings were in alignment with herring spawning expectations based on EMODnet seabed substrate data (BBWFL, 2022). This information is shown in Volume 4, Figure 9.5.

32. As requested by the MMO and Cefas during scoping (Table 9.3), a herring spawning assessment was undertaken for English waters using the MarineSpace Ltd (2013b) guidance (Volume 3, Appendix 9.1). In accordance with the MarineSpace Ltd (2013b) guidance, the herring spawning assessment involved processing and mapping various data sources considered to be indicators of herring spawning (e.g. BGS sediment data and IHLS data) to produce a heat map. The heat map was then used to understand the confidence in herring spawning at a particular location within the fish and shellfish ecology study area in English waters. Further details on the methodology are provided in Volume 3, Appendix 9.1.

33. The herring spawning assessment concluded that the majority of the fish and shellfish ecology study area in English waters was assessed as ‘medium’ confidence / heat for herring spawning, with only a small proportion (1.7%) identified as being ‘high’ or ‘very high’ confidence / heat for herring spawning. Therefore, it was considered that the Marine Scheme in English waters overlaps with only a small extent of herring spawning grounds in the context of the wider distribution of suitable habitats in the North Sea.

9.7.1.2.2. SANDEEL HABITAT SUITABILITY

34. Sandeel are seabed dependent for the vast majority of their adult and juvenile lives and inhabit burrows except when feeding and spawning (Van Deurs *et al.*, 2011; Tien *et al.*, 2017). During winter, they hibernate and remain inactive in their burrows for extended periods of time (Van Deurs et al., 2011). Sandeel spawning usually occurs in sandy sediments with a high proportion of medium and coarse sand and a low silt content (Holland et al., 2005; BEIS, 2022). Based on their dependence on the seabed across their lifecycles, sandeel are generally considered to be sensitive to disturbance and habitat loss. The Scottish Government Feature Activity Sensitivity Tool (FEAST) states that sandeel have a high sensitivity to sub-surface abrasion or penetration and a medium sensitivity to surface abrasion (Scottish Government, 2023).

35. As discussed in section 9.7.1.2, sandeel are thought to use the seabed in the vicinity of the Marine Scheme as both nursery grounds and during spawning (Coull et al., 1998; Ellis et al., 2012). The majority of the Offshore Export Cable Corridor overlaps with low intensity sandeel spawning grounds. However, the northern most extent of the part of the Marine Scheme within in Scottish waters overlaps with high intensity spawning areas (Ellis et al., 2012). Sandeel spawning occurs between November and February (Coull et al., 1998; Ellis et al., 2012).

36. The area of the Marine Scheme within Scottish waters which overlaps BBWF array area shows increased probability of sandeel presence compared to the majority of the Offshore Export Cable Corridor (Volume 4, Figure 9.6). Within the northernmost extent of the Marine Scheme, the probability of presence is 0.5-1 in places. Along the rest of the Marine Scheme area the probability of sandeel presence is largely zero. The density across the majority of the Marine Scheme is <30 per m^2 (Langton et al., 2021).

37. Sandeels prefer a substrate with a low percentage of fines (<10% mud) and a higher proportion of sand (>50%) for spawning. As above, the proportion of muds in the sediment ranged from 4.23% to 58.52% (average 21.05%). The proportion of sands ranged from 31.24% to 93.26% (average 72.98%) (Natural Power, 2023).

38. Sandeel spawning suitability was inferred from the PSA using the methods and habitat suitability categories devised by Latto *et al*. (2013), presented within MarineSpace Ltd (2013a, as cited in MarineSpace Ltd, 2018). Sample locations were categorised as “preferred”, “marginal” and “unsuitable” habitat for sandeel spawning, per the definitions in Table 9.9.

Table 9.9 Sandeel potential habitat (Latto *et al*., 2013)

% Particle Contribution (muds = <63 µm, sands = 63-2000 µm)	Habitat Sediment Preference	Folk Classification	Habitat Sediment Classification
<1% mud, >85% sand	Prime	Part Sand, part slightly gravely Sand and part gravelly Sand	Preferred
<4% mud, >70% sand	Sub-prime	Part Sand, part slightly gravelly Sand and part gravelly Sand	Preferred
<10% mud, >50% sand	Suitable	Part gravelly Sand and part sandy Gravel	Marginal
>10% mud, <50% sand	Unsuitable	Everything excluding Gravel, part sandy Gravel and part gravelly sand	Unsuitable

39. The PSA results from the survey indicated that the habitat along the Marine Scheme was mainly 'unsuitable' for sandeel spawning. While the proportion of sand within the samples was often consistent with sandeel preferences, the proportion of muds was inconsistent with sandeel spawning habitat. At only seven sample locations, the sediment was considered to be 'suitable (marginal)' habitat for sandeel spawning. These samples were either located within 4 km of the coastline at the landfall in English waters or associated with an area of seabed further offshore in English waters, close to the boundary of the BBWF. The remaining 50 sample locations were all considered to be 'unsuitable' for sandeel spawning. The suitability of the sediments in the fish and shellfish ecology study area for sandeel spawning habitat is shown in Volume 4, Figure 9.7.

40. The Blyth Demonstrator Offshore Wind Farm documentation suggested that the majority of the seabed surveyed in the development area was unsuitable for sandeel spawning. Therefore, the area as a whole was not considered to be prime habitat for sandeel populations (Narec, 2020).

41. The BBWF survey data showed that the majority of the array in Scottish waters area was considered to be marginal to sub-prime habitat for sandeel spawning. One localised sample was identified to be prime sandeel habitat. Only a small patch of unsuitable habitat was identified in the northwest of the BBWF array area. This generally aligned with the EMODnet habitats predicted to be within the array area (BBWFL, 2022). This is shown in Volume 4, Figure 9.5.

42. As per herring, the MMO and Cefas also requested a sandeel habitat assessment for English waters using the MarineSpace Ltd (2013a) guidance (Volume 3, Appendix 9.1). The sandeel habitat assessment follows a similar methodology to the herring spawning assessment described above, combining a range of data sources to understand the confidence in sandeel spawning or burrowing within the fish and shellfish ecology study area in English waters. Further details on the methodology are provided in Volume 3, Appendix 9.1.

43. The sandeel habitat assessment concluded that the majority of the fish and shellfish ecology study area in English waters overlaps with areas of 'medium' or 'high' confidence / heat for sandeel habitat, with increasing confidence in the north of the study area. However, it was highlighted that the heat map for sandeel habitat may overestimate sandeel spawning and burrowing. In line with the MarineSpace Ltd (2013a) guidance, the heat map uses VMS data for demersal fishing gear as an indicator of sandeel habitat. However, demersal trawlers within the region mainly target Nephrops, and therefore, the use of this data source may overrepresent sandeel spawning and burrowing activity. Furthermore, slight discrepancies between the PSA data (described above) and the BGS sediment data were identified, including areas in the north of the fish and shellfish ecology study area that were interpreted as 'preferred' habitat (i.e. gravelly Sand, slightly gravelly Sand and Sand) by BGS sediment data that was not reflected in the PSA data. Overall, it was considered that the Marine Scheme in English waters overlaps with only a small extent of sandeel habitat in the context of the wider distribution of suitable habitats in the North Sea.

9.7.1.3. SPECIES OF COMMERCIAL IMPORTANCE

44. There are several fish species of commercial importance within the fish and shellfish ecology study area. The most commercially caught fish in the fish and shellfish ecology study area include herring, whiting, halibut, monkfish/anglerfish, turbot, cod, mackerel, haddock, and sandeel (MMO, 2023). Sandeel was only caught in in the furthest offshore areas of the fish and shellfish ecology study within English waters. Further detail on fish and shellfish species of commercial importance in the vicinity of the Marine Scheme has been provided in Volume 2, Chapter 12: Commercial Fisheries.

45. There are several shellfish of commercial importance located within the fish and shellfish ecology study area, including crustaceans and molluscs. The most commercially caught shellfish include Nephrops, brown crabs, scallops, lobsters, velvet swimming crabs, and squid.

46. Drop down video (DDV) footage taken during the site-specific survey observed some fish species which were identified as belonging to the order *Pleuronectiformes* (flatfish) and the family *Gadidae* (cod fishes) (Natural Power, 2023).

47. Epibenthic trawls conducted in the BBWF array area recorded the following species: common dab, long rough dab, lesser sandeel *Ammodytes tobianus* and pogge *Agonus cataphractus*. Of these species, long rough dab was by far the most abundant fish species in beam trawls with over 14 individuals per 1,000 m trawled. Lesser sandeel were recorded at comparatively lower abundances. Other commercially important species including cod, lemon sole and plaice were only recorded at very low abundances (e.g. between one and three individuals per 1,000 m trawled) (BBWFL, 2022).

9.7.1.4. DIADROMOUS SPECIES

48. Diadromous fish are fish that are highly mobile and migrate between fresh water and the marine environment to fulfil their lifecycles. There are several forms of diadromy, however, here a focus is placed on anadromy – where a species migrates from marine waters to freshwater to spawn (Salmonoids, lamprey) and catadromy – where a species migrates from freshwater to oceans and seas to spawn (European eel). There is the potential for diadromous fish species to migrate to and from Scottish and English rivers in the vicinity of the Marine Scheme and, therefore, they may migrate through the fish and shellfish ecology study during certain periods of the year (SNH, 2017a and NBN Atlas, 2019).

49. The EIAs for the BBWF and the neighbouring Seagreen Alpha/Bravo OWF (which lie partly within the fish and shellfish ecology study) noted five migratory species considered to be present and of relevance: Atlantic salmon (*Salmo salar*), sea trout (*Salmo trutta*), sea lamprey (*Petromyzon marinus*), river lamprey (*Lampetra fluviatilis*), and European eel (*Anguilla Anguilla*). None of these species were recorded within the marine ecological surveys undertaken for the Seagreen Alpha/Bravo OWF however due to the presence in the surrounding rivers and coastline it would be likely for these migratory species to be present within the surrounding area (Seagreen, 2018, 2020; BBWFL, 2022). Therefore, these species have also been considered within the fish and shellfish ecology study area for the Marine Scheme.

50. As stated in section 9.3, a 100 km buffer around the Marine Scheme has been considered in order to capture possible interactions between migratory species and the Marine Scheme. The River Tweed SAC, River Teith SAC, River Tay SAC, River Dee SAC, River South Esk SAC, and Tweed Estuary SAC all fall within this buffer area (Table 9.6). Therefore, these river SAC's have been considered in the EIA due to likelihood of migratory species associated with these sites crossing the Marine Scheme.

9.7.1.4.1. ATLANTIC SALMON

51. Atlantic salmon *Salmo salar* are an anadromous migratory species, which utilise both freshwater and the marine environment to fulfil their lifecycles. Spawning of salmon typically occurs from November to December, but may extend from October to late February in certain areas, such as larger rivers. Spawning occurs in the upper reaches of rivers in gravelly substrate (Heessen, Daan and Ellis, 2015; NASCO, 2012). At approximately 10 cm, the salmon goes through a transformation to enable survival in saline condition (smoltification). The migration of smolts to the marine environment occurs following one to five years in the freshwater environment. This migration usually occurs from spring to early summer (Thorstad, et al., 2012; Malcolm et al., 2015). Malcolm et al. (2015) additionally suggested that there was evidence of smolt migration is becoming earlier (by around 1.5 days per decade over a period of around 50 years).

52. Smolt migration is expected to be triggered by environmental cues, such as changes in current flow or temperature (Simmons et al., 2021). Migration typically occurs in spring and is predominantly nocturnal (Thorstad et al., 2012). This timing is consistent with observations from the River Tweed

Commission (RTC) which found that most smolts will move to the open sea in April and May but may still be migrating through the fish and shellfish study area to their feeding grounds in June (RTC, 2023). Results from a study undertaken by the University of Glasgow on behalf of the Beatrice Offshore Windfarm, in the Moray Firth, also showed the majority of migrating smolts remain predominantly within the upper 1 m of the water column during migration (BOWL, 2017).

53. Once in the marine environment, post-smolts migrate offshore towards feeding grounds in the northeast Atlantic. Trawl surveys have found post-smolts along the continental shelf edge in, or en route to, deep sea feeding grounds (Malcolm et al., 2010; NatureScot, 2023). Based on this understanding, it should be assumed that smolts or migrating salmon returning to rivers will pass through the Marine Scheme.

54. Once Atlantic salmon have spent one to five years at sea, they return to their natal rivers to spawn. Gauld, Campbell and Lucas (2016) suggest that salmon migrate from the North Sea to the River Tweed almost all year round. However, throughout the year, this migration may experience peaks. The RTC report that the timing of the salmon run has changed in the past few years and now the peak of the salmon run is from May to July (RTC, 2023). Adult salmon generally swim at depths between 0 and 5 m below the sea surface, with brief dives into deeper water to approximately 64 m (Godfrey et al., 2015).

55. Since 2010, estimated numbers of spawning salmon in Scotland have declined significantly. This is largely attributed to Atlantic Salmon being exposed to a number of pressures including, but not limited to, exploitation, disease and parasites, sea lice, and marine development activities. Marine development activities encompass renewable developments which may affect salmon through impacts on EMF which are integral to fish migration, amongst others. This decline has necessitated the publication of a Scottish Wild Salmon Strategy which aims to establish a new path of restoration and recovery for salmon in Scotland (Scottish Government, 2022).

56. In addition to the SACs listed in section 9.7.1.4, there are a number of additional rivers which are important in supporting Atlantic salmon populations. In Scotland, these are referred to as Scottish Salmon Rivers (Volume 4, Figure 9.8).

57. In England, the status of salmon populations in rivers was assessed in 2021. Of the 42 principal salmon rivers in England, 37 were assessed as being ‘at risk’ or ‘probably at risk’ (Environment Agency, 2022). Several principal salmon rivers are located within the fish and shellfish ecology study area which applies to migratory fish species: the Aln, Coquet, Tyne, Wear, Tees and Esk.

58. Atlantic salmon is an Annex II species under the Habitat Directive, on the OSPAR list of threatened and/or declining species and habitats, a Scottish PMF species, and is of cultural and conservation importance. Atlantic salmon are a qualifying feature (both primary and non-primary), for selection of several SACs which are identified in section 9.7.1.1.2 throughout the fish and shellfish ecology study area in both English and Scottish waters. Atlantic salmon are also a host species of protected freshwater pearl mussels (see section 9.7.1.4.5).

9.7.1.4.2. BROWN TROUT (SEA TROUT)

59. Sea trout (*Salmo trutta*) are the anadromous form of brown trout. They are found in rivers and streams preferring well-oxygenated upland waters. Sea trout are also host species of protected freshwater pearl mussels (see section 9.7.1.4.5). Sea trout spawn in rivers and streams with swift currents, usually characterised by downward movement of water into gravel, favouring large streams in the mountainous areas with adequate cover in the form of submerged rocks, undercut banks, and overhanging vegetation (Fishbase, 2023a). Sea trout have a similar life cycle to Atlantic salmon, conducting outward marine migrations as smolts and returning to native rivers to spawn as adults, following a period at sea (NatureScot, 2022a). Smolts typically migrate out to the marine environment between April and May (Ferguson et al., 2019) and may still migrate through the fish and shellfish ecology study area to feeding grounds in June.

60. There is a considerable variation in timing and duration for adult homeward migration, in which individuals known as 'finnock' return to their native rivers in July and September of the same year as their seaward migration and other individuals known as 'maidens' may return after a migration duration of over 12 months (NatureScot, 2022a). The peak for homeward migration is usually between May and July. There is limited information regarding sea trout migration patterns, however available information suggests predominantly inshore and local (to the river) use of the marine environment (Malcolm et al., 2010). Sea trout migrate to/from a number of rivers in the vicinity of the fish and shellfish ecology study area; however, sea trout mainly stay close to the coastline and do not travel very far from the estuaries of their natal rivers.

61. Considering the above, sea trout are likely to be present within the fish and shellfish study area at some point over the course of a year, likely in the spring months. Given their relatively localised migratory patterns (compared to species like salmon), they may be more limited to areas within the fish and shellfish study area proximal to the coast. Therefore, sea trout are considered within the assessment.

62. Sea trout are PMF species in Scotland (see section 9.7.1.1).

9.7.1.4.3. LAMPREY SPECIES

63. There are three species of lamprey, including river (*Lampetra fluviatilis*), sea (*Petromyzon marinus*), and brook lamprey (*Lampetra planeri*). Lamprey species are listed as Annex II species of the Habitats Directive, a Scottish PMF species, and sea lamprey are listed on the OSPAR list of threatened and/or declining habitats and species. Brook lamprey are exclusively freshwater therefore have not been considered further in this assessment. River and sea lamprey are diadromous, spawning in freshwater environments and migrating out to sea as juveniles. Most adults are parasitic on other fish or marine megafauna (NatureScot, 2022b).

64. River lamprey typically inhabit coastal waters, estuaries and accessible rivers for approximately one to two years following their migration to sea. Spawning typically occurs in autumn and spring, and migration out to sea occurs from late autumn onwards (Maitland and Herdson, 2003). They live on the hard bottoms or attached to larger fish, with spawning taking place in pre-excavated pits in riverbeds. Due to their preference for estuarine and inshore waters (Maitland and Herdson, 2003), it is unlikely they will be found within the vicinity of the fish and shellfish ecology study area.

65. Sea lamprey occur in estuaries and easily accessible rivers (JNCC, 2021). Sea lamprey migrate further offshore than river lamprey for approximately 18 to 24 months before returning to rivers in spring / early summer to spawn (NatureScot, 2022b). Sea lampreys need clean gravel for spawning, and marginal silt or sand for the burrowing of juveniles. Sea lamprey spend most of their adult lives in the sea and have a preference for warmer waters in which to spawn (JNCC, 2021). Unlike salmon and sea trout, lamprey do not display a homing behaviour (Waldman et al., 2008).

66. The at-sea behaviour and migratory behaviour of lamprey remains relatively unknown (Malcom et al., 2010).

9.7.1.4.4. EUROPEAN EEL

67. European eel undergo two migrations over their lives, during their juvenile and adult phases. Adult European eel migrate 5,000 to 10,000 km to the Sargasso Sea to spawn and die (Aarestrup et al., 2009). A recent tagging study of eels in the Azores archipelago, an area en route to the Sargasso Sea from the northeast Atlantic, has shed light on European eel spawning migrations and emphasised the importance of the Sargasso Sea for spawning (Wright et al., 2022).

68. Once the eggs hatch in the Sargasso Sea, larvae drift eastwards towards Europe. It is thought that a significant proportion of juvenile eels arriving in northern Europe will pass through UK waters. By the time they reach Europe, the juveniles will be glass eels rather than larvae. Some of these glass

eels remain in the sea while others ascend the rivers of Europe. Eventually, all juveniles achieve pigmentation and become yellow eels (Malcolm et al., 2010).

69. Eels migrate upstream into freshwater predominately during spring but may continue to do so until early autumn (Heessen, Daan, and Ellis, 2015). Conversely, evidence presented by the RTC suggests that this migration occurs between January and June (RTC, 2023).

70. After a continental growth stage which can last from 3-60 years depending on environmental conditions, the yellow eels metamorphose into silver eels and begin the return migration to the spawning grounds, at which point the cycle begins again (Malcolm et al., 2010). Downstream migration of silver eels is thought to occur predominantly between August and December (Behrmann-Godel and Eckmann, 2003; Tesch, 2003; Chadwick, Knights and Bark, 2007). Observational evidence presented by the RTC suggests that European eel downstream migration now occurs in late spring (RTC, 2023), somewhat earlier than the literature suggests.

71. European eel are critically endangered according to IUCN red list of threatened species, on the OSPAR list of threatened and/or declining species and habitats, and a PMF species. In 2007 an EU Regulation establishing measures for the recovery of the stock of the European eel (1100/2007), the ‘Eel Recovery Plan’, was enacted. Eel Management Plans were developed in England and Scotland in response to the Eel Recovery Plan (Defra, 2010a; 2010b).

72. Considering the range in reported migratory timings for this species, European eel may be present within the fish and shellfish study area at any point in a year. Therefore, as the species may be found in the Marine Scheme area it has been considered within the assessment.

9.7.1.4.5. FRESHWATER PEARL MUSSEL

73. Freshwater pearl mussel *Margaritifera margaritifera* is an endangered species of freshwater mussel. Freshwater pearl mussels can grow as large as 20 cm and live for more than 100 years, making them one of the longest-lived invertebrates (Skinner et al. 2003). These mussels live on the beds of clean, fast flowing rivers, where they can be buried partly or wholly in coarse sand or fine gravel. Freshwater pearl mussels are fully protected under Schedule 5 of Wildlife and Countryside Act of 1981 and are also listed on Annexes II and V of Habitats Directive and Appendix III of the Bern Convention. The species is also listed as Endangered under the IUCN invertebrate Red List. Freshwater pearl mussel is a qualifying feature of the river South Esk SAC located 62 km from the fish and shellfish ecology study area (see section 9.7.1.1.2).

74. Freshwater pearl mussels are reliant on salmonids during the glochidial stage of their life cycle, when they live on the gills of Atlantic salmon or sea trout as parasites (NatureScot, 2022c). As a result, the fish and shellfish ecology study area only has the potential to impact freshwater pearl mussels indirectly through effects on Atlantic salmon or sea trout.

