BERWICK BANK WIND FARM
ENVIRONMENTAL IMPACT ASSESSMENT REPORT

Volume 2, Chapter 9: Fish and Shellfish Ecology

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9. FISH AND SHELLFISH ECOLOGY

9.1. INTRODUCTION

1. This chapter of the Offshore Environmental Impact Assessment (EIA) Report presents the assessment of the likely significant effects (as per the "EIA Regulations") on the environment of the Berwick Bank Wind Farm offshore infrastructure which is the subject of this application (hereafter referred to as "Proposed Development") on fish and shellfish ecology. Specifically, this chapter considers the potential impacts of the Proposed Development seaward of Mean High Water Springs (MHWS) during the construction, operation and maintenance, and decommissioning phases.

2. Likely significant effect is a term used in both the "EIA Regulations" and the Habitat Regulations. Reference to likely significant effect in this Offshore EIA Report refers to "likely significant effect" as used by the "EIA Regulations". This Offshore EIA Report is accompanied by a Report to Inform Appropriate Assessment (RIAA) (SSER, 2022c) which uses the term as defined by the Habitats Regulations Appraisal (HRA) Regulations.

3. The assessment presented is informed by the following technical chapters and appendices:

- volume 3, appendix 7.1: Physical Processes Technical Report;
- volume 2, chapter 8: Benthic Subtidal and Intertidal Ecology;
- volume 3, appendix 8.1: Benthic Subtidal and Intertidal Ecology Technical Report;
- volume 3, appendix 9.1: Fish and Shellfish Ecology Technical Report;
- volume 2, chapter 10: Marine Mammals;
- volume 3, appendix 10.1: Subsea Noise Technical Report;
- volume 2, chapter 11: Offshore and Intertidal Ornithology; and
- volume 3, appendix 12.1: Commercial Fisheries Technical Report.

4. This chapter summarises information contained within volume 3, appendix 9.1. The technical report provides a detailed characterisation of the fish and shellfish ecology present in the northern North Sea and within the fish and shellfish ecology study area, as presented within section 9.3. This characterisation is based on existing literature sources and site specific surveys, which provide information on the fish and shellfish assemblages present within clearly defined study areas (as described in section 9.3), and the identification and valuation of fish and shellfish receptors (i.e. Important Ecological Features (IEFs); see section 9.7.3 relevant to the fish and shellfish ecology assessment.

9.2. PURPOSE OF THIS CHAPTER

5. The primary purpose of the Offshore EIA Report is outlined in volume 1, chapter 1. It is intended that the Offshore EIA Report will provide the Scottish Ministers, statutory and non-statutory stakeholders with sufficient information to determine the likely significant effects of the Proposed Development on the receiving environment.

6. In particular, this Fish and Shellfish Ecology EIA Report chapter:

- presents the existing environmental baseline established from desk studies, site-specific surveys and consultation with stakeholders;
- identifies any assumptions and limitations encountered in compiling the environmental information;
- presents the likely significant environmental impacts on fish and shellfish ecology arising from the Proposed Development and reaches a conclusion on the likely significant effects on fish and shellfish ecology, based on the information gathered and the analysis, assessments and (where relevant) modelling undertaken; and
- highlights any necessary monitoring and/or mitigation measures which are recommended to prevent, minimise, reduce or offset the likely significant adverse environmental effects of the Proposed Development on fish and shellfish ecology.

7. Impacts on commercial fisheries are considered separately to fish and shellfish ecology in volume 2, chapter 12.

9.3. STUDY AREA

8. Fish and shellfish are spatially and temporally variable, therefore for the purposes of the fish and shellfish ecology characterisation, two study areas are defined. These are shown in Figure 9.1 and described here, as agreed with stakeholders through consultation (see section 9.5):

- The Proposed Development fish and shellfish ecology study area has been defined with reference to the Proposed Development boundary that existed prior to the boundary refinement in June 2022. As the refinement resulted in a reduction of the Proposed Development array area, the fish and shellfish ecology study area is considered to present a conservative baseline against which the fish and shellfish assessment is undertaken. The Proposed Development fish and shellfish ecology study area has not therefore been realigned to the current Proposed Development boundary.
- The Proposed Development northern North Sea fish and shellfish ecology study area encompasses the Proposed Development fish and shellfish ecology study area and a surrounding area defined by the boundary of the northern North Sea as defined by the biogeographic region identified as part of the Review of Marine Nature Conservation (RMNC) (2004). This is the regional study area and also encompasses waters of the Forth and Tay Scottish Marine Region (SMR). The Proposed Development northern North Sea fish and shellfish ecology study area provides a wider context for the fish and shellfish species and populations identified within the Proposed Development fish and shellfish ecology study area and will inform assessments of those impacts affecting fish and shellfish receptors over a larger scale (e.g. underwater noise).