9.7.1.5. ELASMOBRANCHS

75. Elasmobranchs are a cartilaginous fish group that utilise EMF to help navigate and forage for food and comprises of sharks, rays and skates. There is potential for several elasmobranch species to be present along the fish and shellfish ecology study area, including blue skate (*Dipturus batis*), spotted ray (*Raja montagui*), spurdog (*Squalus acanthias*), and tope shark (*Galeorhinus galeus*) (Ellis et al, 2012, MarLIN, 2020) (see Volume 2, Figure 9.2, 9.3 and 9.4 for which species utilise the fish and shellfish study area as nursery or spawning grounds). Some of these species are of conservation concern, the common skate is listed as Critically Endangered whilst the spurdog is listed as vulnerable on the IUCN Red List. There are no specific fisheries for these species, however most of these species have commercial value, but not locally to the fish and shellfish ecology study area. Some of these species of elasmobranch have nursery grounds in or in close proximity to the fish and shellfish ecology study area (Ellis et al., 2012).

76. It should be noted that, whilst classified as an elasmobranch fish, basking shark (*Cetorhinus maximus*) have been scoped out of this EIA during the scoping process with MS-LOT and the MMO, due their rarity within the marine environment off southeast Scotland/northeast England (BBWF, 2022).

9.7.1.6. SHELLFISH

77. Shellfish are exoskeleton bearing aquatic invertebrates, including various molluscs, crustaceans, and echinoderms. Commercial fisheries landing data can be used as a proxy to identify the shellfish present in the vicinity of the fish and shellfish ecology study area, which include Nephrops, brown (or edible) crab (*Cancer pagurus*), European lobster (*Homarus gammarus*), velvet swimming crab (*Necora puber*), king scallop (*Pecten maximus*), and squid (*Loligo sp*.) (see Volume 2, Chapter 12: Commercial Fisheries).

78. Nephrops, brown crab and king scallop were all recorded within site-specific epibenthic trawls conducted for BBWF, albeit in low abundances. Shellfish found in high abundances included brown shrimp (*Crangon crangon*) and other shrimp species (*Pandalidae*). However, these species do not constitute main targets of commercial fisheries in the area (BBWFL, 2022). Site-specific surveys for Seagreen Alpha/Bravo reported brown crab, velvet swimming crab, and king scallops in the results of beam trawls (Seagreen, 2012).

79. Habitats within the Firth of Forth Banks Complex MPA support aggregations of ocean quahog, which are a designated feature of this MPA. As impacts to ocean quahog are dependant to impacts on subtidal habitats and supporting habitats within the MPA, ocean quahog are assessed in Volume 2, Chapter 8: Benthic Subtidal and Intertidal Ecology.

9.7.1.6.1. SCALLOPS

80. Scallops show a preference for areas of clean firm sand, fine or sandy gravel, and may occasionally be found on muddy sand. Distribution of this species is invariably patchy (Marshal and Wilson, 2009; Carter, 2009), but the areas with greatest abundance tends to be areas of little mud and good current strength. Given the PSA results for the Marine Scheme area (Natural Power, 2023), the prevalence of mud in the sediment samples suggests that the Marine Scheme area is less suitable for scallops. Spawning occurs in the autumn of their second year and subsequently spawn every spring or autumn after.

81. Conversely, sediments within the northwest of the BBWF array area within the Marine Scheme were thought to be suitable for spawning scallop populations. Spawning activity for scallops is thought to occur from March into May (BBWFL, 2022). As a species, they are targeted by commercial fisheries, particularly within this section of the Marine Scheme. To the north beyond the Marine Scheme fish and shellfish study area, scallop dredging intensity increases (BBWFL, 2022). Please see Volume 2, Chapter 12: Commercial Fisheries for additional context on scallops in the vicinity of the Marine Scheme.

9.7.1.6.2. EUROPEAN LOBSTER

82. The European lobster is predominantly found throughout the British coast on rocky substrata, down to depths of 60m. Lobsters are solitary species and inhabit holes and tunnels that they build within rocks and boulders (Wilson, 2008). European lobster are actively fished in the vicinity of the Marine Scheme (see Volume 2, Chapter 12: Commercial Fisheries).

9.7.1.6.3. CRAB SPECIES

83. Brown crab is a relatively long-lived species found along the coast of Britain from the intertidal zones to depths of 100 m. They reside on rocky, gravelly substrate, which they burry into (Neal and

Wilson, 2008). Following spawning, there is a larval dispersal phase that lasts between 30 to 50 days. Like European lobster, brown crab are actively fished in areas within the vicinity of the fish and shellfish ecology study area and will likely be found within the fish and shellfish ecology study area (see Volume 2, Chapter 12: Commercial Fisheries).

84. Velvet swimming crabs are found along the coast in Britain on stony/rocky intertidal substrate up to depths of 100 m (Howson and Picton, 1997). Velvet swimming crab are caught in commercial fisheries alongside European lobster and brown crab and therefore, assumed to be present within the fish and shellfish ecology study area.

9.7.1.6.4. SQUID

85. Squid species are found over sand and muddy bottoms (Wilson, 2006) and are predominantly demersal by nature and therefore often caught as bycatch in demersal fisheries (Bellido *et al.* 2001) with research determining they are most likely batch spawners. However, this can vary depending on species, with others utilising hard substrate for spawning purposes (Guerra and Rocha, 1994). Squid are targeted by commercial fisheries predominantly along coastal waters and will likely be found in the fish and shellfish ecology study area (see Volume 2, Chapter 12: Commercial Fisheries).

9.7.1.6.5. NEPHROPS

86. *Nephrops* is a slim, orange pink lobster which grows up to 25 cm long and is considered to be the most commercially valuable crustacean in Europe (Bell et al., 2006). Nephrops predominantly inhabit muddy seabed sediments and show a strong preference for sediments with more than 40% silt and clay (Bell et al. 2006) and are considered to be opportunistic predators, mainly feeding on crustaceans, molluscs, and worms. They build and spend significant amount of time in semi-permanent burrows, which typically are 20 to 30 cm in depth (Dyebern and Hoisaeter, 1965). Nephrops have a strong habitat preference and therefore distribution patterns are determined by presence of suitable habitat, with higher abundances found on more favourable substrate.

87. Female Nephrops mature by three years old and will reproduce every year after. Mating begins in the early summer and spawning occurs shortly after in September. During spawning, females carry their eggs under their tails until they hatch in April or May. The larvae develop into plankton before settling into the seabed six to eight weeks later (Coull et al., 1998). Nephrops have nursing and spawning grounds (of an undetermined intensity) located within the fish and shellfish ecology study area. Nephrops aggregations may be present along the south of Marine Scheme within English waters throughout much of the year, according to habitat suitability maps prepared under the ScotMER programme (Franco, Smyth and Thomson, 2022).

88. The Marine Scheme overlaps with an area of suitable Nephrops habitat that is managed under a functional unit known as Farne Deeps (Scottish Government, 2017), which is targeted predominantly by local UK vessels and international vessels, to a lesser extent (see Volume 2, Chapter 12: Commercial Fisheries). While the functional unit extends into both Scottish and English waters, the area within the unit which comprises suitable habitat for *Nephrops* is entirely in English waters, in particular in the southeast of the part of the Marine Scheme within English waters and close to the Landfall.

9.7.1.7. SUMMARY OF BASELINE AND KEY RECEPTORS

89. Given the large range and mobile nature of fish and shellfish as receptors, it is not possible or appropriate to identify the geographical location of impacts to these species. Therefore, the impact assessment presented here applies to the Marine Scheme as a whole entity in each of Scottish and English waters unless explicitly stated. The key fish and shellfish receptors for consideration within this impact assessment are outlined in Table 9.10.

Table 9.10 Summary and key receptors for fish and shellfish

Receptor Group	Location / Jurisdiction	
	Scotland	England
Demersal spawners (herring and sandeel)	✓	✓
Marine finfish	✓	✓
Diadromous fish	✓	✓
Elasmobranchs	✓	✓
Shellfish	✓	✓

9.7.2. Future Baseline Scenario

90. The fish and shellfish baseline will continue to evolve over time as a result of a number of factors. Key drivers of change include climate change, predator-prey interactions, and fishing activities. Evidence of changes in the fish and shellfish distribution as a result of increased warming has already been observed, including northward shifts of population boundaries for a number of species (Perry et al., 2005; Wright et al., 2020).

91. Increasing sea surface temperatures may result in a regional shift of fish species into deeper and colder waters. Declines in recruitment may occur if these environments do not contain the specific habitat requirements of some species (e.g. sandeel spawning grounds). Shifts in migratory timings, or other life history stages, that are influenced by environmental cues such as temperature, may also occur (BEIS, 2022; Wright et al., 2020). While the reason for the change in timings to species migration throughout section 9.7.1.4 (noted by the RTC, 2023) is not known, this evidence indicates that further changes to these migration behaviours are likely over time. It is anticipated that these changes would occur regardless of whether the Marine Scheme proceeds.

92. Further to potential change associated with existing cycles and processes, it is necessary to take into account the potential effects of climate change on the marine environment. Variability and long-term changes on physical influences may bring direct and indirect changes to fish and shellfish populations and communities in the mid to long term future (Heath et al., 2012). Changes in fishing patterns may also alter the fish and shellfish populations within the fish and shellfish ecology study area. Elasmobranchs that have a slow growth rate and low fecundity are particularly sensitive to overfishing. It should be noted that there have been some improvements in some stocks in recent years which may continue (BEIS, 2022).

93. Any changes that may occur during the design life of the Marine Scheme should be considered in the context of both greater variability and sustained trends occurring on national and international scales in the marine environment.

9.7.3. Data Assumptions and Limitations

94. The data sources listed in section 9.6.1 represent the most up-to-date desk-based data to characterise the fish and shellfish ecology baseline.

95. The key data gaps are considered to be diadromous fish migratory patterns and routes in the Marine Scheme area, and this relates to a wider lack of understanding of the migratory patterns and at-sea behaviours of diadromous fish. These data gaps have been considered when assessing the potential effects of the Marine Scheme.

96. Site-specific surveys were carried out for benthic ecology requirements (Volume 2, Chapter 8: Benthic Subtidal and Intertidal Ecology), therefore were not specifically targeting fish and shellfish species, and therefore some species may have been missed. However, commercial fisheries information has been incorporated into the baseline characterisation, which itself was informed by consultation with the fishing industry, as presented in Volume 2, Chapter 12: Commercial Fisheries. As such, this additional information will have filled any gaps missed through site specific surveys. These surveys provided opportunistic additional fish and shellfish data which has been incorporated into the assessment. However, given the detailed desktop study completed, covering a long time series and a wide variety of information sources (e.g. including scientific literature, grey literature, commercial fisheries information) and the conservative approach adopted, which has included identification of a wider study area it is unlikely that key species have been omitted from the assessment.

9.8. Scope of the Assessment

9.8.1. Impacts Scoped into the Assessment

97. The following impact pathways have been scoped into the assessment, as agreed through the Scoping process and follow up consultation with stakeholders and consultees[8]:

- Temporary habitat and species loss or disturbance (C & D);
- Temporary increases in suspended sediment concentrations (SSC) and associated sediment deposition and potential release of contaminants (C & D);
- Underwater noise (C & D);
- EMF effects (O&M);
- Permanent habitat loss (O&M); and
- Thermal emissions from operational cables (O&M).

9.8.2. Impacts Scoped Out of the Assessment

98. Impacts scoped out of the assessment were agreed with key stakeholders through consultation following receipt of the Scoping Opinion from MD-LOT and MMO in February and March 2023 respectively. These are summarised below for completeness:

- Accidental release of pollutants (C, O&M, D).

9.9. Key Parameters for the Assessment

9.9.1. Maximum Design Scenario

99. The maximum design scenario(s) summarised here have been selected as those having the potential to result in the greatest effect on an identified receptor or receptor group. These scenarios have been selected from the details provided in the Volume 2, Chapter 5: Project Description. Effects of greater adverse significance are not predicted to arise should any other development scenario, based on details within the PDE (e.g., different infrastructure layout), to that assessed here, be taken forward in the final design of the Marine Scheme.

[8] C = Construction, O&M = Operation and maintenance, D = Decommissioning

100. Given that the maximum design scenario is based on the design option (or combination of options) that represents the greatest potential for change, confidence can be held that development of any alternative options within the design parameters will give rise to no worse effects than assessed in this impact assessment. Table 9.11 presents the maximum design scenario for potential impacts on fish and shellfish ecology study area during construction, operation and maintenance and decommissioning.

101. Site preparation works, in advance of construction, are predicted to commence in Q4 of 2026 and will continue until all installation activities have ceased. Landfall construction is expected to occur between Q4 of 2027 until Q4 of 2028. Export cable installation is expected to begin in Q3 2028 and is expected to last until Q4 of 2029. All activities associated with the Marine Scheme are predicted to conclude by the end of 2029. Until detailed design of the Marine Scheme is progressed and further refined pre-construction, this programme for the Marine Scheme as a whole is indicative and is subject to further refinement, but is used to inform assessment of construction phase impacts for the Marine Scheme.

Table 9.11 Maximum design scenario specific to fish and shellfish ecology impact assessment

Potential Impact	Maximum Design Scenario	Maximum Design Scenario – Scottish waters and English waters	Justification
Construction and Decommissioning			
Temporary habitat and species disturbance or loss	Up to 18 km^2 of temporary habitats loss / disturbance due to: • Up to 18 km^2 of disturbance from installation of cables with seabed disturbance width of 25 m per cable for cable installation and seabed preparation activities including Pre-Lay Grapnel Run (PLGR), boulder clearance, seabed levelling, sea trials, pre-lay trenching through harder sediment and cable laying and protection. • Up to 5,000 m^2 of disturbance from the use of jack-up vessels in the nearshore area; • Up to five exit pits, each 20 x 5 m, for up to four cable ducts (with one spare) due to trenchless cable installation at the Landfall; and • Maximum duration of the construction phase of up to 39 months.	**In Scottish waters:** Up to 4 km^2 of temporary habitats loss / disturbance in Scottish waters due to: • Up to 4 km^2 of disturbance from installation of cables with seabed disturbance width of 25 m per cable for cable installation and seabed preparation activities including PLGR, boulder clearance, seabed levelling, sea trials, pre-lay trenching through harder sediment and cable laying and protection. **In English waters:** Up to 14 km^2 of temporary habitats loss / disturbance in English waters due to: • Up to 14 km^2 of disturbance from installation of cables with seabed disturbance width of 25 m per cable for cable installation and seabed preparation activities including Pre-Lay Grapnel Run (PLGR), boulder clearance, sabed levelling, sea trials, pre-lay trenching through harder sediment and cable laying and protection; • Up to 5,000 m^2 of disturbance from the use of jack-up vessels in the nearshore area; and • Up to five exit pits, each 20 x 5 m, for up to four cable ducts (with one spare) due to trenchless cable installation at the intertidal.	Maximum footprint which would be affected during the construction phase. Based on the assumption that the width of disturbance for seabed levelling at sandwaves (across 20% of the Marine Scheme) and all other seabed preparation activities encompasses subsequent cable installation as repeat disturbance. The maximum design scenario assumes that cable installation in the intertidal area will involve trenchless techniques only. It is assumed that the footprint of the exit pits out associated with trenchless techniques (e.g. HDD) within the subtidal area are within the width of disturbance assumed for Offshore Export Cables installation.

Potential Impact	Maximum Design Scenario	Maximum Design Scenario – Scottish waters and English waters	Justification
Temporary increases in SSC and associated sediment deposition and potential release of contaminants	• Seabed preparation: – Pre-lay grapnel run; boulder clearance; route preparation at sandwaves; sea trials (as required); pre-sweep; and pre-installation trenching through harder sediment; and – Sand waves may be cleared to a width of 25 m, average height 5 m and clearance along approximately 20% of the Marine Scheme length (3.6 km²). • Cable installation: – Offshore Export Cables length up to 720 km; – Installation using any of the following methods: ploughs (displacement and/or non-displacement), jetting machines, mechanical trenchers, MFE. Of these, MFE has been assumed as the worst case with regards to SSC – Installation is expected to mobilise sediments from a 3 m deep and 2.5 m wide trench; and – Cable installation at the Landfall via trenchless technique with potential for drilling releases associated with trenchless techniques (e.g., HDD), up to 2,000 m³ per HDD of which 1,900 m³ is water and 100 m³ is drilling mud / solids (e.g. bentonite), totalling 10,000 m³ (9,500 m³ water and 500 m³ drilling mud / solids) for 5 drilling HDD bores (4 used and 1 contingency). HDDs will be drilled sequentially, so the fluids will be released in 5 separate releases of up to 2,000 m³ i.e. the 10,000 m³ will not be released in a single event.	**In Scottish waters:** • Seabed preparation: – All seabed preparation activities apply as listed previously; – Sandwaves may be cleared to a width of 25 m, average height 5 m and clearance along approximately 20% of the Marine Scheme length (0.8 km²) • Cable installation: – Offshore Export Cables length up to 160 km; and – Installation using techniques listed previously which mobilises sediment from a 3 m deep and 2.5 m wide trench. **In English waters:** • Seabed preparation: – All seabed preparation activities apply as listed previously; – Sandwaves may be cleared to a width of 25 m, average height 5 m and clearance along approximately 20% of the part of the Marine Scheme within English waters (2.8 km²) • Cable installation: – Offshore Export Cables length up to 560 km; – Installation using techniques listed previously which mobilises from a 3 m deep and 2.5 m wide trench;	Greatest volume of sediment released into the water column (see Volume 2, Chapter 7: Offshore Physical Environment and Seabed Conditions).

Potential Impact	Maximum Design Scenario	Maximum Design Scenario – Scottish waters and English waters	Justification
		– Up to five exit pits, each 20 x 5 m, for up to four cable ducts (with one spare) due to trenchless cable installation at the intertidal; and – Potential drilling fluid releases associated with trenchless techniques.	
Underwater noise	• Site preparation works expected to take up to 39 months; • Installation of the Offshore Export Cables is expected to take up to 18 months; • Noise sources include construction activities and geophysical surveys; • Construction of a maximum of four cables, within a 180 km corridor.	**In Scottish waters:** • A maximum of four cables within a 40 km long cable corridor installed in Scottish waters. **In English waters:** • A maximum of four cables within a 140 km long cable corridor installed in English waters.	Maximum duration and nature of construction activities, including pre-construction.
Operation and Maintenance			
EMF effects	• Presence of up to four 180 km long High Voltage Direct Current (HVDC) cables in a 320 kV symetrical monopole arrangement or two 180 km long HVDC cables as a bipole arrangement at 525 kV; • Minimum target burial depth of 0.5 m; • Operation and maintenance phase of up 35 years.	**In Scottish waters:** • Presence of up to four 40 km long HVDC cables in a 320 kV symmetrical monopole arrangement or two 40 km long HVDC cables as a bipole arrangement at 525 kV; and • Minimum target burial depth of 0.5 m. **In English waters:** • Presence of up to four 140 km long HVDC cables in a 320 kV symmetrical monopole arrangement or two 140 km long HVDC cables as a bipole arrangement at 525 kV; and • Minimum target burial depth of 0.5 m.	Modelling completed for the Marine Scheme provides data on the level and attenuation of EMF for a symmetrical monopole configuration at 320 kV and a bipole configuration at 525 kV, assuming a horizontal separation distance of 25 m (further details are provided in Volume 2, Chapter 5: Project Description). The worst-case EMF level and attenuation is calculated for each HVDC cable as a worst-case under the assumption that a bundled arrangement will not be used. Based on this modelling, the maximum

Potential Impact	Maximum Design Scenario	Maximum Design Scenario – Scottish waters and English waters	Justification
			design scenario is associated with a bi-pole arrangement at 525 kV.
Permanent habitat loss	Up to 1.46 km^2 of permanent habitat loss due to: • Up to 1.41 km^2 of cable protection associated with up to 37.1 km of per cable (154.8 km in total) at a width of up to 9.5 m; • Up to 0.05 km^2 of cable protection for five cable crossings and up to 200 m of cable requiring protection per crossing at a width of up to 12.5 m; and • Operation and maintenance phase of up 35 years.	**Scottish waters:** Up to 0.23 km^2 of permanent habitat loss due to: • Up to 0.23 km^2 of cable protection associated with 6 km of per cable (24 km in total) at a width of up to 9.5 m; • Operation and maintenance phase of up 35 years. **English waters:** Up to 1.24 km^2 of permanent habitat loss due to: • Up to 1.18 km^2 of cable protection associated with 31.1 km of per cable (124.4 km in total) at a width of up to 9.5 m; • Up to 0.05 km^2 of cable protection for five cable crossings at a width of up to 12.5 m; and • Operation and maintenance phase of up 35 years.	Maximum footprint which would be affected during the operation and maintenance phase. The total cable protection area and length for the Marine Scheme exceeds the sum of English and Scottish Waters. This is due to the worst-case for the Marine Scheme as a whole being associated with the eastern option for the Marine Scheme Offshore Export Cable Corridor to avoid double counting of both routes for total length.
Thermal emissions from operational cables	• Presence of up to four 180 km long HVDC cables in a 320 kV symmetrical monopole arrangement or two 180 km long HVDC cables as a bipole arrangement at 525 kV; • Minimum target depth depth of 0.5 m; • Operation and maintenance phase of up 35 years.	**In Scottish waters:** • Presence of up to four 40 km long HVDC cables in a 320 kV symmetrical monopole arrangement or two 40 km long HVDC cables as a bipole arrangement at 525 kV; and • Minimum target burial depth of 0.5 m. **In English waters:** • Presence of up to four 140 km long HVDC cables in a 320 kV symmetrical monopole arrangement or two 140 km long HVDC cables as a bipole arrangement at 525 kV; and	Modelling completed for the Marine Scheme provides data on the level and attenuation of EMF for a symmetrical monopole configuration at 320 kV and a bipole configuration at 525 kV, assuming a horizontal separation distance of 25 m (further details are provided in Volume 2, Chapter 5: Project Description). The worst-case EMF level and attenuation is calculated for each HDVC cable as a worst-case under the assumption

Potential Impact	Maximum Design Scenario	Maximum Design Scenario – Scottish waters and English waters	Justification
		• Minimum target burial depth of 0.5 m.	that a bundled arrangement will not be used. Based on this modelling, the maximum design scenario is associated with a bi-pole arrangement at 525 kV.

9.10. Methodology for the Assessment of Effects

9.10.1. Overview

102. The fish and shellfish ecology assessment of effects has followed the methodology set out in Volume 2, Chapter 3: EIA Methodology. In addition, the assessment of fish and shellfish ecology has considered the legislative framework as defined in Volume 2, Chapter 3: EIA Methodology and section 9.6. The following guidance has been followed in conducting the assessment:

- Chartered Institute for Ecology and Environmental Management (CIEEM) Guidelines for Ecological Impact Assessment in Britain and Ireland – Terrestrial, Freshwater, Coastal and Marine (CIEEM, 2018, and updated September 2019); and
- Descriptions of Scottish Priority Marine Features (PMFs) (NatureScot, 2014) (Scottish waters only).

9.10.2. Impacts Assessment Criteria

103. Determining the significance of effects is a two-stage process that involves defining the magnitude of the potential impacts and the sensitivity of the receptors. This section should describe the criteria applied in this chapter to assign values to the magnitude of potential impacts and the sensitivity of the receptors. The terms used to define magnitude and sensitivity are based on those which are described in further detail in Volume 2, Chapter 3: EIA Methodology.

104. The criteria for defining magnitude in this chapter are outlined in Table 9.12 below.

Table 9.12 Definition of terms relating to the magnitude of an impact

Magnitude of Impact	Definition
High	The impact occurs over a large spatial extent resulting in widespread, and/or long-term, permanent changes in baseline conditions or affects a proportion of a receptor population. The impact is very likely to occur and/or will occur at a high frequency or intensity.
Medium	The impact occurs over a local to regional spatial extent and/or a short- to medium-term change to baseline conditions or affects a moderate proportion of a receptor population. The impact is likely to occur and/or will occur at a moderate frequency or intensity.
Low	The impact is localised and/or temporary or short-term, leading to a detectable change in baseline conditions or a noticeable effect on a small proportion of a receptor population. The impact is unlikely to occur or may occur but at low frequency or intensity.
Negligible	The impact is highly localised and/or short-term, with full rapid recovery expected to result in very slight or imperceptible changes to baseline conditions or a receptor population. The impact is very unlikely to occur; if it does, it will occur at a very low frequency or intensity.

105. The criteria for defining sensitivity in this chapter are outlined in Table 9.13 below.

Table 9.13 Definition of terms relating to the sensitivity of the receptor

Value (Sensitivity of the Receptor)	Description
Very High	Very high importance and rarity, international receptor with no capability to 'absorb' or accommodate change and no ability to recover or adapt.
High	High importance and rarity, international and/or national receptor and very limited capability to 'absorb' or accommodate change without fundamentally altering the character of the receptor.
Medium	High or medium importance and rarity, regional receptor with some capacity to absorb or accommodate change without significantly altering character, however some damage to the receptor is anticipated to occur.
Low	Low or medium importance and rarity and the receptor is considered tolerant to change without significant detriment to its character; some limited or minor change may occur.
Negligible	Very low importance and rarity, local receptor and is tolerant to change with no effect on its fundamental character.

106. The significance of the effect upon fish and shellfish ecology is determined by correlating the magnitude of the impact and the sensitivity of the receptor, as outlined in Table 9.14 below.

Table 9.14 Matrix used for the assessment of the significance of the effect

		Magnitude of Impact			
		Negligible	**Low**	**Medium**	**High**
Sensitivity of Receptor	**Negligible**	Negligible	Negligible to Minor	Negligible to Minor	Minor
	Low	Negligible to Minor	Negligible to Minor	Minor	Minor to Moderate
	Medium	Negligible to Minor	Minor	Moderate	Moderate to Major
	High	Minor	Minor to Moderate	Moderate to Major	Major
	Very High	Minor	Moderate to Major	Major	Major

107. Definitions for the significance of effect are provided in Table 9.15. For the purposes of the Marine Scheme ES, any effect which is deemed to result in a significance or moderate or greater, is generally considered to be 'significant' in EIA terms and will require additional mitigation. Effects considered to be 'minor' or 'negligible' are generally considered to be 'not significant' in EIA terms.

Table 9.15 Assessment of consequence

Assessment Consequence	Description	Significance of Effect
Major Effects	Effects (beneficial or adverse) are likely to result in highly noticeable and long-term, or permanent impacts to the character of the baseline and which are likely to disrupt the function and/or status/value of a marine mammal receptor. These effects are a priority for mitigation in order to avoid or reduce the significance of the effect.	Significant
Moderate Effects	Effects (beneficial or adverse) are likely to result in noticeable and lasting impacts to the character of the baseline and which may cause degradation of the marine mammal receptor. These effects are a priority for mitigation in order to avoid or reduce the significance of the effect.	Significant
Minor Effects	Effects (beneficial or adverse) are likely to result in noticeable changes to baseline conditions, beyond the natural variation, but which are not anticipated to result in long-term degradation to the function or value of the marine mammal receptor. Such effects will not generally require additional mitigation but may be of interest to relevant stakeholders.	Not Significant
Negligible	Effects are anticipated to be likely indistinguishable from baseline conditions or within the natural level of variation. These effects do not require additional mitigation and are not anticipated to be a stakeholder concern. Effect not considered an issue in the decision-making process.	Not Significant

108. In line with the Scottish Ministers' Scoping Opinion, the Assessment of Impacts identifies where impacts are relevant only to Scottish waters, only to English waters, or are relevant to both jurisdictions. Where there is no separation of assessment of impacts, the assessment for the Marine Scheme (as a whole entity) applies to the Marine Scheme in both Scottish waters and English waters concurrently.

9.11. Measures Adopted as Part of the Marine Scheme

109. As part of the project design process, a number of measures have been proposed to reduce the potential for impacts on fish and shellfish ecology (see Table 9.16). These include measures which have been incorporated as part of the Marine Scheme design (referred to as 'designed in measures') and measures which will be implemented regardless of the impact assessment (referred to as 'tertiary mitigation'). As there is a commitment to implementing these measures, they are considered inherently part of the design of the Marine Scheme and have therefore been considered in the assessment presented in section 9.12 below (i.e. the determination of magnitude and therefore significance assumes implementation of these measures). These measures are considered standard industry practice for this type of development.

Table 9.16 Measures adopted as part of the Marine Scheme (designed in measures & tertiary mitigation)

Mitigation Measure	Justification	Applicable Jurisdiction
Route Selection and Avoidance.	The Marine Scheme has been specifically refined to avoid interactions with key designations, environmental sensitivities, and notable inshore fishing grounds as far as reasonably practicable. On the approach to the Landfall at Cambois, the route has been selected to minimise the footprint within European Sites. Nearshore routes with greater levels of interactivity with European Sites along the English and Scottish coast have been de-selected. Further detail on this is provided in Volume 2, Chapter 6: Route Appraisal and Consideration of Alternatives	Scottish and English waters
Cable protection.	The use of cable protection will be minimised as far as practicable, and only used where required. Additional external cable protection (e.g. rock placement) will only be used where the minimum target burial depth cannot be achieved, for example in areas of hard ground or at third-party crossings. This will be informed by outputs from the Cable Burial Risk Assessment completed by the installation contractor(s) prior to the commencement of installation. Rock utilised in berms will be clean with low fines. Use of graded rock and 1:3 profile berms at areas of rock protection will reduce potential fishing gear snagging risk.	Scottish and English waters
Vessel best-practice / MARPOL.	Compliance with MARPOL regulations and best-practice protocols to prevent and manage incidents of accidental release of marine contaminants.	Scottish and English waters
Shipboard Oil Pollution Emergency Plan (SOPEP).	All vessels to be used as part of any phase of the Project will adopt a waste management plan in line with the requirements set out as part of the International Convention for the Prevention of Pollution from Ships (MARPOL) and the SOPEP.	Scottish and English waters
Cable grouping.	Grouping cables of opposite polarity will result in deleterious interference between the EMFs from adjacent cables, which will further reduce the field EMF strengths resulting from the Marine Scheme. Furthermore, the design of the Marine Scheme will be further refined, informed by onward detailed engagement with the supply chain and various technical, practical, and commercial considerations. As part of this refinement, the cable configuration will be optimised and options to reduce EMF assessed. Beyond the configuration commitment detailed above, practical solutions for reducing EMF arising from the Offshore Export Cables may include reducing cable separation or adopting a bundled solution.	Scottish and English waters

Mitigation Measure	Justification	Applicable Jurisdiction
Landfall construction.	Trenchless techniques, such as Horizontal Directional Drilling (HDD) will be used at the Landfall for the construction of the Marine Scheme. Works associated with Landfall construction activities will avoid any works in the intertidal environment and will reduce the potential for sediment disturbance.	English waters
Pose Little or No Risk (PLONOR) substances.	During trenchless installation activities at Landfall, there will be an interface between the sea and the drilling fluids used to create the exit pits at the breakouts. Small quantities of drilling fluids may be discharged to the marine environment, however best practice mitigation will be implemented to reduce the amount of drill mud / cuttings released in the event of a release. To limit environmental damage, only biologically inert PLONOR listed drilling fluid will be used.	English waters
Environmental Management Plan (EMP).	An EMP will be developed and employed to ensure potential release for pollutants will be reduced as far as practicable. This will include a Marine Pollution Contingency and Control Plan (MPCCP) and an Invasive and Non-Native Species Management Plan (INNSMP). An outline EMP has been provided as part of this application (Volume 5, Appendix 5.1) and will be updated for submission to MMO and MD-LOT prior to construction.	Scottish and English waters
Decommissioning Plan.	The aim of this plan is to adhere to the existing UK and international legislation and guidance, with decommissioning industry practice applied. Overall, this will reduce the amount of long-term disturbance to the environment as far as reasonably practicable. While this measure has been committed to as part of the Marine Scheme, the maximum design scenario for the decommissioning phase has been considered in each of the assessments of effects.	Scottish and English waters
Cable Plan (CaP).	Suitable implementation and monitoring of cable protection through the Marine Scheme and adherence to a CaP. This will be produced and consulted on (in line with consent conditions) prior to installation and will include a detailed cable laying plan including geotechnical data, cable laying techniques and informed by a Cable Burial Risk Assessment (CBRA) which will include details on minimum target burial depths.	Scottish and English waters

9.12. Assessment of Impacts

110. The potential impacts arising from the construction, operation and maintenance and decommissioning phases of the Marine Scheme are listed in Table 9.11 along with the maximum design scenario against which each impact has been assessed.

111. An assessment of the likely significance of the effects of the Marine Scheme on fish and shellfish ecology receptors caused by each identified impact is given below.

9.12.1. Potential Effects During Construction

9.12.1.1. TEMPORARY HABITAT AND SPECIES DISTURBANCE OR LOSS

112. During the pre-installation and construction phases of the Marine Scheme, temporary habitat loss or disturbance may occur as a result of the following activities:

- Installation of the Offshore Export Cables at the Landfall using Trenchless Technology (e.g. HDD)
- Seabed preparation (including PLGR, boulder clearance, seabed levelling, and pre-lay trenching); and
- Installation of the Offshore Export Cables (trenching) and additional cable protection.

113. Temporary habitat disturbance or loss may affect individuals directly through injury or physical harm and also indirectly through the disturbance or loss of habitats used for foraging, nursery and spawning.

114. This impact is consistent along the entire length of the Offshore Export Cable Corridor therefore the following discussion is applicable to the whole Marine Scheme within both Scottish and English waters, with the exception of Landfall activities which are only relevant to the Marine Scheme within English waters.

115. Due to the different level of sensitivity of different species groups, the receptor sensitivity appraisal has been split into the key receptor groupings (marine finfish (excluding herring and sandeels)), herring, sandeels, diadromous fish (including freshwater pearl mussels), shellfish, and elasmobranchs).

9.12.1.1.1. MAGNITUDE OF IMPACT

116. As described in the maximum design scenario in section 9.9.1, up to 18 km^2 of seabed will be disturbed by the activities listed above. Of this total area of disturbance, up to 4 km^2 will take place in Scottish waters and up to 14 km^2 will take place in English waters.

117. Burial of the Offshore Export Cables will occur within the area previously disturbed during seabed preparation activities (including seabed levelling and/or boulder clearance). Therefore, there will be areas of localised repeat disturbance within the 25 m wide corridor required for the installation of each Offshore Export Cable.

118. Works associated with the Landfall in English waters including the use of jack up barges and the excavation of exit pits associated with the landfall trenchless technique will also result in temporary seabed disturbance. However, as detailed in section 9.9.1, these activities will be located within the 25 m wide zone of disturbance for route preparation and the Offshore Export Cable installation activities, so the overall area of disturbance will not be increased.

119. Landfall activities will affect an estimated 5,000 m^2. This area is associated with up to five exit pits, each 20 m by 5 m. This area of impact is entirely within English waters.

120. The site-specific benthic ecology survey established that the sediment consisted mostly of muddy sand with small areas of gravelly muddy sand and muddy sandy gravel (Natural Power, 2023). Within the part of the Marine Scheme within Scottish waters which overlaps the BBWF array area, mud features less within the sediments. Instead, the majority of samples acquired across the array area are classed as Slightly Gravelly Sand (BBWFL, 2022).

121. A review commissioned by The Crown Estate (RPS, 2019) on seabed recovery post-installation of cables associated with offshore windfarms in the UK found that sandy sediments recover quickly following cable installation; infilling occurs quickly in the wake of cable installation. In coarse and mixed sediments and muddy sediments, remnant cable installation trenches were conspicuous for several years after installation. However, these remnant trenches constituted shallow depressions which were of limited depth (i.e. tens of cm) when compared against the surrounding seabed (RPS, 2019). Given the sediment type in the Marine Scheme area, there is likely to be some limited evidence of disturbance after installation activities have concluded.

122. This disturbance will occur intermittently over a period of up to 39 months (specifically, 15 months for Landfall construction and 18 months for installation of the Offshore Export Cables) during construction, inclusive of seabed preparation in advance of construction. Activities, from seabed preparation to completion of installation, will not all occur at the same time, although some activities may overlap and occur simultaneously for a period of time. Given the intermittent nature of the activities, only a small area of seabed is expected to be disturbed at any one time.

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

9.12.1.1.2. SENSITIVITY OF THE RECEPTOR

Marine finfish

124. The marine finfish most vulnerable to any temporary habitat loss or disturbance are those which spawn on or near the seabed and have a demersal egg phase. Sandeel and herring, as demersal spawners, are sensitive to such disturbance. Given the vulnerability of these species compared to other marine finfish, the effects of temporary habitat loss and disturbance during construction on sandeel and herring have been assessed separately below.

125. In general, mobile fish species are able to avoid areas subject to temporary habitat disturbance (EMU, 2004). All other marine finfish species (excluding sandeel and herring) are considered to be of low sensitivity to temporary habitat disturbance or loss.

126. A number of species are likely to inhabit the fish and shellfish ecology study area (see section 9.7.1.2). However, any temporary habitat disturbance or loss is unlikely to affect the long term functioning of these species. The majority of marine finfish are mobile and therefore can avoid injury or physical harm associated with temporary habitat disturbance or loss. These species which are pelagic spawners are not restricted by seabed conditions therefore have access to a wide availability of spawning grounds.

127. Marine finfish (excluding sandeel and herring) are deemed to be of low vulnerability, high recoverability and of local importance. The sensitivity of the receptor is therefore, considered to be low.

Sandeel

128. As described in section 9.7.1.2, published literature suggests the Marine Scheme area is used by sandeel during spawning. However, the PSA results indicate that the seabed along the majority of the Offshore Export Cable Corridor is not suitable spawning habitat. Within the portion of the Marine Scheme within Scottish waters, there are a few locations where the sediment is considered to be 'suitable (marginal)' habitat. However, these areas of sandier substrate are patchy and highly localised. If sandeel spawn within the Marine Scheme area, this behaviour is likely to be confined to these limited areas of sandy substrate.

129. The recovery of sandeels is dependent on the recovery of sediments. Sandeels exhibit a high degree of site fidelity once settled so are susceptible to local impacts (Jensen et al., 2011). While not analogous to construction impacts associated with the installation of the Offshore Export Cables, a number of studies have been conducted on sandeel recolonisation post-installation of an offshore wind farm. These studies noted that, in the wake of construction, sandeel abundance remained unchanged (Jensen et al., 2004; Stenberg et al., 2011; van Deurs et al., 2012; and BOWL, 2021a).

130. The footprint of direct impact will be limited to a 25 m wide corridor centred on each of the Offshore Export Cables (up to 4 in total). Tidal flows within the Marine Scheme area are relatively low and consequently sediment transport is also relatively low (see Volume 2, Chapter 7: Offshore Physical Environment and Seabed Conditions). This suggests that the seabed may take some time to return to pre-disturbance conditions. However, it is expected that the seabed will ultimately recover. Regardless, the seabed within the majority of the Marine Scheme is not considered to be suitable for sandeel.

131. As described in section 9.7.1.2.2, sandeel are dependent on the seabed for the majority of their life cycle, beyond spawning. Consequently, the Scottish Government FEAST tool states that sandeel have a high sensitivity to sub-surface abrasion or penetration and a medium sensitivity to surface abrasion (Scottish Government, 2023).

132. Sandeel are deemed to be of high vulnerability, medium recoverability and are of national importance. The sensitivity of the receptor is therefore, considered to be medium.

Herring

133. Similar to sandeel, herring have specific sediment requirements for spawning with a demersal egg phase, making them vulnerable to habitat loss and disturbance. However, unlike sandeel, herring are only dependent on the seabed for this phase. As adults, herring are comparatively more mobile than sandeel, thus are able to avoid direct disturbance impacts.

134. The sediment at all but one sample location within the Marine Scheme in English waters was considered to be 'unsuitable' for herring spawning, owing to the high proportion of fines in the sediment. In Scottish waters, there are limited areas of sub-prime and marginal habitat in the northernmost extent of the Marine Scheme within the BBWF array area. Overall, the Marine Scheme is considered to provide very limited potential herring spawning habitat, therefore, the area of herring spawning grounds affected by this impact is expected to be of negligible extent.

135. Overall, any temporary disturbance or habitat loss during the construction phase of the Marine Scheme is unlikely to affect the long term functioning of spawning herring populations, particularly in the context of the low importance of the area for spawning.

136. Consequently, herring is deemed to be of medium vulnerability, high recoverability and of regional importance; however, the majority of the Marine Scheme does not constitute suitable spawning habitat for the species, with the exception of limited areas of suitable habitat in the north of the Marine Scheme in Scottish waters. Overall, the sensitivity of the receptor is considered to be low.

Diadromous fish

137. Diadromous species are only likely to pass through the Marine Scheme area on their migration to/from rivers along the Scottish and English coasts; including those identified as SACs (the River Tweed SAC (which spans Scotland and England) being the closest at approximately 44 km from the Marine Scheme boundary; section 9.7.1.1). Consequently, the habitats within the Marine Scheme area are not expected to be particularly important to diadromous species. Furthermore, the Offshore Export Cable installation activities and associated seabed preparation works will be short-term in duration and occur intermittently over the construction period so may not directly coincide with periods of migratory behaviour. Therefore, no direct impact on these species is anticipated as a result of the installation activities.

138. Diadromous fish species are considered to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is therefore, considered to be low.

Shellfish

139. A number of commercially important shellfish species such as brown crab, lobster, Nephrops, scallop and velvet swimming crab are known to inhabit the fish and shellfish ecology study area (section 9.7.1.6). Of these, Nephrops are known to use the Marine Scheme area for spawning and as nursery grounds per Coull et al. (1998) and on the basis of the Farnes Deep functional unit (Scottish Government, 2017). Generally, shellfish species are less mobile than finfish. Consequently, they are more vulnerable to temporary habitat loss or disturbance.

140. Larger crustacea (e.g. Nephrops and European lobster) are classed as equilibrium species (Newell et al., 1998) and are only capable of recolonising an area once the original substrate type has returned. Furthermore, larvae of Nephrops generally remain in the hatching areas of adults and are not transported long distances by hydrographic processes. Consequently, recoverability of Nephrops populations to substratum loss is considered moderate (Sabatini and Hill, 2008).

141. Shellfish communities associated with mud or sand habitats have been shown to return to baseline species abundance after a number of months, as such effects are anticipated to be short term (Newell et al., 1998). These habitats are characteristic of the southern extent of the Marine Scheme in English waters, beyond the area of overlap with BBWF. Nephrops typically inhabit areas characterised by muddy sediments. As the recoverability of Nephrops is dependent on the recovery of the sediment, timescales of recovery for the species are likely to align with what is expected of the sediments across the Marine Scheme area.