9. The offshore topic of Proposed Development fish and shellfish ecology study area includes the intertidal area. This intertidal area overlaps with the onshore topics of ecology and ornithology. Impacts on fish and shellfish receptors in the intertidal area have been scoped out from the assessment (see volume 3, appendix 9.1 and Table 9.16) as agreed with stakeholders (Table 9.8).

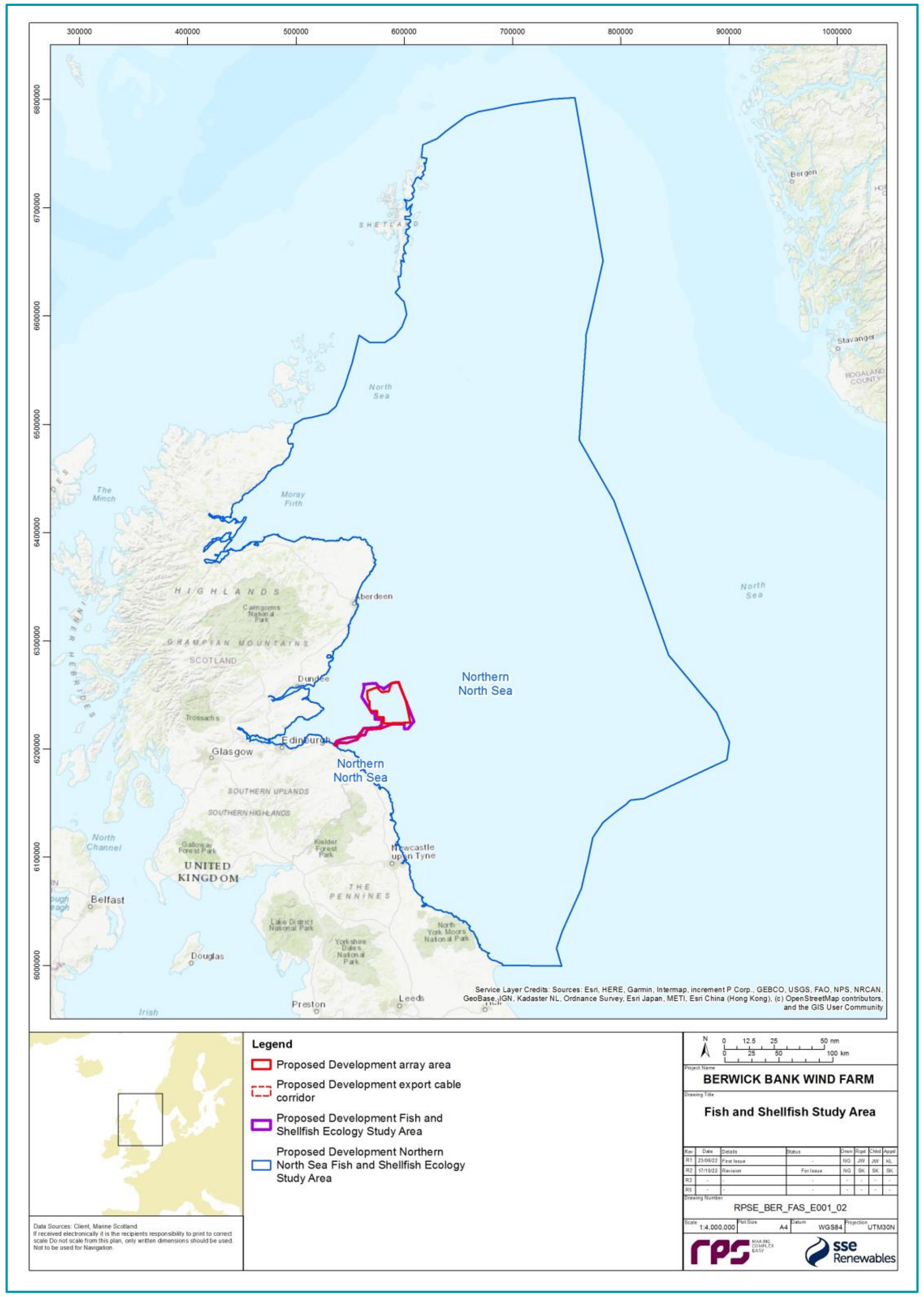

Figure 9.1: Proposed Development Fish and Shellfish Ecology Study Area

9.4. POLICY AND LEGISLATIVE CONTEXT

10. Policy and legislation on renewable energy infrastructure is presented in volume 1, chapter 2 of the Offshore EIA Report. Policy and legislation specifically in relation to fish and shellfish ecology, is contained in the Marine (Scotland) Act 2010, the Marine and Coastal Access Act (MCAA) 2009, the Habitats Regulations, Scotland's National Marine Plan, The Sectoral Marine Plan and the UK Marine Policy Statement. A summary of the legislative provisions relevant to fish and shellfish ecology are provided in Table 9.1 to Table 9.3, with other relevant policy provisions set out in Table 9.4 to Table 9.7.

11. All the policy and legislation provided in Table 9.1 to Table 9.7 is also relevant to the intertidal area.

Table 9.1: Summary of Marine (Scotland) Act 2010 Relevant to Fish and Shellfish Ecology

Summary of Relevant Legislation	How and Where Considered in the Offshore EIA Report
Habitat Health	
The Scottish Ministers, and public authorities must act in the way best calculated to further the achievement of sustainable development, including the protection and, where appropriate, enhancement of the health of that area.	The assessment of the potential environmental impacts of the Proposed Development on the fish and shellfish are considered in section 9.11 to best inform ministers of the sustainability of the development.
Marine Protected Areas (MPAs)	
The Marine (Scotland) Act 2010 provides for the development of a marine spatial planning system, creating a framework for marine developments in future, and enables the creation of protected marine sites/MPAs within the 12 nm limit (Scottish territorial seas). These measures aim to fulfil Scotland (and the United Kingdom (UK)) commitments to protection of habitats and species.	All relevant MPAs are listed in section 9.7.2, and further described in volume 3, appendix 9.1 and effects on these are considered in section 9.11.

Table 9.2: Summary of Marine Coastal Access Act 2009 Relevant to Fish and Shellfish Ecology

Summary of Relevant Legislation	How and Where Considered in the Offshore EIA Report
Marine Conservation Zones (MCZs)/MPAs	