142. European lobster typically inhabit hard substrata, therefore they are not dependent on softer sediments, as across the majority of the Marine Scheme. Only a change from rock to sediment would result in loss of suitable habitat and loss of the species from the affected area. Consequently, changes to sediment type (as might occur during Marine Scheme activities) are considered not relevant to this species (Gibson-Hall et al., 2020). As mobile species, they are also able to avoid disturbance.

143. Shellfish are deemed to be of medium vulnerability, medium recoverability and of regional importance, given their commercial significance. The sensitivity of the receptor is therefore, considered to be medium.

Elasmobranchs

144. The Marine Scheme overlaps with nursery grounds of tope shark, common skate, spotted ray, and spurdog. However, none of these species are likely to spawn in the Marine Scheme area (section 9.7.1.2). With the exception of tope shark, these species lay egg cases which are deposited on the seabed. Due to their reproductive method, these species are vulnerable to seabed disturbance. During the juvenile and adult phase of their lifecycle, as when they would be utilising the Marine Scheme area, they are less vulnerable.

145. Common skate have since been split and recognised as two separate species, flapper skate and blue skate. Common skate are considered to be of low sensitivity to substratum loss and are expected to exhibit high recoverability (Neal and Pizzolla, 2006). However, the FEAST tool categorises common skate (prior to the recognition of flapper skate and blue skate as two separate species) as having a medium sensitivity to surface abrasion due to the potential disturbance to egg cases (Scottish Government, 2023). This is likely to be analogous for other species which lay egg cases.

146. Generally, elasmobranchs reach sexual maturity after a number of years, exhibit relatively low fecundity, and have long gestational periods. Therefore, they are likely to take some time to recover in the wake of disturbance and loss of spawning grounds. However, as the Marine Scheme area is unlikely to be used by elasmobranch species for spawning, they are likely to recover and return to the area once installation activities are complete.

147. Consequently, elasmobranchs are deemed to be of medium vulnerability, high recoverability and of national and international value. The sensitivity of the receptor is therefore, considered to be low.

9.12.1.1.3. SIGNIFICANCE OF THE EFFECT

Marine finfish

148. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low, given the mobile nature of marine finfish (excluding sandeel and herring) and their ability to avoid disturbance. The effect will, therefore, be of **negligible to minor** adverse significance, for the Marine Scheme as a whole, which is not significant in EIA terms.

Sandeel

149. Sandeel are considered to be more sensitive to temporary habitat disturbance, due to their vulnerability during spawning and across their lifecycle. However, considering the Marine Scheme area is largely unlikely to be suitable for this behaviour, and that proposed activities will occur intermittently over the 39 months of construction, considerable populations of sandeel are unlikely to be affected.

150. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of minor adverse significance, for the Marine Scheme as a whole, which is not significant in EIA terms.

Herring

151. The habitat within the Marine Scheme area is similarly unsuitable for herring spawning, when they are most vulnerable to disturbance.

152. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **negligible to minor** adverse significance, for the Marine Scheme as a whole, which is not significant in EIA terms.

Diadromous fish

153. Diadromous species are only likely to pass through the Marine Scheme area during migrations, so the area is unlikely to constitute important grounds for these species.

154. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **negligible to minor** adverse significance, for the Marine Scheme as a whole, which is not significant in EIA terms.

Shellfish

155. Shellfish are less mobile and therefore are more susceptible to disturbance impacts. Additionally, their recoverability may be slow or limited to the rate of seabed recover post-cable installation.

156. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of minor adverse significance, for the Marine Scheme as a whole, which is not significant in EIA terms.

Elasmobranchs

157. Some elasmobranchs lay egg cases on the seabed, therefore are sensitive to disturbance during this phase. However, the Marine Scheme area is only thought to support elasmobranch species as a nursery ground, not during spawning.

158. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **negligible to minor** adverse significance, for the Marine Scheme as a whole, which is not significant in EIA terms.

9.12.1.1.4. SECONDARY MITIGATION AND RESIDUAL EFFECTS

159. Given that there are no likely significant effects in EIA terms, secondary mitigation is not required.

9.12.1.2. TEMPORARY INCREASES IN SSC AND ASSOCIATED SEDIMENT DEPOSITION AND POTENTIAL RELEASE OF CONTAMINANTS

160. Increased SSC will occur during the construction phase of the Marine Scheme as a result of seabed disturbance caused the following activities:

- Installation of the Offshore Export Cables at the Landfall using Trenchless Technology (e.g. HDD);
- Seabed preparation (including PLGR, boulder clearance, seabed levelling, and pre-lay trenching);
- Installation of the Offshore Export Cables (trenching) and additional cable protection; and
- Releases of drilling fluids during Landfall construction in English waters.

161. The deposition of the suspended sediments may result in localised changes to the sediment type and burial of specific habitats used by fish and shellfish receptors. In addition, increased SSC can result in reduced feeding success of visual predators due to decreased visibility, and mortality of eggs and larvae which are intolerant to increased sediment loads. Less mobile species can be affected through clogging of respiratory apparatus. Additionally, the disturbance of sediments during the above activities can result in the potential release of contaminants within the sediment.

162. This impact is consistent along the Marine Scheme and therefore the following discussion is applicable to the whole Marine Scheme within both Scottish and English waters, with the exception of Landfall activities which are only relevant to the Marine Scheme in English waters.

163. Due to the different level of sensitivity of different species groups, the receptor sensitivity appraisal has been split into the key receptor groupings (marine finfish (with sandeel and herring being addressed individually)), diadromous fish, shellfish, and elasmobranchs).

9.12.1.2.1. MAGNITUDE OF IMPACT

164. Temporary increases in SSC and associated deposition also constitute a direct impact on fish and shellfish receptors.

165. Depending on method of installation, seabed levelling activities and Offshore Export Cable installation have the potential to generate sediment plumes. In particular, the use of MFE for seabed levelling and jet trenchers for cable burial can generate increased SSC. MFE has been used throughout Volume 2, Chapter 7: Offshore Physical Environment and Seabed Conditions to determine the maximum SSC and deposition which forms the basis of this assessment.

166. The greatest instantaneous increases in SSC would only occur in the immediate vicinity of the installation activities. However, finer sediments at reduced sediment concentrations could travel larger distances as a plume. In Volume 2, Chapter 7: Offshore Physical Environment and Seabed Conditions it was determined that the majority of sediment disturbed (on average over 90%) would settle out in the immediate vicinity of the disturbance within the order of seconds. A smaller proportion of finer sediments (approximately 10%) could be carried in suspension, as a plume, no further than the extent of a tidal ellipse, the extent of which is defined within Volume 2, Chapter 7: Offshore Physical Environment and Seabed Conditions. The sediments within the plume are expected to settle out within a tidal cycle i.e. after 12 hours, the plume will have dissipated.

167. The maximum deposition scenario is associated with seabed levelling by MFE, which is conservatively used as the base case for all cable installation activities. As outlined in Volume 2, Chapter 7: Offshore Physical Environment and Seabed Conditions, MFE occurs at the seabed so local flows have been taken into account when calculating deposition extent and thickness. Flow speeds range between 0.2 m/s and 0.6 m/s. Heights of 5 m, 10 m and 15 m above the seabed are used to represent the height which sediment could be ejected up to during the MFE clearance. While the full range of deposition thickness are available in Volume 2, Chapter 7: Offshore Physical Environment and Seabed Conditions, for the purposes of fish and shellfish ecology, an ejection height of 5 m has been used as this represents a low-point in the range of ejection heights considered in Volume 2, Chapter 7: Offshore Physical Environment and Seabed Conditions. As outlined in Volume 2, Chapter 7: Offshore Physical Environment and Seabed Conditions, the ejection height of 5 m is associated with the thickest deposits and there is only a small difference in the maximum deposition extent for most sediment types. Therefore, this ejection height is considered to represent worst-case.

168. Under the 5 m ejection height assumption, deposition thicknesses of fine sand of approximately 0.17 m may occur, covering an area of 3.11 km^2. Deposition of fine gravel sediments of thicknesses of approximately 0.4 m may occur over areas of 0.1.49 m^2. This is also based on flow speeds being 0.4 m/s, as is typical of the Marine Scheme area. The range of deposition thicknesses and extents is shown in Table 9.17 which covers a number of sediment types which may occur across the Marine Scheme area. In practical terms, the actual level of deposition will be within this range.

169. Deposition thickness and extent are inversely correlated; as deposit extent increases, the thickness is reduced. Thicker deposits cover a smaller area.

Table 9.17 Deposition extent and thickness associated with seabed levelling activities (undertaken by MFE) (taken from Volume 2, Chapter 7: Offshore Physical Environment and Seabed Conditions)

Sediment type	Current speed (m/s)	Ejection height (m)	Deposition thickness (m)	Deposition extent (km^2) (whole Marine Scheme)	Deposition extent (km^2) (Scottish Waters)	Deposition extent (km^2) (English Waters)
Fine gravel	0.4	5	0.4	1.49	0.33	1.16
Coarse sand			0.3	3.09	0.69	2.40
Medium sand			0.3	3.11	0.69	2.42
Fine sand			0.17	3.11	0.69	2.42

170. While the direct footprint of activities will remain within 25 m either side of each the Offshore Export Cables, deposition attributed to different activities will vary. The extent of deposition associated with Offshore Export Cable installation is shown in (Table 9.18 as compared to seabed levelling in Table 9.17). The worst case assumption is that both activities will be undertaken by MFE.

171. The calculation method for cable installation is slightly different owing to the more rapid rate of MFE movement compared to seabed levelling. Due to the increased movement, the extent of deposition is instead described as distance travelled by sediment in the wake of the MFE equipment. Due to the more targeted nature of trenching, the MFE disturbance height has been assumed to be lower than the seabed levelling, therefore disturbance heights of 1 m, 5 m, and 10 m are used in the analyses in Volume 2, Chapter 7: Offshore Physical Environment and Seabed Conditions. The deposition analysis again takes into account a range of flow speeds (0.2 m/s, 0.4 m/s and 0.6 m/s), in addition to the range of sediments, as are known to occur in the Marine Scheme.

172. Under the assumed ejection height of 5 m and flow speeds of 0.4 m/s, the deposition of fine sand in thicknesses of approximately 0.03 m may occur for extents of up to 200 m in the wake of the installation activity. Deposition of coarser grained sediments (fine gravel) of 0.07 m may occur of comparatively smaller extents of approximately 6.9 m (Table 9.18).

Table 9.18 Deposition extent and thickness associated with cable installation (undertaken by MFE) (taken from Volume 2, Chapter 7: Offshore Physical Environment and Seabed Conditions)

Sediment type	Current speed (m/s)	Ejection height (m)	Distance travelled (m)	Deposition thickness (m)
Fine gravel	0.4	5	6.9	0.07
Coarse sand			14.3	0.05
Medium sand			40	0.04
Fine sand			200	0.03

173. The thicknesses and extents reported in Table 9.17 and Table 9.18 represent the middle ground within the possible range of deposition, which when balancing deposition thickness (which reduces with ejection height) and dispersion distance (which increases with ejection height) is considered to represent worst-case. In reality, deposition will not be uniform and also will be temporary as

deposited sediments may be reincorporated into the local sediment transport regime (see Volume 2, Chapter 7: Offshore Physical Environment and Seabed Conditions).

174. Furthermore, the sediments were found to be consistently muddy sand across the Marine Scheme area (Natural Power, 2023). Therefore, any deposition associated with disturbed sediments will likely be in keeping with the surrounding seabed. Consequently, the extent of changes to the sediment type will be limited.

175. Modelling of SSC was undertaken for the BBWF (BBWFL, 2022). Average levels of SSC increased to between 50 mg/l and 500 mg/l across the plume extent (noting that this is not inclusive of the instantaneous maxima likely to occur at the disturbance site) as a result of the BBWF Offshore Export Cable installation. These levels dropped to background levels on the slack tide. As peak currents within the BBWF array area are of a similar magnitude to the Marine Scheme, it is likely that any changes in SSC as a result of the BBWF Offshore Export Cables will be of a similar magnitude to the changes in SSC within the Marine Scheme as a result of cable installation.

176. At the Landfall in English waters, up to 10,000 m3 of drilling fluids may be released for five bores (four used and one contingency), resulting in increases of SSC of hundreds of thousands of mg/L at the release site. As outlined in Volume 2, Chapter 7: Physical Environment and Seabed Conditions, the SSC at the release site will disperse rapidly in the form of a plume with decreasing SSC with distance from the source and solids settling completely within 1.4 hours. The deposition of released drilling fluids will be up to 0.05 m thick in slower current speeds (0.1 m/s) with a plume extent of 500 m. At faster current speeds, associated with the fastest spring flow speeds, the deposition thickness reduces to 0.2 m with a plume that extends over a larger area of 3 km.

177. The majority of contaminant levels at sampled stations were below Cefas Action Level 1 thresholds and Canadian Interim Sediment Quality Guidelines. THC levels were above Cefas Action Level 1 at two locations. These locations were within the inshore Marine Scheme area in English waters, relatively close to the shore in proximity to the Port of Blyth. Overall, sediment analysis results showed low levels of chemical contaminants within the Marine Scheme area as a whole (Natural Power, 2023). Therefore, the limited extent of installation activities is unlikely to mobilise significant levels of contaminants.

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

9.12.1.2.2. SENSITIVITY OF THE RECEPTOR

Marine finfish

179. Most marine finfish are not dependent on the seabed during their lifecycles in the sense that demersal spawners are. Sandeel and herring, as demersal spawners are more sensitive to changes in sediment attributed to deposition. Therefore, these species are considered individually in the following sections.

180. Prior to deposition, the installation activities will generate localised increases in SSC. It has been shown that adult finfish can show avoidance behaviour within areas affected by increased SSC (EMU, 2004). However, less mobile juveniles are known to utilise the fish and shellfish ecology study area (section 9.7.1.2).

181. Appleby and Scarratt (1989) suggested that the development of eggs and larvae can be affected by SSC when concentrations reach thousands of mg/l. Consequently, SSC attributed to Marine Scheme activities may affect the development of eggs and larvae. However, these high SSCs are expected to be highly localised in the immediate vicinity of the release site. Furthermore, the plume associated with the disturbed material will have dissipated on successive tides.

182. Deposition of the sediments once they fall out of suspension is unlikely to affect those species which spawn pelagically. As their eggs are released into the water column, they will not be affected by processes occurring on the seabed.

183. Marine finfish deemed to be of low vulnerability, high recoverability and of local importance. The sensitivity of the receptor is therefore, considered to be low.

Sandeel

184. As described previously, the PSA results indicate that the seabed along the majority of the Offshore Export Cable corridor is not suitable for spawning, with the exception of some suitable and sub-prime habitat across the Marine Scheme within the BBWF area in Scottish waters. Therefore, the extent to which increased SSC and deposition will affect sandeel is limited. Adult individuals are adaptable to disturbance and will return to the area upon installation activities ceasing.

185. The FEAST tool considers sandeel to be highly sensitive to physical change (to another seabed type), as may occur when disturbed sediments are deposited. Sandeel are also deemed highly sensitive to high levels of siltation (Scottish Government, 2023) due to their specific sediment requirements. An increase in silt content could either infill burrows and directly affect individuals, or could more generally reduce the carrying capacity of sediment with consequences on populations (Wright et al., 2000). Siltation is dependent on the sediment size and, though the PSA results for the Marine Scheme area indicate fines have a relatively high presence (average of 21% across samples; Natural Power, 2023), the sediment is mixed and not exclusively fines based. Therefore, such scenarios as described above detailing extreme siltation are highly unlikely to occur.

186. As stated above, the area of deposition may be variable. However, the overall area of deposition associated with MFE (for seabed levelling activity and cable installation) will occur within an area which sandeel are not highly dependent on. In the north of the Marine Scheme in Scottish waters, where the seabed is more suitable for sandeel spawning, disturbance of sediments will result in deposition, however the sediments deposited are likely to be consistent with those found in this area of the Marine Scheme. Therefore, the deposition will not result in a material change to the sediment composition of the seabed. Overall, the extent of deposition will not result in subsequent losses of spawning habitat further afield as deposition will be localised to an area already largely considered to be muddy sand.

187. Sandeel are deemed to be of medium vulnerability, medium recoverability and are of national importance. The sensitivity of the receptor is therefore, considered to be medium.

Herring

188. Adult herring, as with other marine finfish are tolerant of disturbance. They are able to avoid areas which are being affected by the proposed Marine Scheme activities. As demersal spawners, this phase is when they are likely to be most affected by SSC and deposition.

189. However, herring eggs are thought to be tolerant of high levels of SSC and deposition (Messieh et al., 1981; Kiørboe et al., 1981). Considering that deposited sediments will ultimately be reincorporated into the local sediment transport regime, increased sediment deposition is not expected to affect herring and other demersal spawners. Furthermore, as described previously, the Marine Scheme area is largely ‘unsuitable’ for herring spawning, with the exception of some more suitable habitat limited to the northernmost extent of the Marine Scheme within the BBWF array area in Scottish waters.

190. Herring are deemed to be of medium vulnerability, high recoverability and of regional importance. The sensitivity of the receptor is therefore, considered to be low.

Diadromous fish

191. While salmonids can be sensitive to increased SSC through reduced visual ability to detect prey (Abbotsford, 2021), effects to migratory fish from increased SSC will be limited to times when they pass through during migrations. Given the Marine Scheme area itself is unlikely to be of significance to diadromous species, exposure will be limited in duration.

192. Furthermore, diadromous fish species are generally expected to have some tolerance to elevated SSC, given their migration routes typically pass through estuarine habitats which are often characterised by more turbid waters. Additionally, migratory salmonids tend to swim within the top 5 m of the water column (Godfrey et al., 2014). As much of the immediate disturbance associated with Marine Scheme activities will occur at the seabed, and SSC will be highest here, species like salmon are unlikely to encounter plumes.

193. Diadromous fish are deemed to be of low vulnerability, high recoverability and of national to international importance. The sensitivity of the receptor is therefore, considered to be low.

Shellfish

194. Generally, many shellfish species are known to be tolerant of increased SSC. The exception to this is during times when species are berried (i.e. carrying eggs). At this time, eggs require regular aeration which may be impeded by increased SSC.

195. Nephrops, which are likely to be found in the Marine Scheme area, are considered tolerant of increases in SSC and smothering. As scavengers, they are not dependent on suspended sediment for food availability (Sabatini and Hill, 2008). Furthermore, as a burrowing species, they will be able to excavate any sediment deposited as a result of Marine Scheme activities.

196. Brown crabs (and most crab species) are able to escape from under silt and migrate away from an area. Smothering is unlikely to cause mortality therefore an intolerance of low has been recorded (Neal and Wilson, 2008). However, it has been noted that brown crab have been reported to avoid areas of spoil dumping, possibly due to SSC or decreased macrofauna. This species relies on visual acuity to find prey which could also contribute to their avoidance of such conditions.

197. Shellfish are deemed to be of low vulnerability, high recoverability and of regional importance, given their commercial significance. The sensitivity of the receptor is therefore, considered to be low.

Elasmobranchs

198. Due to the mobility of elasmobranchs, they are not considered to be vulnerable to increases in SSC and subsequent deposition. Species with demersal reproductive strategies may be more susceptible to SSC and deposition impacts.

199. Common skate, which are known to partly utilise the Marine Scheme area as nursery grounds, are not considered to be sensitive to smothering. Neal and Pizzolla (2006) predict that some stress may be caused due to loss of food and energetic costs of migrating to new foraging areas. Furthermore, considering the limited spatial extent of potential sediment plumes and associated deposition, the degree of avoidance by elasmobranchs is unlikely to be significant.

200. Elasmobranchs are deemed to be of low vulnerability, high recoverability and of national and international value. The sensitivity of the receptor is therefore, considered to be low.

9.12.1.2.3. SIGNIFICANCE OF EFFECT

Marine finfish

201. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **negligible to minor** adverse significance, for the Marine Scheme as a whole, which is not significant in EIA terms.

Sandeel

202. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor** adverse significance, for the Marine Scheme as a whole, which is not significant in EIA terms.

Herring

203. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **negligible to minor** adverse significance, for the Marine Scheme as a whole, which is not significant in EIA terms.

Diadromous fish

204. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **negligible to minor** adverse significance, for the Marine Scheme as a whole, which is not significant in EIA terms.

Shellfish

205. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **negligible to minor** adverse significance, for the Marine Scheme as a whole, which is not significant in EIA terms.

Elasmobranchs

206. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **negligible to minor** adverse significance, for the Marine Scheme as a whole, which is not significant in EIA terms.

9.12.1.2.4. SECONDARY MITIGATION AND RESIDUAL EFFECTS

207. Given that there are no likely significant effects in EIA terms, secondary mitigation is not required.

9.12.1.3. UNDERWATER NOISE

208. During the pre-construction, construction, operation and maintenance and decommissioning phases of the Marine Scheme, underwater sound emissions from acoustic (e.g. geophysical) surveys, site preparation and construction activities have the potential to result in physiological or behavioural effects on fish and shellfish receptors, at an individual or population level. Behavioural effects, such as disturbance or displacement, may impact acoustic communication in fish, reproductive success, foraging, predator avoidance and navigation (Radford et al., 2014; De Jong et al., 2020; Hawkins and Myrberg, 1983).

209. Underwater sound can result from a number of activities, including:

- Geophysical surveys;
- Cable laying activities;
- Installation of cable protection which could include the placement of rock on the seabed;
- Drilling or trenching at the Landfall locations;

- Vessel movements during construction activities (including cable lay vessels with dynamic positioning (DP); and
- Operational cable surveys using acoustic methods.

210. Underwater sounds can be categorised as either impulsive (e.g. geophysical survey equipment); or non-impulsive (or continuous) in nature (e.g. those generated by cable laying, trenching and from vessel operations). The potential impacts of anthropogenic underwater sound on fish and shellfish receptors are influenced by the characteristics of the sound (i.e., determined by the frequency and intensity of the sound source), the duration of the sound against baseline background levels and the sensitivity of the species.

211. This impact is consistent along the Offshore Export Cable length therefore the following discussion is applicable to the whole Marine Scheme within both Scottish and English waters, with the exception of Landfall activities which are only relevant to the Marine Scheme within English waters.

212. For this assessment of acoustic impacts on fish and shellfish, the principal metric for describing the intensity of underwater sound is the sound pressure level (SPL). The SPL is a measure of the amplitude or intensity of a sound and, for impulsive sounds, is measured as a peak value or as a root-mean-square value which is more appropriate for non-impulsive sound sources.

213. Underwater sound has both a pressure and particle motion component, and the majority of research on the impact of underwater sound on the marine environment focuses on the former (Nedelec et al., 2016). Sound pressure changes may be detected by fish with a swim bladder, as the gas within the swim bladder changes as a result of changing sound pressure. If the swim bladder is near the ear or connected to the hearing system, the hearing sensitivity is even greater (Popper et al., 2014). Fish without a swim bladder cannot detect sound pressure. However, most fish species are expected to be able to detect particle motion.

214. Particle motion has a directional component and attenuates differently in the marine environment than sound pressure (Hawkins and Popper, 2017). Fish and shellfish may not only detect changes in particle motion in the water column, but those in close contact with the seabed may also detect particle motion in the substrate (Popper and Hawkins, 2018). Fish detect particle motion through otolithic organs in the inner ear which are of a greater density than the surrounding tissues and also through sensory hair cells in the lateral line (Popper and Hawkins, 2018). The hearing system of shellfish is uncertain. However, it is likely that they can only detect particle motion, potentially via sensory cells associated with hairs or statocyst or through vibrations of exoskeletons (Popper and Hawkins, 2018).

215. The most relevant criteria for considering potential impacts on fish and shellfish are considered to be those provided in the Sound Exposure Guidelines for Fishes and Sea Turtles (Popper et al., 2014). Fish species are grouped into hearing sensitivity categories defined by a number of factors such as their hearing anatomy, particle motion detection, the use of sound during navigation or mating and the presence or absence of a swim bladder:

- **Fishes that do not have a swim bladder**. These species are likely to only use particle motion (and not sound pressure) for sound detection, and therefore only show sensitivity to a narrow band of frequencies (< 400 Hz). This group includes all elasmobranchs (sharks, skates and rays) and flatfish;
- **Fishes with swim bladders that do not appear to play a role in hearing**. These species are likely only to be sensitive to particle motion, but could be susceptible to barotrauma9. They

[9] Barotrauma is a term which refers to physical damage to tissues caused by a difference in pressure between the tissues and the surrounding external environment.

only show sensitivity to a narrow band of frequencies (<1000 Hz). This group includes salmonids, e.g. Atlantic salmon; and

- Fishes with swim bladders (or other structure containing gas) that are connected to the ear. These species are sensitive to both particle motion and sound pressure extending up to around 500 Hertz (Hz) and in some cases, several kHz. This group includes Atlantic cod, and herring and other clupeids.

216. Although there is some evidence that some physiological impacts can occur from the impact of noise on marine invertebrates, the majority of these impacts likely relate to the effect of particle motion, rather than sound pressure (Popper and Hawkins, 2018). There are no threshold criteria for either particle motion or sound pressure for shellfish, with respect to injury or disturbance. Crustacean species such as brown crab, lobster and Norway lobster are not considered sensitive to underwater sound because they lack any air-filled spaces in their body cavities. As there is no evidence for impacts from underwater sound on these key species, and there are no thresholds by which to assess any impacts for shellfish receptors, shellfish species are not considered further in this assessment.

217. This section focuses on the acoustic impacts arising from activities associated with the Marine Scheme on fish species. The sound characteristics of activities associated with the Marine Scheme have been determined by a significant body of knowledge from common sound generating activities from existing literature (as summarised in Table 9.19). Where a range of sound source levels were identified for an activity, a reasonable, realistic worst-case level has been assumed for the assessment.

Table 9.19 Characteristics of underwater sound sources generated by indicative equipment which may be used for Marine Scheme construction activities

Underwater Sound Generating Activity	Frequency Range (kHz)	Indicative SPL (SPL[1] dB re 1µPA)	Assessed further in this chapter
Survey vessel and support vessel	Acoustic energy from vessel is strongest at frequencies <1 kHz	172 – 188 (rms)	X
Sub Bottom Profiler (SBP)	8-12	235	✓
Multi-Beam Echo Sounder (MBES)	400-700	180-240	X
Side Scan Sonar (SSS)	300-900	213-225	X
Ultrashort Baseline (USBL)	19.5-33.5	207	X
Rock placement	-	Below ambient noise	X
Horizontal directional drilling (HDD)	< 1	142 – 145 (rms)	X
Ploughing, jetting and trenching (cable installation)	0.01 – 150	178 (rms) (principally associated with vessel sound)	X

[1]SPLs are peak unless otherwise stated.

218. A number of the underwater sound sources associated with pre-construction surveys, construction, operation and maintenance and decommissioning phases can be removed at this stage of the fish and shellfish ecology assessment, based on the nature of the sound and/or the likelihood that they will be masked by ambient noise within the marine environment. A justification for scoping out those underwater sound sources has been provided below:

- **Vessel operations**: the underwater sound pressure levels associated with survey and construction vessel activities are likely to be too low to result in injury or large-scale disturbance to fish or shellfish species. There will be a limited number of vessels associated with the survey and construction phase of the Marine Scheme, with the associated underwater sound profile considered not significant in the context of existing shipping and navigation activities throughout the North Sea (see Volume 2, Chapter 13: Shipping and Navigation for further information on existing vessel baseline conditions associated with the Marine Scheme). As the presence of vessels is not likely to be significantly above baseline levels, no significant impacts from vessel movements on fish and shellfish species are anticipated.
- **Sub-bottom profiler**: sub-bottom profilers (SBP) are directional acoustic sources, usually hull-mounted or towed, which are used to characterise ground conditions and geological

formations below the seabed (typically within the first few metres). There are several classes of SBP, referred to as sparkers, boomers, pingers and chirps. This type of geophysical survey equipment can generate sound pressure levels >235 dB re 1 µPa, which could have the potential to cause mortality, injury and behavioural disturbance to some fish and shellfish species. The impact of sound produced during SBP surveys has been considered further in this assessment;

- **Multi-beam echosounder**: MBES is typically used at high frequencies (>200 kHz) that will fall outside the known hearing range of any fish or shellfish species. Due to the high source frequency, sounds produced from MBES will also attenuate quickly with distance. Therefore, there will be no impacts from MBES activities on fish or shellfish species and this underwater sound source has not been considered further in this assessment;
- **Side-scan sonar (SSS):** similar to MBES, SSS operates at high frequencies (typically >300 kHz) outside the known hearing range of fish or shellfish species. Therefore, there will be no impacts from SSS activities on fish or shellfish species and this underwater sound source has not been considered further in this assessment;
- **USBL**: peak sound pressure levels associated with USBL transponders, used for underwater positioning, can be ca. 207 dB re 1µPa. This is above the amplitude at which physiological or behavioural impacts on some fish species could be expected. However, these types of equipment typically operate at >10 kHz, which is above the hearing range of all fish species. Therefore, no impacts from USBL operations on fish and shellfish species are anticipated and this underwater sound source has not been considered further in this assessment.
- **Cable protection**: where this involves the use of rock placement it is likely that some fish species have the ability to faintly hear rocks falling through a fall tube to the seabed (Nedwell and Edwards, 2004), it is likely that vessel noise will dominate the soundscape in the vicinity of this activity (Nedwell, Brooker, & Barham, 2012). As vessel noise will comprise the dominant contribution to the soundscape, and owing to the short term and transient nature of this activity, no additional impacts from rock placement on fish or shellfish species are anticipated and this underwater sound source has not been considered further in this assessment;
- **Horizontal Directional Drilling (HDD):** existing studies into the sound profile of HDD operations within shallow, riverine waters concluded that, in the absence of vessel noise, HDD produced a maximum unweighted SPL of 129.5 dB re 1 µPa (Nedwell, Brooker, and Barham, 2012), when drilling below the riverbed. Erbe and McPherson (2017) reported an SPL of 142-145 dBrms re 1 µPa at 1 m, generated by a jack-up drilling rig undertaking geotechnical drilling in shallow water in western Australia. It is assumed that sound from HDD operations would be similar to this geotechnical drilling. At an offshore HDD emergence location, it is most likely that vessel noise would comprise the dominant contribution to the soundscape. The sound pressure levels associated with HDD are not of a level which could introduce a risk of injury or disturbance to fish and shellfish, and owing to the short term and transient nature of this activity, no impacts from HDD operations on fish or shellfish species are anticipated and this underwater sound source has not been considered further in this assessment; and
- **Ploughing, jetting and trenching cable during construction:** Sound monitoring was conducted during the installation of the offshore transmission cable for the North Hoyle wind farm using a mechanical trencher. The source noise levels were reported to be 178 dB re 1µPa at 1m, with a mixture of broadband noise, tonal components, and transients associated with rock breakage. The sound levels were highly variable, and were directly related to the seabed type (Nedwell *et al.,* 2003). However, the primary source of underwater sound from ploughing, jetting and trenching activities will result from the construction vessel itself. Owing to the short term and transient nature of cable installation activities, no additional impacts from ploughing, jetting and trenching activities on fish or shellfish species are anticipated and this underwater sound source has not been considered further in this assessment.

219. The only activity associated with the Marine Scheme that is considered to generate an underwater sound profile above the thresholds of impacts to fish and shellfish species (and therefore likely to result in a significant effect) is geophysical survey using sub-bottom profiler.

Underwater sound associated with sub-bottom profilers

220. Geophysical surveys use acoustic sound sources which introduce sound energy into the marine environment. The Marine Scheme will employ the use of SBP as a geophysical survey method to characterise ground conditions and geological formations below the seabed (typically within the first few metres). SBP generate acoustic pulses at peak SPL which could cause injury or mortality in fish species.

221. Although SBP pings can be considered individually impulsive in nature, the high frequency of pings (up to 50 pings per second for an exemplar system, the Innomar SES-2000) results in a sound source with characteristics more closely related to a continuous source. For this reason, the sound generated by SBP can be better considered in terms of its root-mean-square SPL than the peak metric, and it is more appropriate to assess against thresholds for injury and behavioural effects for mid-frequency sonar than seismic surveys.

9.12.1.3.1. MAGNITUDE OF IMPACT

222. SBP operations associated with the Marine Scheme will occur during pre-construction surveys. SBP will be utilised from a moving vessel, and any impacts will be transient and of a short duration as the vessel moves through an area engaged in survey operations. SBP use a downward-facing transponder which transmits sound energy towards the sea floor. Sound associated with SBP will radiate from the (hull-mounted or towed) transponder, with acoustic propagation loss meaning the sound will lose intensity with increasing distance from the vessel. There is evidence that due to the highly-directional (downward-facing) beam pattern, the propagation loss associated with SBP sound pulses appears to be much greater than would be expected for a sound source which produces omnidirectional pulses. A study in Danish waters by Pace et al., (2021) measured SPL associated with SBP. This study reported that beyond ca. 500 m from the source, the sound of a SBP was barely detectable above background noise, in spite of a expected SPLrms of 235 db re 1 µPa at 1 m.

223. Due to the directionality of this type of equipment, it would be expected that fish and shellfish directly below the SBP transponder would be exposed to the highest sound pressure levels. However, due to this directionality, received SPLs at increasing distance from the source are expected to decline rapidly.

224. To estimate the distance beyond which injurious impacts to fish would not be expected, a simplistic geometric spreading law can be used to approximate the sound propagation loss:

$$RL = SL - A.\log_{10}(R)$$

225. where RL = the received sound pressure level (in dB re 1 µPa), SL = the source SPL (typically approximated as the SPL in dB re 1 µPa at 1 m from the source), A = a geometric spreading loss coefficient, which is commonly considered to be 15 (representative of an intermediate model of sound propagation between spherical and cylindrical spreading), and R = the distance, in metres, from the sound source. Note that Pace et al., (2021) estimated a geometric spreading loss coefficient of A = ~44 from SBP recordings, which means the use of A = 15 in the geometric spreading calculation is a very conservative assumption.

226. This geometric spreading model can be used to determine the distance at which injury thresholds are no longer exceeded, based on the information in Popper et al. (2014) in relation to mid-frequency naval sonar. Popper *et al*. (2014) does not specifically assess sound emitted by SBP, however seismic airguns and mid-frequency naval sonar are described. Mid-frequency naval sonar is a better proxy comparison for SBP than seismic airguns due to the properties of the sound source. Hence, this has been presented in Table 9.20.

Table 9.20 Distance to injury thresholds for mid-frequency sonar for three hearing-sensitivity groups of fish, and eggs and larvae (adapted from Popper *et al.,* 2014)

Fish hearing group	Source SPL_{peak} of SBP (dB re 1 µPa at 1 metre)	Mortality, potential mortal injury, recoverable injury threshold (SPL_{rms} re 1 µPa)	Distance at which injury threshold is no longer exceeded	Behavioural impacts threshold (SPL_{rms} re 1 µPa)	Distance at which disturbance threshold is no longer exceeded
Fish with no swim bladder (particle motion detection)	235	(N) Low (I) Low (F) Low	"Near field"	N/A	N/A
Fish with swim bladder that is not involved in hearing (particle motion detection)		> 210	47 m	N/A	N/A
Fish with swim bladder that is involved in hearing (primarily pressure detection)		> 210	47 m	> 209	55 m
Eggs and larvae		N/A	N/A	N/A	N/A
Notes: rms sound pressure levels dB re 1 µPa. All criteria are presented as sound pressure even for fish without swim bladders since no data for particle motion exist. Relative risk (high, moderate, low) is given for animals at three distances from the source defined in relative terms as near (N; tens of metres), intermediate (I; hundreds of metres), and far (F; thousands of metres).					

227. It is anticipated that the risk of injury to fish and shellfish receptors from SBP operations will be highly localised (i.e., within a radius of <50 m from the sound source), and that any behavioural impacts will be short-term and recoverable.

228. The impact of SBP operations on marine fish will be of highly localised spatial extent, short term duration, intermittent and, other than in the near field, of high reversibility. It is predicted that the impact will affect fish and shellfish receptors directly. The magnitude is therefore considered to be low.

9.12.1.3.2. SENSITIVITY OF THE RECEPTOR

229. There is no documented evidence of impacts on fish from SBP. When considering the body of evidence from similar or related sound sources, (e.g., seismic airguns, mid-frequency sonar), there is no evidence for injury (to ear or non-auditory tissues) or mortality in fish (Popper et al., 2014).

230. Sound generated by SBP operations could mask signal detection for fish species that use sound for communication, although this would be short-lived due to the transient nature of SBP operations. No observed behavioural reactions were observed in Atlantic herring exposed to mid-frequency sonar up to 209 dB re 1 µPa (Doksaeter et al., 2009), thus it is not likely that strong behavioural effects would be seen in fish species without specialised hearing. There is insufficient evidence to identify behavioural disturbance thresholds for fish with no swim bladder/swim bladder not involved in hearing (Popper et al., 2014).

- For fish with no swim bladder and fish with a swim bladder that is not involved in hearing there is no evidence of mid-frequency sonar having behavioural effects. The risk of mortality or injury is considered to be likely only within the near-field (tens of metres), so any impacts will be spatially limited. As SBP operations will be transient and of a short duration, impacts to these species are likely to be minor and spatially constrained.
- For fish with a swim bladder that is involved in hearing it is likely that sound associated with SBP operations will be audible and could cause masking, and possibly behavioural disturbance at high amplitudes. The risk of mortality, injury or strong behavioural effects is considered to be low beyond the near-field (tens of metres). As stated previously, impacts will be transient and of a short duration, so injury or behavioural impacts to these species are likely to be minor and spatially constrained.
- No data exists for impacts of SBP (or analogous sound sources) on fish eggs and larvae. As any impacts from SBP will be transient and of a short duration, it is not likely that there will be any impacts on fish eggs/larvae associated with SBP surveys.

231. The species group that is most sensitive to impacts from sound associated with SBP operations are fish species where the swim bladder is involved in hearing. In the fish and shellfish Study Area, these species include gadoids, such as cod, haddock and whiting, and herring. Several of these species have spawning or nursery areas which overlap with the fish and shellfish study area and many of these species are of high commercial value (Volume 2, Chapter 12: Commercial Fisheries). However, their spawning and nursery grounds are typically very large and widespread, relative to any transient, short duration and small-scale (< 1000 m) mortality, injury or behavioural effects that could be associated with SBP surveys in the Marine Scheme.

232. All other fish and shellfish species known to occur within the fish and shellfish study area, including those where known spawning or nursery grounds overlap with the study area, occur widely across the North Sea and the northeast Atlantic Ocean. Given the limited impacts that are predicted to result from SBP surveys, population level impacts are not anticipated.

233. Fish without swim bladders and fish with a swim bladder that is not involved in hearing are deemed to be of low vulnerability, high recoverability and high value. The sensitivity of the receptor is therefore, considered to be negligible.

234. Fish with a swim bladder that is involved in hearing are deemed to be of medium vulnerability, high recoverability and high value. The sensitivity of the receptor is therefore, considered to be low.

235. Shellfish are deemed to be of low vulnerability, high recoverability and high value. The sensitivity of the receptor is therefore, considered to be negligible.

9.12.1.3.3. SIGNIFICANCE OF EFFECT

236. SBP operations associated with pre-construction surveys are not expected to pose a significant risk of mortality, injury or behavioural disturbance to fish and shellfish receptors, as SBP operations will be of short duration and transient.

237. There is no evidence of SBP sound (or analogous sound sources) causing mortality or injury in fish or shellfish, and behavioural impacts are likely to be limited to the near-field from SBP sources. As a result, SBP sound is considered to be of negligible significance to fish and shellfish, and the magnitude of any impacts is negligible.

Fish with no swim bladder/fish with a swim bladder that is not involved in hearing

238. For fish without swim bladders and fish with a swim bladder that is not involved in hearing, the magnitude of the impact is deemed to be negligible and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **negligible to minor** adverse significance, for the Marine Scheme as a whole, which is not significant in EIA terms.

Fish with a swim bladder that is involved in hearing

239. For fish with a swim bladder that is involved in hearing, the magnitude of the impact is deemed to be negligible and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **negligible to minor** adverse significance, for the Marine Scheme as a whole, which is not significant in EIA terms.

Shellfish

240. For shellfish, the magnitude of the impact is deemed to be negligible and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **negligible to minor** adverse significance, for the Marine Scheme as a whole, which is not significant in EIA terms.

9.12.1.3.4. SECONDARY MITIGATION AND RESIDUAL EFFECTS

241. Given that there are no likely significant effects in EIA terms, secondary mitigation is not required.

9.12.2. Potential Effects During Operation and Maintenance

9.12.2.1. EMF EFFECTS

242. The operation of the Offshore Export Cables as outlined in section 9.9.1, will result in emission of localised EMFs. This could potentially affect the sensory mechanisms of certain fish and shellfish species. Elasmobranchs, diadromous fish and lobsters and crabs in particular are known to be electrosensitive (CMACS, 2003; Hutchison et al., 2021).

243. This impact is consistent along the Offshore Export Cable length therefore the following discussion is applicable to the whole Marine Scheme within both Scottish and English waters.

244. Due to the different level of sensitivity of different species groups, the receptor sensitivity appraisal has been split into the key receptor groupings (marine finfish, diadromous fish, shellfish, and elasmobranchs).

9.12.2.1.1. MAGNITUDE OF IMPACT

245. EMF comprise electrical fields (E-fields), measured in volts per metre (V/m), and magnetic fields (B-fields), measured in microtesla (μT). B-fields penetrate most materials and so are emitted into the marine environment which, can result in an induced electric field (iE-field). Comparatively, direct E-fields are blocked by conductive sheathing, and are not emitted from the cables. The Earth has its own natural geomagnetic field (GMF), with associated B and iE-fields, which species rely on for navigation (Winklhofer, 2009; Gill and Desender, 2020).

246. In the North Sea, background measurements of the magnetic field are approximately 50 μT, and the naturally occurring electric field in the North Sea is approximately 25 microvolts per metre (μV/m) (Tasker et al., 2010).

247. The strength of B-fields (and iE-fields) decreases rapidly in all directions with distance from the source due to field decay. Consequently, burying a cable results a reduced B-field at the seabed as a result of field decay with distance from the cable (Nordmandeau et al., 2011; CSA, 2019; Hutchison et al., 2021). While cable burial and use of measures such as cable protection are not thought to be effective means of mitigating against B-fields (Hutchison et al., 2021), the separation does reduce the maximum field strength likely to be encountered by marine species on or near the seabed (Copping et al., 2020).

248. B-fields associated with DC cables are higher than those associated with equivalent AC cables because DC cables transmit electricity using a static current (as opposed to alternating) which

enables formation of a static EMF. In the case of AC cables, this alternating current results in varying EMF, therefore the B-field is weaker.

249. High level modelling has been completed for the Marine Scheme on the level and attenuation of the EMF emissions (B-fields only) for both a paired symmetrical monopole configuration rated at 320 kV (comprising four HVDC cables) and a bipole configuration rated at 525 kV (two HVDC cables), as detailed in Volume 2, Chapter 5: Project Description.

250. As detailed in section 9.9.1, the maximum EMF strengths are associated with a bipole HVDC cable configuration rated at 525 kV. The four HVDC cable 320 kV symmetrical monopole configuration resulted in lower EMF strengths, but a wider footprint of elevated EMF levels given the additional two HVDC cables. The modelling estimates that:

- For the 525 kV bipole configuration including a pair of HVDC cables separated by 25 m and buried to a minimum depth of 0.5 m, the resulting EMF strength is approximately 658 µT. This is shown to decay with distance to the natural background GMF strengths within the vicinity of the Marine Scheme (50 µT; Volume 2, Chapter 5: Project Description) at a distance of between 10-20 m from the Offshore Export Cables, both vertically and horizontally, and falls below the FEAST tool benchmark (section 9.12.2.1.2) within 10 m of the Offshore Export Cable. In reality, it is likely that the Offshore Export Cables will be buried to a greater depth than this in some areas with favourable ground conditions, where EMF strengths will dissipate to the GMF even more rapidly.
- For the 320 kV symmetrical monopole configuration including four HVDC Cables, separated by up to 25 m and buried to a minimum depth of 0.5 m, the resulting EMF strength is approximately 541 µT. This is shown to decay with distance to the natural GMF strength at a distance of between 10-20 m from the Offshore Export Cables, both vertically and horizontally and falls below the FEAST tool benchmark (section 9.12.2.1.2) within 5-10 m of the Offshore Export Cables. In reality, it is likely that the Offshore Export Cables will be buried to a greater depth than this in some areas with favourable ground conditions, where EMF strengths will dissipate to the GMF even more rapidly.

251. The impact is predicted to be of local spatial extent, short term duration, continuous and not reversible during the operational phased of the Marine Scheme. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

9.12.2.1.2. SENSITIVITY OF RECEPTOR

252. Generally, electrosensitive species are responsive to low intensity E-fields between 0.02 and 100 µV/cm and frequencies of 0–15 Hertz (Hz) (Tricas and Sisneros, 2004; Stoddard, 2010; Hutchison *et al*., 2020). The FEAST tool benchmark for EMF changes is set as a change in the local E-field of 1 V/m or local B-field of 10 µT, due to anthropogenic means (Scottish Government, 2023).

Marine finfish (including herring and sandeel)

253. Pelagic species are unlikely to encounter the EMF associated with the Offshore Export Cables as these species are not closely associated with the seabed. Conversely, demersal species, including eggs and larvae, on or above the seabed may overlap with the EMF associated with the buried Offshore Export Cables. Consequently, these species are more sensitive to EMF effects (Nyqvist et al., 2020). As stated in section 9.7.1.2, sandeel and herring are unlikely to spawn within the Marine Scheme area.

254. Overall, it is acknowledged that the evidence base for EMF effects on fish is limited and uncertain, particularly with regards to field studies. The existing knowledge on EMF suggests that, under laboratory conditions, potential developmental, genetic and physiological implications of exposure to B-fields only occur when exposure levels are in the range of several milli Tesla (mT), rather than

µT (Gill and Desender, 2020; Copping et al. 2021). This is somewhat higher than would be expected of the Marine Scheme. Generally, research findings, although limited, suggest that EMF associated with offshore renewable developments are unlikely to result in substantial impacts on fish species (Gill and Desender, 2020; Copping et al. 2021).

255. Ultimately, the range over which most marine finfish can detect EMF is limited to centimetres, rather than metres (CSA, 2019).

256. Marine finfish are deemed to be of low vulnerability, high recoverability and of local importance. The sensitivity of the receptor is therefore, considered to be low.

Diadromous fish

257. Contained within the skeletal structure of diadromous fish is magnetically sensitive material which enables them to use EMFs as a navigational tool during migration (Gill and Bartlett, 2010). Consequently, the introduction of anthropogenic EMF into the marine environment has the potential to alter these migratory behaviours, potentially resulting in increased energy expenditure. Although the extent of the effect of EMF on migratory species in unclear (Gill and Bartlett, 2010).

258. Atlantic salmon, sea trout, sea lamprey, river lamprey, and European eel may pass through the Marine Scheme area during migrations (section 9.7.1.4). While exact migration pathways are little understood, and are likely to be diffuse across the fish and shellfish ecology study area, rivers important to such species are present along the coastline within the regional buffer area.

259. No field studies are available on the response of Atlantic salmon to EMF. Wyman et al. (2018) investigated the effect of EMF from a DC undersea cable near San Francisco, California on Chinook salmon. It was concluded that the EMF emitted did not affect salmon migration and survival, although slight deviation from typical migratory routes was observed. In a laboratory setting, Armstrong et al. (2015) also did not find any physiological or behavioural response of Atlantic salmon to B-fields at intensities of 95 µT and below.

260. Most migratory salmonids swim within the top 5 m of the water (Godfrey et al., 2014). Therefore, they would not be affected by EMF emitted from buried cables, given the limited influence of EMF within a matter of metres of the seabed (section 9.12.2.1.1). Conversely, other species such as eels, may be found throughout the water column, including near the seabed.

261. Studies on European eel have concluded that subsea cables did not pose a prohibitive barrier to crossing (Hvidt *et al*., 2003); however, some individuals did show limited effects on directional movement (Westerberg and Begout-Anras, 2000) and speed (Westerberg and Langenfelt, 2008). However, these were not strong avoidance behaviours, nor were they judged likely to influence an overall migration (Westerberg and Begout-Anras, 2000; Westerberg and Langenfelt, 2008). Under laboratory conditions, Orpwood *et al*. (2015) observed no change in the movement or behaviour of European eels as a result of EMF.

262. Diadromous fish species are deemed to be of low vulnerability, high recoverability and of national to international importance. The sensitivity of the receptor is therefore, considered to be low.

Shellfish

263. The body of literature on responses in shellfish to EMF is varied. Recent evidence suggests that crustaceans, including lobster and crab, have been shown to demonstrate a response to B-fields (CSA, 2019). Nevertheless, recent research on brown crab in laboratory conditions (Scott et al., 2021), found that there were no adverse physiological or behavioural impacts at B-fields of 250 µT. At B-field levels of 500 µT and above attraction to the areas emitting EMF and increased time spent roaming was observed. The attraction of crabs to EMF sources is not thought to impact overall crab movements (Love et al., 2017). Research undertaken by Hutchison et al. (2018; 2020) on American

lobster observed behavioural response to EMF associated with a HVDC cable. However, the response was subtle (Hutchison et al., 2018; 2020).

264. Exposure to EMF during embryonic development was found to lead to physiological deformities and reduced swimming test success rates in lobster and brown crab larvae. However, these deformities arose in response to exposure of EMF levels of 2,800 μT (Harsanyi et al., 2022). These levels are likely to be higher than, and therefore not comparable to, EMF levels expected for the Offshore Export Cables. Scott (2019) also found that EMF exposure during development resulted larvae which were significantly smaller than the controls. However, there were no difference in the number of hatched larvae, mortality or fitness.

265. Shellfish species are deemed to be of medium vulnerability, high recoverability and of local to national importance. The sensitivity of the receptor is therefore, considered to be medium.

Elasmobranchs

266. Elasmobranchs detect magnetic fields directly, due to their possession of specialist magnetic receptor cells. It is widely accepted that they are more responsive to magnetic fields in comparison to other species (Gill et al., 2005; Hutchison et al., 2020). Gill et al. (2009) reported that several species of elasmobranchs showed some attraction to cables and reduced swimming activity. It is unlikely that elasmobranchs with demersal egg laying reproductive strategies utilise the Marine Scheme for spawning (section 9.7.1.2), therefore this is an unlikely pathway of effect.

267. Gill and Taylor (2001) found that spurdog, which are likely to be found within the fish and shellfish ecology study area, avoided electrical fields at 10 μV/cm. This is comparatively much higher that EMF levels expected of the Marine Scheme cables. Gill et al. (2009) found that lesser spurdog and thornback ray responded to B-fields of 8 μT and iE-fields of 2.2 μV/m, but noted that the observed response was unpredictable and, in some instances, did not occur altogether.

268. Hutchison et al. (2018; 2020) also demonstrated that little skate, a north American species, showed an increased exploratory behaviour in response to EMF exposure. But ultimately, the cable did not represent a barrier to skate movement (Hutchison et al., 2018). Overall, the extent of EMF influence on elasmobranchs is variable. However, the consensus from much of the literature appears to suggest that EMF levels higher than those expected of the Marine Scheme would be required to cause behavioural change in individuals.

269. Elasmobranchs are deemed to be of medium vulnerability, high recoverability and of local to national importance. The sensitivity of the receptor is therefore, considered to be medium.

9.12.2.1.3. SIGNIFICANCE OF EFFECT

Marine finfish (including herring and sandeel)

270. The expectation is that most marine finfish can only detect EMF within a very small distance of the emitting cable. Furthermore, there is no pathway of impact between the cables and pelagic species. Given the intention to bury the Marine Scheme cables where practicable, EMF levels are likely to decay such that impacts on fish species are unlikely to be notable.

271. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of negligible to minor adverse significance for the Marine Scheme as a whole, which is not significant in EIA terms.

Diadromous fish

272. Diadromous species are thought to be reliant on EMF for migration. Scientific study suggests that while some subtle behavioural changes can often occur as a result of exposure to elevated EMF levels, this is insufficient to influence migration patterns on the whole.

273. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **negligible to minor** adverse significance for the Marine Scheme as a whole, which is not significant in EIA terms.

Shellfish

274. Shellfish are less mobile and the evidence base for EMF effects suggests that chronic exposure can have developmental consequences. However, the levels of EMF required to see such effects is considerably higher than will be associated with the Marine Scheme and EMF decay due to cable burial where practicable will further reduce exposure.

275. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor** adverse significance for the Marine Scheme as a whole, which is not significant in EIA terms.

Elasmobranchs

276. Elasmobranchs are considered to be most responsive to magnetic fields compared to other marine species. Despite this, behaviour upon exposure to such fields is unpredictable and typically has been associated with EMF levels higher than those which are likely to arise from the Marine Scheme.

277. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be medium, due to their increased ability to detect EMF. The effect will, therefore, be of **minor** adverse significance for the Marine Scheme as a whole, which is not significant in EIA terms.

9.12.2.1.4. SECONDARY MITIGATION AND RESDIUAL EFFECTS

278. Given that there are no likely significant effects in EIA terms, secondary mitigation is not required.

9.12.2.2. PERMANENT HABITAT LOSS

279. Permanent habitat loss will arise as a result of the placement of external cable protection, as described within the maximum design scenario (section 9.9.1).

280. This impact is consistent along the Offshore Export Cable length therefore the following discussion is applicable to the whole Marine Scheme within both Scottish and English waters, with the exception of Landfall activities which are only relevant to the Marine Scheme within English waters.

281. Due to the different level of sensitivity of different species groups, the receptor sensitivity appraisal has been split into the key receptor groupings (marine finfish (excluding herring and sandeels), herring, sandeels, diadromous fish, shellfish, and elasmobranchs).

9.12.2.2.1. MAGNITUDE OF IMPACT

282. As described in section 9.9.1, up to 1.46 km^2 of cable protection will be placed in association with the Marine Scheme as a whole. Of this total, up to 0.23 km^2 will be located within Scottish waters and the remaining 1.24 km^2 will be located within English waters. The rock placement total is additionally inclusive of rock associated with the five crossings located along the Offshore Export Cable. These crossings are all located in English waters. The presence of rock is considered permanent owing to its being left in-situ for the duration of the Marine Scheme and potentially beyond.

283. The impact is predicted to be of local spatial extent, permanent in duration, continuous and low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

9.12.2.2.2. SENSITIVITY OF RECEPTOR

Marine finfish

284. As for construction, the majority of marine finfish are tolerant of localised seabed habitat loss as they are not dependent on the seabed during their lifecycle. Sandeel and herring, being the exceptions to this, are addressed separately below.

285. Analogous evidence from windfarms throughout the North Sea suggests that the presence of operational wind farm structures does not lead to adverse effects on fish populations and assemblages (Stenberg et al., 2011; van Deurs et al., 2012; Degraer et al., 2020). With regards to introduction of hard substrates, in Belgian waters Degraer et al. (2020) found that there was some evidence of increases in numbers of species associated with these types of substrates, including sea bass and common squid. However, this was linked to foundations which might have been used for egg deposition. While the infrastructure associated with the Marine Scheme is not comparable to a windfarm, the installation of hard substrate (through rock placement) is unlikely to result in changes to marine finfish assemblages.

286. Marine finfish are deemed to be of low vulnerability, high recoverability and of local importance. The sensitivity of the receptor is therefore, considered to be low.

Sandeel

287. The FEAST tool categorises sandeel as having a high sensitivity to a physical change in seabed type, and therefore sandeel are considered to have a high vulnerability to this impact (Scottish Government, 2023); the introduction of hard substrate in the form of rock protection limits the sandeels ability to burrow. However, as discussed previously, the Marine Scheme is largely not suitable habitat for sandeel spawning. Beyond spawning, sandeel are reliant on specific habitats throughout their lifecycle, therefore their sensitivity extends beyond spawning.

288. However, evidence from windfarms within the North Sea suggests that the presence of infrastructure has not resulted in adverse effects on sandeel populations (van Deurs et al., 2012; Stenberg et al., 2011). In fact, post-consent monitoring of the Beatrice Offshore Windfarm in Scotland reported an increase in sandeel abundance (BOWL, 2021). The scale of permanent habitat loss associated with these windfarm developments is not analogous to the predicted habitat loss associated with the Marine Scheme. Consequently, it is likely that the limited presence of rock installed as part of the Marine Scheme will have a proportionately lesser effect on sandeel populations.

289. Sandeel are deemed to be of high vulnerability, medium recoverability and of national importance. The sensitivity of the receptor is therefore, considered to be medium.

Herring

290. Herring are considered to be less vulnerable to habitat loss than sandeel as they are less dependent on specific substrate types – as demersal spawners, they only require suitable habitat for reproductive behaviours. However, herring are not likely to heavily utilise the Marine Scheme area as the habitat is considered to be largely ‘unsuitable’ for herring spawning.

291. Herring are deemed to be of medium vulnerability, high recoverability and of regional importance. The sensitivity of the receptor is therefore, considered to be low.

Diadromous fish

292. As for construction, it is unlikely that migrating fish species will utilise the Marine Scheme area beyond passing through. The loss of habitat associated with the proposed rock placement will constitute a small loss of feeding grounds in the wider regional context. As these species are highly

mobile, they can avoid areas which have undergone seabed changes and no longer constitute suitable feeding grounds.

293. Diadromous fish species are considered to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is therefore, considered to be low.

Shellfish

294. Species such as brown crab and European lobster prefer harder substrates. Lobster in particular favour rocky habitats which provide them with adequate shelter (Gristina et al., 2011). Brown crab are typically found under boulders, mixed coarse grounds, and offshore in muddy sand (Neal and Wilson, 2008). Therefore, placement of hard substrate such as rock, will not affect them adversely. Within windfarms in Belgian waters, Degraer et al. (2020) found some evidence of increased numbers of species associated with hard substrates, including crustaceans (edible crab). This suggests that an introduction of hard substrate can be beneficial to some species.

295. Conversely, Nephrops are dependent on muddy habitat for burrowing. While this is a mobile species, it is thought that if disturbed they are likely to seek refuge within their burrows (Sabatini and Hill, 2008). As burrowing species they can avoid immediate disturbance, as would occur during initial placement of rock. However, long term this would constitute a loss of habitat for the species, albeit highly localised in scale.

296. Overall, shellfish are deemed to be of medium vulnerability, medium recoverability and of regional importance, given their commercial significance. The sensitivity of the receptor is therefore, considered to be medium.

Elasmobranchs

297. Overall, the Marine Scheme is unlikely to be used by elasmobranch species for spawning, so there is no direct loss to spawning grounds. As highly mobile species, elasmobranchs will be able to avoid the hard substrate and the habitat lost does not constitute a significant loss in the context of wider available habitat.

298. Elasmobranchs are deemed to be of medium vulnerability, high recoverability and of national and international value. The sensitivity of the receptor is therefore, considered to be low.

9.12.2.2.3. SIGNIFICANCE OF EFFECT

Marine finfish

299. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low, given the mobile nature of marine finfish and their ability to relocate following loss of habitat. The effect will, therefore, be of **negligible to minor** adverse significance, which is not significant in EIA terms.

Sandeel

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

Herring

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

Diadromous fish

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

Shellfish

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

Elasmobranchs

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

9.12.2.2.4. SECONDARY MITIGATION AND RESDIUAL EFFECTS

305. Given that there are no likely significant effects in EIA terms, secondary mitigation is not required.

9.12.2.3. THERMAL EMISSIONS FROM OPERATIONAL CABLES

306. Power cables in the marine environment generate and dissipate heat. Heat emitted into the sediment from the buried Marine Scheme cables has the potential to directly affect fish and shellfish receptors.

307. Water has a high specific heat capacity, therefore thermal emissions from the Offshore Export Cables will not be able to heat the overlying seawater. Consequently, only sediments along the proposed cable route may be subject to potential heating. Therefore, only species which depend on the seabed for spawning or shelter may be affected by thermal emissions.

308. This impact is consistent along the cable length therefore the following discussion is applicable to the whole Marine Scheme within both Scottish and English waters.

309. The sensitivity appraisal of receptors has been split into demersal fish and shellfish, as these are the receptor groups most likely to be affected by thermal emissions.

9.12.2.3.1. MAGNITUDE OF IMPACT

310. Thermal emissions from cables increase the temperature of the surrounding sediments. Taormina et al. (2018) found that a maximum increase of 2.5°C occurs 50 cm directly below the cable. Sediment temperature increases above the cables were reduced, due to the increasing influence of the seawater towards the seabed.

311. Emeana et al. (2016) found that heat transfer within sediments was dependent on sediment type, with coarse silts experiencing the greatest temperature change. However, this greatest difference was more localised to the source. In comparison, coarser sediments had a lower temperature change but were affected over a greater distance. This is due to the increased interstitial space between coarser sediment particles. Considering the nature of the sediments within the Marine Scheme, it is likely that the increase in temperature within the sediments will be highly localised to the source.

312. The impact is predicted to be of highly localised spatial extent, long-term duration, continuous and not reversible during the operational phased of the Marine Scheme. It is predicted that the impact will affect the receptor directly. The magnitude is considered to be low.

9.12.2.3.2. SENSITIVITY OF RECEPTOR

Demersal fish

313. Benthic and demersal fish species are closely associated with the seabed. This includes species such as cod, plaice, sandeel and whiting which are likely to be found in the Marine Scheme area (section 9.7.1.2). Given the predicted extent of thermal emissions (section 9.12.2.3.1), only those species which spend time within the sediment are expected to be affected. Sandeel and plaice burrow within sediments. The former during times of low light intensity (at night and in winter; Fishbase, 2023b) and the latter during the day (Fishbase, 2023c).

314. Sandeel productivity is understood to be affected by temperature in multiple life stages including during their reproductive cycle (Wright et al., 2017a, 2017b) and during their egg development (Régnier et al., 2018). However, the available research largely focusses on wider temperature increases associated with warming seas. Conversely, heating of seabed sediments is so highly localised that it is unlikely demersal species will experience any effects because of thermal emissions.

315. Furthermore, sandeel and plaice are shallow burrowers (Ruiz, 200; Rowley, 2008). Therefore, they are not likely to encounter thermal emissions from the Marine Scheme cables as this will be minimal in the uppermost layers of sediment.

316. Demersal fish are deemed to be of low vulnerability, high recoverability and of local importance. The sensitivity of the receptor is therefore, considered to be low.

Shellfish

317. Of the shellfish species known to inhabit the fish and shellfish ecology study area, Nephrops are known for burrowing into muddier sediments and forming often comprehensive networks of shallow burrows. Nephrops burrows are 20 to 30 cm in depth (Dyebern and Hoisaeter, 1965), so are unlikely to be within the immediate vicinity of the buried cable and the burrows will be filled with water which will act to further dissipate heat, thus reducing their exposure to heating.

318. Brown crab are active predators and have been known to dig large pits in softer sediments to access molluscs (Neal and Wilson, 2008). However, the depth of such pits is likely to be limited to the uppermost layer of sediments, owing to the size of the crabs and their corresponding prey which are unlikely to bury to depths at which the Offshore Export Cable may be encountered. Additionally, there is some evidence that brown crab females burrow to brood their eggs in areas where sediments are soft (NIFCA, 2023).

319. Shellfish are deemed to be of low vulnerability, high recoverability and of local importance. The sensitivity of the receptor is therefore, considered to be low.

9.12.2.3.3. SIGNIFICANCE OF EFFECT

Demersal fish

320. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **negligible to minor** adverse significance for the Marine Scheme as a whole, which is not significant in EIA terms.

Shellfish

321. Overall, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **negligible to minor** adverse significance for the Marine Scheme as a whole, which is not significant in EIA terms.

9.12.2.3.4. SECONDARY MITIGATION AND RESDIUAL EFFECTS

322. Given that there are no likely significant effects in EIA terms, secondary mitigation is not required

9.12.3. Potential Effects During Decommissioning

323. At the end of the operation and maintenance phase of the Marine Scheme, the options for decommissioning works will be assessed, taking into consideration constraints (e.g., safety and liability) and the potential environmental impacts associated with decommissioning works.

324. The principal options for decommissioning include:

- Leaving the cable in-situ, trenched;
- Leaving the cable in-situ and providing additional protection;
- Remove sections of the cable that present a risk to other sea users; and
- Remove the cable entirely.

325. Should complete removal of the Offshore Export Cables be required, the significance of effect is considered to result in similar impacts to those assessment as part of the construction phase of the Marine Scheme. Impacts are anticipated to be of similar or lower magnitude to the construction phase (depending on the decommissioning option selected). Complete removal of the Offshore Export Cables represents the most significant adverse effects, and therefore if the other decommissioning options were to be progressed, they would have no more significant adverse effects.

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

9.13. Proposed Monitoring

327. No fish and shellfish ecology monitoring to test the predictions made within the assessment of likely significant effects on fish and shellfish ecology is considered necessary.

9.14. Cumulative Effects Assessment

9.14.1. Methodology

328. The Cumulative Effects Assessment (CEA) takes into account the impact associated with the Marine Scheme together with other relevant plans, developments and activities. Cumulative effects are therefore the complete set of effects arising from the Marine Scheme together with the effects from a number of different developments, on the same receptor or resource. Please see Volume 2, Chapter 3: EIA Methodology for detail on the CEA methodology.

329. The developments selected as relevant to the CEA presented within this chapter are based upon the results of a screening exercise and the development of a 'long list' of cumulative developments relevant to the Marine Scheme (see Volume 3, Appendix 3.4 and Volume 4, Figure 9.9). Each development has been considered on a case by case basis for screening in or out of this chapter's assessment based upon data confidence, relevant impact pathways and the spatial/temporal scales involved, to create the 'short list' as summarised in Table 9.21. This approach was agreed during Scoping and further consultation and technical engagement undertaken with consultees, as detailed in Table 9.3.

330. The 'short list' has taken into account the 10 km fish and shellfish study area, as depicted within Volume 4, Figure 9.9. Developments have been considered where there is a spatial or temporal overlap with the Marine Scheme and its programme. For the avoidance of doubt, the 'short list' does not include any currently operational developments – these have been considered as part of the baseline characterisation.

331. The specific developments scoped into the CEA for fish and shellfish ecology, are outlined in Table 9.21.

332. Of the developments listed in Table 9.21, the Northumberland Energy Park (Phase 3) is in very early planning stages and no publicly available information on development details have been identified. Furthermore, the timeline is uncertain. Overall, whilst it has been considered for the CEA no meaningful assessment can be derived from its inclusion in the CEA and therefore it is not considered further for assessments.

333. It is appropriate to consider the Landfall area in further detail in the context of the Cambois Connection Onshore Scheme. Based on the maximum design scenario for the Marine Scheme, a trenchless technique, such as HDD, will be deployed to bring the Offshore Export Cables ashore via ducts that will be installed from a point landward of MHWS to an exit point at least 250 m seaward of MLWS, thus completely bypassing the intertidal area. All construction works and infrastructure associated with the Onshore Scheme will be above MHWS, and landward of the dune system on Cambois beach, and therefore there is no potential for any direct interaction with the intertidal area. Given there will be no construction works associated with the Onshore Scheme within the intertidal area, there is no potential for any direct effects on intertidal species. Therefore, the Onshore Scheme is not considered further within this CEA. Further detail on the Onshore Scheme is provided in Volume 2, Chapter 5 Project Description.

Table 9.21 List of other developments considered within the CEA for Fish and Shellfish Ecology

Development/Plan	Location	Status	Distance from Marine Scheme (km)	Description of Development /Plan	Dates of Construction (If Applicable)	Dates of Operation (If Applicable)	Overlap with the Marine Scheme
BBWF	Scottish waters	In planning	0	Offshore wind farm and associated grid connection infrastructure	2025-2033	2033 onward (35 year operational life)	Construction phase of Marine Scheme overlaps spatially and temporally with the development's construction phase. O&M phases will overlap.
Eastern Green Link 1	Scottish and English waters	In planning	0	Transmission infrastructure	2024-2027	2027 onward (~50 year operational life)	Construction phase of Marine Scheme overlaps spatially and temporally with the development's construction phase. O&M phases will overlap.
Eastern Green Link 2	Scottish and English waters	In planning	3	Transmission infrastructure	2026-2029	2029 onward (~40 year operational life)	Construction phase of Marine Scheme overlaps with development's construction phase. O&M phases will overlap.
Blyth Demonstrator Offshore Wind Farm - Phase 2	English waters	Consented	1	Offshore wind farm	Complete by 2025	Current lease secured until 2050	Construction phase of Marine Scheme overlaps with O&M phase of the development. O&M phases will overlap.
Blyth Demonstration Phase 2 (&3) Cable Corridor	English waters	Consented	0	Transmission infrastructure	Complete by 2025	Assumed to be consistent with Blyth Demonstrator Offshore Wind Farm - Phase 2	Construction phase of Marine Scheme overlaps spatially and temporally with the O&M phase of the development. O&M phases will overlap.
Seagreen 1	Scottish waters	Under Construction	5	Offshore wind farm	2022 to 2023	2023 to 2048	Construction phase of Marine Scheme overlaps with the O&M phase of the development. O&M phases will overlap.

Development/Plan	Location	Status	Distance from Marine Scheme (km)	Description of Development /Plan	Dates of Construction (If Applicable)	Dates of Operation (If Applicable)	Overlap with the Marine Scheme
Inch Cape Offshore Wind Farm	Scottish waters	Under Construction	8	Offshore wind farm	2022 to 2025	2025 to 2075	Construction phase of Marine Scheme overlaps with O&M phase of the development. O&M phases will overlap.
Inch Cape OFTO	Scottish waters	Consented – pending variation	10	Transmission infrastructure	2022 to 2025	2025 to 2075	Construction phase of Marine Scheme overlaps with O&M phase of the development. O&M phases will overlap.

9.14.2. Cumulative Effects Assessment

334. An assessment of the likely significance of the cumulative effects of the Marine Scheme together with other relevant plans, projects, developments and activities upon fish and shellfish ecology receptors arising from each identified impact is given below.

9.14.2.1. POTENTIAL EFFECTS DURING CONSTRUCTION

9.14.2.1.1. TEMPORARY HABITAT AND SPECIES DISTURBANCE OR LOSS

335. All developments within the fish and shellfish ecology study area which met the CEA criteria (those listed in Table 9.21 will result in some temporary habitat and species disturbance or loss. These developments have been considered cumulatively in the following sections.

9.14.2.1.1.1. Magnitude of impact

336. The area of temporary habitat loss associated with the Marine Scheme and other developments has been quantified in Table 9.22. It is important to note that the areas here are likely overestimates for the purposes of the respective environmental assessment processes. In reality, the area of disturbance may be reduced.

337. The area of temporary habitat loss in Table 9.22 is associated with the construction phase of the respective developments. Note that Seagreen 1, the Inch Cape Offshore Wind Farm and associated OFTO, Blyth Demonstrator Offshore Wind Farm - Phase 2 and Blyth Demonstration Phase 2 (&3) Cable Corridor (Table 9.21) will be operational by the time Marine Scheme construction begins. Consequently, disturbance during installation will have ceased and therefore there is no opportunity for cumulative temporary habitat loss impacts between these two projects and the Marine Scheme.

Table 9.22 Area of cumulative temporary habitat loss

Development	Area of temporary habitat loss (km^2)	Source
Marine Scheme	18	Section 9.11
BBWF	113.97	BBWFL (2022)
Eastern Green Link 1	8.8	National Grid and Scottish Power (2022)
Eastern Green Link 2	15.2	National Grid and SSEN (2022)
Total	155.97	

338. The cumulative project with the greatest extent of spatial and temporal overlap is the BBWF, given that the Marine Scheme wholly overlaps the BBWF array area and that construction activities in the BBWF array area are expected to occur between 2025 and 2033. Therefore, there is potential for temporary habitat loss and disturbance resulting from activities associated with the BBWF such as seabed preparation, foundation installation (for turbines and OSPs/OCSPs), and cable installation (inter array, interconnector and export cables) to occur at the same time as installation of the Marine Scheme.

339. Overall, with the exception of disturbance associated with BBWF, the areas of temporary habitat loss for the other projects included in Table 9.22 above are unlikely to temporally coincide with Marine Scheme activities. Construction timelines occur over a number of years when activity will be occurring across a wide area therefore the potential for activities to coincide is limited. Regarding temporary habitat disturbance within the BBWF array area, given the Marine Scheme cable

installation activities will continually progress along the lengths of the Export Cable Corridor, the duration of the habitat disturbance within the BBWF array area will be limited both in the context of the wider construction timelines and the spatial extent of the area of habitat loss or disturbance associated with the Marine Scheme which will only affect a highly localised and discrete part of the wider BBWF array area.

340. The scale of the developments in Table 9.22 is not necessarily equivalent to the Marine Scheme. For example, the Eastern Green Link 2 development involves installation of three cables (two HVDC and one fibre optic), each approximately 436 km in length. The area of temporary habitat loss associated with this development proximal to the Marine Scheme will be proportionately a much smaller area (and not the total of 15.2 km^2).

341. Additionally, the habitats within which this disturbance will occur will not be the same. Therefore, the area of temporary habitat and species disturbance or loss is small in the context of the wider available habitat throughout the North Sea.

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

9.14.2.1.1.2. Sensitivity of the receptor

343. The sensitivities of the relevant fish and shellfish ecology receptors is presented below. These appraisals are consistent with the Marine Scheme assessment (in section 9.12.1.1.2).

Marine finfish

344. Marine finfish are deemed to be of low vulnerability, high recoverability and of local importance. The sensitivity of the receptor is therefore, considered to be low.

Sandeel

345. Sandeel are deemed to be of high vulnerability, medium recoverability and are of national importance. The sensitivity of the receptor is therefore, considered to be medium.

Herring

346. Herring is deemed to be of medium vulnerability, high recoverability and of regional importance. The sensitivity of the receptor is considered to be low.

Diadromous fish

347. Diadromous fish species are considered to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is therefore, considered to be low.

Shellfish

348. Shellfish are deemed to be of medium vulnerability, medium recoverability and of regional importance. The sensitivity of the receptor is therefore, considered to be medium.

Elasmobranchs

349. Elasmobranchs are deemed to be of medium vulnerability, high recoverability and of national and international value. The sensitivity of the receptor is therefore, considered to be low.

9.14.2.1.1.3. Significance of Effect

Marine finfish

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

Sandeel

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

Herring

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

Diadromous fish

353. Overall, the magnitude of the cumulative effect is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of negligible to minor adverse significance, which is not significant in EIA terms.

Shellfish

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

Elasmobranchs

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

9.14.2.1.1.4. Secondary Mitigation and Residual Effect

356. Given that there are no likely significant cumulative effects in EIA terms, secondary mitigation is not required.

9.14.2.1.2. TEMPORARY INCREASES IN SSC AND ASSOCIATED SEDIMENT DEPOSITION AND POTENTIAL RELEASE OF CONTAMINANTS

357. All developments within the fish and shellfish ecology study area which met the CEA criteria (those listed in Table 9.21) will result in some temporary increases in SSC and associated sediment deposition and potential release of contaminants. These developments have been considered cumulatively in the following sections.

9.14.2.1.2.1. Magnitude of impact

358. All developments within the fish and shellfish ecology study area which met the CEA criteria (those listed in Table 9.21) will generate temporary increases in SSC and associated sediment deposition and potential release of contaminants. The fish and shellfish ecology study area is based on the tidal excursion which determines the extent of sediment transport in a plume. Therefore, the developments listed in Table 9.21 (BBWF, Eastern Green Link 1, Eastern Green Link 2, Blyth

Demonstrator Offshore Wind Farm - Phase 2, Blyth Demonstration Phase 2 (&3) Cable Corridor) have the potential to act cumulatively with the Marine Scheme.

359. The assessment in section 9.12.1.2.1 defined the magnitude of impact to be low owing to the localised disturbance and deposition. While the sediment plume associated with the Marine Scheme activities may reach up to 2.5 km from the site of disturbance, the level of deposited sediment is very small.

360. As discussed previously, the cumulative project with the maximum extent of temporal and spatial overlap is the BBWF, given that the Marine Scheme wholly overlaps with the BBWF array area boundary and construction programmes also overlap. Based on the information presented in the BBWF EIA, seabed preparation and construction activities including foundation installation (for turbines and OSPs/OCSPs) and installation of inter-array, interconnector and export cable, will result in increased SSCs.

361. Suspended sediment modelling was undertaken for BBWF. The modelling determined that the SSC would be highest in the immediate vicinity of the activity. For instance, releases associated with wind turbine generator drilling showed the SSC within the plume was less than 5 mg/l and dropped to even lower levels within a very short distance, typically less than 500 m. Plumes dissipated within a few tidal cycles (BBWFL, 2022).

362. For cable installation as part of BBWF, a comparable activity to those associated with the Marine Scheme, the BBWF modelling outputs indicated average SSC along the route ranged between 50 mg/l and 500 mg/l. Associated average sedimentation peaks at 0.5 mm to 1.0 mm. One day after cessation of operations this maximum increased to 10-30 mm. However, it was noted that this deposition only accounts for a very small area and deposition thicknesses are considerably reduced with distance from the location of cable installation (BBWFL, 2022).

363. The supporting environmental documentation for the Scotland England Green Link 1/Eastern Link 1 development predicted a maximum extent of SSC (i.e. a plume) would reach 1.4 km from the site of disturbance. Comparatively, coarse sand (typical of the majority of the sediments along the development cable route), were expected to travel up to 200 m. Additionally, the environmental appraisal report anticipated that measurable change in suspended sediment concentrations will be limited to the bottom 5 m of the water column (National Grid and Scottish Power, 2022).

364. Equivalent information is not available for the Blyth Demonstrator Offshore Wind Farm - Phase 2 and the Blyth Demonstration Phase 2 (&3) Cable Corridor developments. However, it can be assumed that the impact from these developments would be less than, or equal to, the BBWF outputs.

365. As the BBWF findings indicate, suspended sediment is readily reincorporated to the local sediment transport regime (over the course of a few tidal cycles; BBWFL, 2022). With the exception of BBWF, cumulatively, it is unlikely that there will be considerable spatial or temporal overlap between the Marine Scheme and these other developments that would result in elevated cumulative SSC.

366. Should activities coincide between multiple developments, as is likely between the Marine Scheme and BBWF, elevated SSC will last a matter of hours to days. Deposition thicknesses associated with increased SSC as part of BBWF in combination with the Marine Scheme will be on the scale of centimetres and will generally be highly localised to the site of disturbance.

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

9.14.2.1.2.2. Sensitivity of receptor

368. The sensitivities of the relevant fish and shellfish ecology receptors is presented below. These appraisals are consistent with the Marine Scheme assessment (in section 9.12.1.2.2).

Marine finfish

369. Marine finfish deemed to be of low vulnerability, high recoverability and of local importance. The sensitivity of the receptor is therefore, considered to be low.

Sandeel

370. Sandeel are deemed to be of medium vulnerability, medium recoverability and are of national importance. The sensitivity of the receptor is therefore, considered to be medium.

Herring

371. Herring are deemed to be of medium vulnerability, high recoverability and of regional importance. The sensitivity of the receptor is therefore, considered to be low.

Diadromous fish

372. Diadromous fish are deemed to be of low vulnerability, high recoverability and of national to international importance. The sensitivity of the receptor is therefore, considered to be low.

Shellfish

373. Shellfish are deemed to be of low vulnerability, high recoverability and of regional importance, given their commercial significance. The sensitivity of the receptor is therefore, considered to be low.

Elasmobranchs

374. Elasmobranchs are deemed to be of low vulnerability, high recoverability and of national and international value. The sensitivity of the receptor is therefore, considered to be low.

9.14.2.1.2.3. Significance of effect

Marine finfish

375. Overall, the magnitude of the cumulative effect is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of negligible to minor adverse significance, which is not significant in EIA terms.

Sandeel

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

Herring

377. Overall, the magnitude of the cumulative effect is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of negligible to minor adverse significance, which is not significant in EIA terms.

Diadromous fish

378. Overall, the magnitude of the cumulative effect is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of negligible to minor adverse significance, which is not significant in EIA terms.

Shellfish

379. Overall, the magnitude of the cumulative effect is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of minor adverse significance, which is not significant in EIA terms.

Elasmobranchs

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

9.14.2.1.2.4. Secondary mitigation and residual effects

381. Given that there are no likely significant cumulative effects in EIA terms, secondary mitigation is not required.

9.14.2.1.3. UNDERWATER NOISE

382. Cumulative impacts associated with underwater noise will be limited to those developments which have construction timelines overlapping with the Marine Scheme, as the potential for generation of underwater noise is limited to geophysical surveys using SBP equipment during construction. Construction timelines for BBWF, Eastern Green Link 2, Blyth Demonstrator Offshore Wind Farm - Phase 2, and Blyth Demonstration Phase 2 (&3) Cable Corridor will in part overlap with the Marine Scheme timeline.

9.14.2.1.3.1. Magnitude of impact

383. As described in section 9.12.1.3, the only activity associated with the Marine Scheme that is considered to generate an underwater sound profile above the thresholds of impacts to fish and shellfish species (and therefore likely to result in a significant effect) is geophysical surveys using SBP equipment during the construction phase.

384. As cable developments, Eastern Green Link 1, Eastern Green Link 2 and the Blyth Demonstration Phase 2 (&3) Cable Corridor developments are similar in nature to the Marine Scheme. Consequently, the underwater noise emissions from these developments are likely to be to those associated with the Marine Scheme due to the similarity in the nature of their activities. Eastern Green Link 2 screened out all noise sources with the exception of SBP, which they estimated would generate SPL of up to 238 dB re 1μP at 1m (peak) (National Grid and SSEN, 2022). This is consistent with wider research findings, presented in section 9.12.1.3. As concluded in section 9.12.3.1., the risk of injury to fish and shellfish receptors from SBP operations will be limited to a range of <50 m from the source. This localised area of effect is likely to be comparable for Eastern Green Link 1, Green Link 2 and the Blyth Demonstration Phase 2 (&3) Cable Corridor. The Blyth Demonstration Phase 2 (&3) Cable Corridor will also already be operational at the time of the Marine Scheme construction with only infrequent underwater sound generating activities.

385. The Blyth Demonstrator Offshore Wind Farm - Phase 2 will be operational at the time of the Marine Scheme construction, and therefore, the scope for generation of noise is limited (EDF Renewables, 2020).

386. Conversely, piling activity associated with the installation of turbines as part of BBWF will generate increased levels of noise compared to SBP. The Marine Scheme overlaps spatially with the BBWF array area. Additionally, construction timelines will coincide. BBWF considered piling of 1,432 piles (for 179 wind turbine foundations) and a further 256 piles (for 10 offshore converter substation platform foundations). Per pile, this will take up to a maximum of 8 hours. A maximum piling hammer energy of 4,000 kJ was modelled. Under maximum parameters, the modelled temporary threshold shift effects to fish and shellfish receptors associated with these activities could extend up to

approximately 7 km away. In the wider context of available habitat, this impact is highly localised and was considered not significant in EIA terms (BBWFL, 2022).

387. The underwater noise impacts to fish and shellfish receptors as a result of Marine Scheme SBP activities is limited to within 50 m of the sound source. This is comparatively a much smaller extent than associated with piling in BBWF. In combination with the potential extent of impact associated with BBWF piling, the Marine Scheme will not contribute discernibly to the existing extent of impact, which was already judged to be not significant.

388. Additionally, where activities resulting in greater underwater noise emissions, such as piling at BBWF, this will effectively mask any sound emissions caused by the Marine Scheme for a short period of time.

389. Overall, the cumulative impact of underwater noise on fish and shellfish receptors will be of limited spatial extent, short term duration, intermittent and of high reversibility. It is predicted that the impact will affect fish and shellfish receptors directly. The magnitude is therefore considered to be negligible.

9.14.2.1.3.2. Sensitivity of receptor

390. The sensitivity is consistent with the Marine Scheme assessment (in section 9.12.1.3).

Fish with no swim bladder/fish with a swim bladder that is not involved in hearing

391. Fish without swim bladders and fish with a swim bladder that is not involved in hearing are deemed to be of low vulnerability, high recoverability and high value. The sensitivity of the receptor is therefore, considered to be negligible.

Fish with a swim bladder that is involved in hearing

392. Fish with a swim bladder that is involved in hearing are deemed to be of medium vulnerability, high recoverability and high value. The sensitivity of the receptor is therefore, considered to be low.

Shellfish

393. Shellfish are deemed to be of low vulnerability, high recoverability and high value. The sensitivity of the receptor is therefore, considered to be negligible.

9.14.2.1.3.3. Significance of effect

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

9.14.2.1.3.4. Secondary mitigation and residual effects

395. Given that there are no likely significant cumulative effects in EIA terms, secondary mitigation is not required.

9.14.2.2. POTENTIAL EFFECTS DURING OPERATION AND MAINTENANCE

9.14.2.2.1. EMF EFFECTS

396. As detailed in section 9.12.2.1.1, the extent of EMF effects are limited to the immediate vicinity of the operational cable. Following the CEA process to arrive at the 'short list', only the cables within the BBWF, Scotland to England Green Link/Eastern Green Link 1, and the transmission cable associated with the Blyth Demonstration Phase 2 (&3) development may act cumulatively with the Marine Scheme owing to their direct spatial overlap.

9.14.2.2.1.1. Magnitude of impact

397. Cables within the BBWF boundary and associated with the Blyth Demonstration development will be buried as far as practicable. The BBWF development assumes a minimum burial depth of 0.5 m (BBWFL, 2022) and the worst-case assumption for the Blyth Demonstration development is stated as 1 m (Narec, 2013). For the Scotland to Eastern Green Link 1 and Eastern Green Link 2 transmission infrastructure, the minimum burial depth is quoted as 0.6 m (National Grid and Scottish Power, 2022 & National Grid and SHE Transmission, 2022). Given these burial depths and the use of cable protection measures where cable crossings are required, EMF levels are anticipated to remain as being highly localised.

398. While the length of some cables, for instance Eastern Green Link 2 at 436 km, is considerably longer than the Marine Scheme, the impacts along the cables will be diffuse and limited to the immediate vicinity of the cable in question. Consequently, the potential for cumulative EMF effects is limited to areas where the Marine Scheme directly overlaps with other cables. While fish are highly mobile, given the area of wider available habitat beyond the immediate vicinity of the cables, the likelihood of the same receptors being affected by these cables along their entire length is very low.

399. Given the overlap with the BBWF array area, it is likely that the Marine Scheme Offshore Export Cables and BBWF cables (inter array, interconnector and export) will be in close proximity for this section of the Marine Scheme, however it is assumed that there will not be any crossings of the BBWF cables. While there is potential for some cumulative impact between the Marine Scheme and BBWF, the extent of EMF effects will be within close proximity of the source, likely within 10-20 m prior to decaying to natural GMF (as is the case for the Marine Scheme; section 9.12.2.1). Therefore, even where other development cables are in close proximity to the Marine Scheme the resultant elevated EMF is limited.

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

9.14.2.2.1.2. Sensitivity of receptor

401. The sensitivities of the relevant fish and shellfish ecology receptors is presented below. These appraisals are consistent with the Marine Scheme assessment (in section 9.12.2.1.2).

Marine finfish

402. Marine finfish are deemed to be of low vulnerability, high recoverability and of local importance. The sensitivity of the receptor is therefore, considered to be low.

Diadromous fish

403. Diadromous fish species are deemed to be of low vulnerability, high recoverability and of national to international importance. The sensitivity of the receptor is therefore, considered to be low.

Shellfish

404. Shellfish species are deemed to be of medium vulnerability, high recoverability and of local to national importance. The sensitivity of the receptor is therefore, considered to be medium.

Elasmobranchs

405. Elasmobranchs are deemed to be of medium vulnerability, high recoverability and of local to national importance. The sensitivity of the receptor is therefore, considered to be medium.

9.14.2.2.1.3. Significance of effect

Marine finfish

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

Diadromous fish

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

Shellfish

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

Elasmobranchs

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

9.14.2.2.1.4. Secondary mitigation and residual effects

410. Given that there are no likely significant cumulative effects in EIA terms, secondary mitigation is not required.

9.14.2.2.2. PERMANENT HABITAT LOSS

411. All developments within the fish and shellfish ecology study area which met the CEA criteria (those listed in Table 9.21) will result in some permanent habitat loss. Therefore, all these developments have been considered cumulatively herein.

9.14.2.2.2.1. Magnitude of impact

412. The area of habitat loss associated with the Marine Scheme and the five other developments has been quantified in Table 9.23. It is important to note that the areas are likely worst-case estimates which have been used in the respective environmental assessment processes. Therefore, these areas are likely to be overestimates.

413. The area of permanent habitat loss associated with the Blyth Demonstration Phase 2 (&3) Cable Corridor is unknown. However, given the cable is proportionally much shorter than the Marine Scheme (approximately 10 km), it is assumed that the quantity of rock protection required will be comparatively considerably smaller.

Table 9.23 Area of cumulative permanent habitat loss

Development	Area of permanent habitat loss (km^2)	Source
Marine Scheme	1.46	Section 9.11
BBWF	7.80	BBWFL (2022)
Scotland to England Green Link/Eastern Green Link 1	0.73	National Grid and Scottish Power (2022)
Eastern Green Link 2	2.00	National Grid and SSEN (2022)
Blyth Demonstrator Offshore Wind Farm - Phase 2	0.06	EDF Renewables (2020)
Blyth Demonstration Phase 2 (&3) Cable Corridor	Unknown	EDF Renewables (2020)
Seagreen 1	2.23	Seagreen (2012)
Inch Cape Offshore Wind Farm	1.87	Inch Cape Offshore Limited (2011)
Inch Cape OFTO	0.60	Inch Cape Offshore Limited (2011)
Total	**16.75**	

414. It is important to note that the areas of rock placement shown above are unlikely to be applied continuously in the same area. For instance, the Eastern Green Link 2 development involves installation of three cables (two HVDC and one fibre optic), each approximately 436 km in length. Therefore, the quantity of rock likely to coincide with the fish and shellfish ecology study area will be much smaller.

415. The northern part of the Marine Scheme wholly overlaps with the BBWF array area. Therefore, both projects will overlap spatially for the duration of their operational period (35 years). With regard to permanent habitat loss, where additional rock protection is required along sections of the Marine Scheme Offshore Export Cables occurring within the BBWF array area, this will contribute to habitat loss associated with the presence of wind farm infrastructure e.g. foundations, scour protection, and any additional protection e.g. rock required along the inter-array cables, interconnector cables and the Branxton export cables.

416. It was identified in the BBWF EIA (BBWFL (2022) that the presence of wind farm infrastructure and additional cable protection could lead to long term habitat loss of up to 7.8 km^2. It was concluded that potential effects on fish and shellfish would be negligible to minor. Considered cumulatively with the Marine Scheme, the total cumulative habitat loss would represent only a small proportion of the fish and shellfish habitat in the fish and shellfish study area in Scottish waters.

417. Given the variation in seabed habitats and substrate types throughout the North Sea, it is unlikely that the cumulative permanent habitat loss resulting from the Marine Scheme and the other developments detailed in Table 9.20 will all affect the same habitat types. Overall, the area of habitat loss is small in the context of the wider available fish and shellfish habitats.

418. The cumulative impact is predicted to be of local spatial extent, permanent in duration, continuous and low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

9.14.2.2.2.2. Sensitivity of receptor

419. The sensitivities of the relevant fish and shellfish ecology receptors is presented below. These appraisals are consistent with the Marine Scheme assessment (in section 9.12.2.2.2).

Marine finfish

420. Marine finfish are deemed to be of low vulnerability, high recoverability and of local importance. The sensitivity of the receptor is therefore, considered to be low.

Sandeel

421. Sandeel are deemed to be of high vulnerability, medium recoverability and of national importance. The sensitivity of the receptor is therefore, considered to be medium.

Herring

422. Herring are deemed to be of medium vulnerability, high recoverability and of regional importance. The sensitivity of the receptor is therefore, considered to be low.

Diadromous fish

423. Diadromous fish species are considered to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is therefore, considered to be low.

Shellfish

424. Shellfish are deemed to be of medium vulnerability, medium recoverability and of regional importance. The sensitivity of the receptor is therefore, considered to be medium.

Elasmobranchs

425. Elasmobranchs are deemed to be of medium vulnerability, high recoverability and of national and international value. The sensitivity of the receptor is therefore, considered to be low.

9.14.2.2.2.3. Significance of effect

Marine finfish

426. Overall, the magnitude of the cumulative effect is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of negligible to minor adverse significance, which is not significant in EIA terms.

Sandeel

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

Herring

428. Overall, the magnitude of the cumulative effect is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of negligible to minor adverse significance, which is not significant in EIA terms.

Diadromous fish

429. Overall, the magnitude of the cumulative effect is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of negligible to minor adverse significance, which is not significant in EIA terms.

Shellfish

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

Elasmobranchs

431. Overall, the magnitude of the cumulative effect is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of negligible to minor adverse significance, which is not significant in EIA terms.

9.14.2.2.2.4. Secondary mitigation and residual effects

432. Given that there are no likely significant cumulative effects in EIA terms, secondary mitigation is not required.

9.14.2.2.3. THERMAL EMISSIONS FROM OPERATIONAL CABLES

433. Owing to the nature of the impact, developments which may act cumulatively with the Marine Scheme are the BBWF, Scotland to England Green Link/Eastern Green Link 1, and the transmission cable associated with the Blyth Demonstration Phase 2 (&3) development due to the spatial overlap and possibility for operational timelines to coincide.

9.14.2.2.3.1. Magnitude of impact

434. Thermal emissions from operational cables are expected to be highly localised (section 9.12.2.3.1). The three developments which may result in cumulative impact are assumed to be buried as far as practicable (see section 9.14.2.2.1.1 above). Considering the high heat capacity of water and the depth of burial proposed for the three developments, the potential for heat to be emitted beyond the immediate seabed is low.

435. Furthermore, the potential for cumulative thermal emissions will be limited to the location of cable crossings. Given the overlap with the BBWF array area, it is likely that the Marine Scheme Offshore Export Cables and BBWF cables (inter array, interconnector and export) will be in close proximity for this section of the Marine Scheme, however it is assumed that there will not be any crossings of the BBWF cables. Therefore, there is potential for some cumulative impact between the Marine Scheme and BBWF. However, the extent of sediment heating will be limited to the immediate vicinity of the source (as is the case for the Marine Scheme; Section 9.12.2.3). Therefore, even where other development cables are in close proximity to the Marine Scheme the resultant elevated thermal emissions are extremely limited.

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

9.14.2.2.3.2. Sensitivity of receptor

437. The sensitivities of the relevant fish and shellfish ecology receptors is presented below. These appraisals are consistent with the Marine Scheme assessment (in section 9.12.2.3.2).

Demersal fish

438. Demersal fish are deemed to be of low vulnerability, high recoverability and of local importance. The sensitivity of the receptor is therefore, considered to be low.

Shellfish

439. Shellfish are deemed to be of low vulnerability, high recoverability and of local importance. The sensitivity of the receptor is therefore, considered to be low.

9.14.2.2.3.3. Significance of effect

Demersal fish

440. Overall, the magnitude of the cumulative effect is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of negligible to minor adverse significance, which is not significant in EIA terms.

Shellfish

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

9.14.2.2.3.4. Secondary mitigation and residual effects

442. Given that there are no likely significant cumulative effects in EIA terms, secondary mitigation is not required.

9.14.2.3. POTENTIAL EFFECTS DURING DECOMMISSIONING

443. At the end of the operation and maintenance phase of the Marine Scheme, the options for decommissioning works will be assessed, taking into consideration constraints (e.g. safety and liability) and the potential environmental impacts associated with decommissioning works.

444. The principal options for decommissioning include:

- Leaving the cable in-situ, trenched;
- Leaving the cable in-situ and providing additional protection;
- Remove sections of the cable that present a risk to other sea users; and
- Remove the cable entirely.

445. Should complete removal of the cable be required, the cumulative significance of effect is considered to result in similar cumulative effects to those assessment as part of the cumulative construction phase of the Marine Scheme. Impacts are anticipated to be of similar magnitude (depending on the decommissioning option selected).

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

9.15. Inter-Related Effects

447. Inter-related effects are the potential effects of multiple impacts, affecting one receptor or a group of receptors. Inter-related effects include interactions between the impacts of the different stages of the Marine Scheme (i.e. interaction of impacts across installation, operation and maintenance and decommissioning), as well as the interaction between impacts on a receptor within a Marine Scheme stage. A description of the likely inter-related effects arising from the Marine Scheme on fish and shellfish ecology is provided below.

448. All stages of the Marine Scheme have the potential to impact various fish and shellfish ecology receptors. Impacts relating to EMF and thermal emissions from operational cables will only occur during the operation and maintenance stage of the Marine Scheme. Therefore, there will be no combined effect with the construction or decommissioning stages.

449. Similarly, the majority of underwater noise will be produced during the construction phase of the Marine Scheme primarily associated geophysical surveys using SBP. Underwater noise during the

operation and maintenance phase will be highly localised and infrequent (in association with cable repair activities) and has not been considered in this assessment. Ultimately, there will be no combined underwater noise effects between stages of the Marine Scheme.

450. Habitat loss and disturbance during operation and maintenance may occur in the same areas as construction and decommissioning. The same can be said of increased SSC and subsequent deposition of sediments. However, as established throughout section 9.12.1.2, these impacts will be temporary and localised, and will be expected to recover once activities conclude. Therefore, there is limited potential for interactions between the stages of the Marine Scheme which would result in a greater effect than each in isolation.

451. Underwater noise effects will have the greatest spatial extent. Therefore, there is a limited potential for a spatial interaction with any highly localised temporary habitat loss and species disturbance or increased SSC and deposition. Fish and Shellfish receptors will be concurrently affected by these impacts as they will likely occur simultaneously for a time. However, each of these impacts is so limited in extent that the combined effect of these three impacts during the construction and decommissioning stages is not expected to result in a greater effect than the assessment of these impacts in isolation.

452. During the operation and maintenance stage, the spatial extent associated with habitat loss and disturbance, EMF and thermal emissions will be similarly limited. Fish and Ecology receptors may be affected by these impacts simultaneously. However, considering the highly localised extent of these effects, the combined effect of these impacts during the operation and maintenance stage is not expected to result in a greater effect than the assessment of these impacts in isolation.

453. These inter-related effects as described above are not anticipated to interact in such a way as to result in combined effects of greater significance than the assessments presented for each individual phases. Therefore, these inter-related effects would not be significant in EIA terms.

9.16. Transboundary Effects

454. Transboundary effects were scoped out for all impacts pertaining to fish and shellfish ecology, as agreed during scoping (see section 9.8).

9.17. Summary of Impacts, Mitigation Measures, Likely Significant Effects and Monitoring

455. Information on fish and shellfish ecology within the fish and shellfish ecology study area was collected through a desk-based review of publicly available data and information sources, with inclusion of site-specific data where appropriate. The approach was also informed by consultation with key stakeholders. Table 9.24 presents a summary of the potential impacts, mitigation measures and the conclusion of likely significant effects in EIA terms in respect to fish and shellfish ecology. The impacts assessed include:

- Temporary habitat and species disturbance or loss;
- Temporary increases in SSC and associated sediment deposition and potential release of contaminants;
- Underwater noise;
- EMF effects;
- Permanent habitat loss; and
- Thermal emissions from operational cables.

456. Given the mobile nature of fish and shellfish receptors, potential impacts are applicable to the Marine Scheme as a whole, both in Scottish and English waters.

457. Overall, it is concluded that there will be no likely significant effects arising from the Marine Scheme during the installation, operation and maintenance or decommissioning phases.

458. Table 9.25 presents a summary of the potential cumulative impacts, mitigation measures and the conclusion of likely significant effects in EIA terms on fish and shellfish ecology receptors. The cumulative impacts assessed include those impacts listed above for individual assessment. Overall, it is concluded that there will be no likely significant cumulative effects from the Marine Scheme alongside other developments/plans.

Table 9.24 Summary of likely significant effects, mitigation and monitoring measures

Description of Impact	Phase I	Phase O	Phase D	Magnitude of Impact	Sensitivity of Receptor	Significance of Effect	Secondary Mitigation	Residual Effect	Proposed Monitoring
Temporary habitat and species disturbance or loss	✓	×	✓	Low	Marine finfish – low Sandeel – low Herring – low Diadromous fish – low Shellfish – medium Elasmobranchs – low	Marine finfish – negligible to minor Sandeel – minor Herring – negligible to minor Diadromous fish – negligible to minor Shellfish – minor Elasmobranchs – negligible to minor	No secondary mitigation is considered necessary	N/A	There is no requirement for additional mitigation over and above the pre-defined designed in measures.
Temporary increases in SSC and associated sediment deposition and potential release of contaminants	✓	×	✓	Low	Marine finfish – low Sandeel – medium Herring – low Diadromous fish – low Shellfish – low Elasmobranchs – low	Marine finfish – negligible to minor Sandeel – minor Herring – negligible to minor Diadromous fish – negligible to minor Shellfish – negligible to minor Elasmobranchs – negligible to minor	No secondary mitigation is considered necessary	N/A	There is no requirement for additional mitigation over and above the pre-defined designed in measures.
Underwater noise	✓	×	✓	Low	Fish with no swim bladder/fish with a swim bladder that is not	Fish with no swim bladder/fish with a swim bladder that is not	No secondary mitigation is considered necessary	N/A	There is no requirement for additional mitigation over and above the

Description of Impact	Phase I	Phase O	Phase D	Magnitude of Impact	Sensitivity of Receptor	Significance of Effect	Secondary Mitigation	Residual Effect	Proposed Monitoring
					involved in hearing – negligible Fish with a swim bladder that is involved in hearing – low Shellfish - negligible	involved in hearing – negligible to minor Fish with a swim bladder that is involved in hearing – negligible to minor Shellfish – negligible to minor			pre-defined designed in measures.
EMF effects	×	✓	×	Low	Marine finfish (including herring and sandeel) – low Diadromous fish – low Shellfish – medium Elasmobranchs – medium	Marine finfish (including herring and sandeel) – negligible to minor Diadromous fish – negligible to minor Shellfish – minor Elasmobranchs – minor	No secondary mitigation is considered necessary	N/A	There is no requirement for additional mitigation over and above the pre-defined designed in measures.
Permanent habitat loss	×	✓	×	Low	Marine finfish – low Sandeel – medium Herring – low Diadromous fish – low Shellfish – medium Elasmobranchs – low	Marine finfish – negligible to minor Sandeel – minor Herring – negligible to minor Diadromous fish – negligible to minor Shellfish – minor Elasmobranchs – negligible to minor	No secondary mitigation is considered necessary	N/A	There is no requirement for additional mitigation over and above the pre-defined designed in measures.
Thermal emissions from operational cables	×	✓	×	Low	Demersal fish – low Shellfish – low	Demersal fish – negligible to minor Shellfish – negligible to minor	No secondary mitigation is considered necessary	N/A	There is no requirement for additional mitigation over and above the

Description of Impact	Phase I	O	D	Magnitude of Impact	Sensitivity of Receptor	Significance of Effect	Secondary Mitigation	Residual Effect	Proposed Monitoring
									pre-defined designed in measures.

Table 9.25 Summary of likely significant cumulative effects, mitigation and monitoring measures

Description of Impact	Phase I	O	D	Magnitude of Impact	Sensitivity of Receptor	Significance of Effect	Secondary Mitigation	Residual Effect	Proposed Monitoring
Temporary habitat and species disturbance or loss	✓	×	✓	Low	Marine finfish – low Sandeel – low Herring – low Diadromous fish – low Shellfish – medium Elasmobranchs – low	Marine finfish – negligible to minor Sandeel – minor Herring – negligible to minor Diadromous fish – negligible to minor Shellfish – minor Elasmobranchs – negligible to minor	No secondary mitigation is considered necessary	N/A	There is no requirement for additional mitigation over and above the pre-defined designed in measures.
Temporary increases in SSC and associated sediment deposition and potential release of contaminants	✓	×	✓	Low	Marine finfish – low Sandeel – medium Herring – low Diadromous fish – low Shellfish – low Elasmobranchs – low	Marine finfish – negligible to minor Sandeel – minor Herring – negligible to minor Diadromous fish – negligible to minor Shellfish – negligible to minor	No secondary mitigation is considered necessary	N/A	There is no requirement for additional mitigation over and above the pre-defined designed in measures.

Description of Impact	Phase I	Phase O	Phase D	Magnitude of Impact	Sensitivity of Receptor	Significance of Effect	Secondary Mitigation	Residual Effect	Proposed Monitoring
						Elasmobranchs – negligible to minor			
Underwater noise	✓	×	✓	Low	Fish with no swim bladder/fish with a swim bladder that is not involved in hearing – negligible Fish with a swim bladder that is involved in hearing – low Shellfish - negligible	Fish with no swim bladder/fish with a swim bladder that is not involved in hearing – negligible Fish with a swim bladder that is involved in hearing – negligible to minor Shellfish - negligible	No secondary mitigation is considered necessary	N/A	There is no requirement for additional mitigation over and above the pre-defined designed in measures.
EMF effects	×	✓	×	Low	Marine finfish (including herring and sandeel) – low Diadromous fish – low Shellfish – medium Elasmobranchs – medium	Marine finfish (including herring and sandeel) – negligible to minor Diadromous fish – negligible to minor Shellfish – minor Elasmobranchs – minor	No secondary mitigation is considered necessary	N/A	There is no requirement for additional mitigation over and above the pre-defined designed in measures.
Permanent habitat loss	×	✓	×	Low	Marine finfish – low Sandeel – medium Herring – low Diadromous fish – low Shellfish – medium Elasmobranchs – low	Marine finfish – negligible to minor Sandeel – minor Herring – negligible to minor Diadromous fish – negligible to minor Shellfish – minor	No secondary mitigation is considered necessary	N/A	There is no requirement for additional mitigation over and above the pre-defined designed in measures.

Description of Impact	Phase I	O	D	Magnitude of Impact	Sensitivity of Receptor	Significance of Effect	Secondary Mitigation	Residual Effect	Proposed Monitoring
						Elasmobranchs – negligible to minor			
Thermal emissions from operational cables	×	✓	×	Low	Demersal fish – low Shellfish – low	Demersal fish – negligible to minor Shellfish – negligible to minor	No secondary mitigation is considered necessary	N/A	There is no requirement for additional mitigation over and above the pre-defined designed in measures.

9.18. References

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