MPAs existing beyond the 12 nm limit in Scottish Waters and Marine Conservation Zones (MCZs) in English waters are designated under the MCAA 2009. These sites (MPAs and MCZs) are areas that have been designated for the purpose of conserving marine flora and fauna, marine habitat or features of geological or geomorphological interest.	All relevant MPAs in Scottish Waters (beyond 12 nm) are listed in section 9.7.2, and further described in volume 3, appendix 9.1 and effects on these are considered in section 9.11. No MCZs in English waters designated for fish and shellfish features were identified in the Proposed Development northern North Sea fish and shellfish study area.

Table 9.3: Summary of the Habitats Regulations Relevant to Fish and Shellfish Ecology

Summary of Relevant Policy Framework	How and Where Considered in the Offshore EIA Report
Designated Sites	
Before deciding to undertake, or give any consent, permission or other authorisation for, a plan or project which is likely to have a significant effect on a European offshore marine site or a European site (either alone or in combination with other plans or projects), and is not directly connected with or necessary to the management of the site, a competent authority must make an appropriate assessment of the implications for the site in view of that site's conservation objectives.	All relevant designated sites are listed in section 9.7.2, along with their proximity to the Proposed Development and effects on these are considered in section 9.11. Section 9.12 also considers impacts on designated sites from other plans and projects cumulatively with the Proposed Development. European sites are further assessed in line accordance with the Habitats Regulations in the RIAA (SSER, 2022c).
Species Protection	
A person is guilty of an offence if they deliberately capture, injures, or kill any wild animal of a European protected species.	All the relevant protected species have been identified in section 9.7.3, and the environmental assessments in section 9.11 considers the conservation status of fish and shellfish receptors in coming to a conclusion regarding the significance of effect and proposing mitigation where the impacts are found to be unacceptable. There may also a need for European Protected Species (EPS) Licences for specific species where relevant, although none of the receptors are identified as EPS.

Table 9.4: Summary of Scotland's National Marine Plan Relevant to Fish and Shellfish Ecology

Summary of Relevant Legislation	How and Where Considered in the Offshore EIA Report
General Policies	
GEN9 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.	Protected species and PMFs are identified in Table 9.14. Section 9.11 presents an assessment of the significance of the effects of the Proposed Development on fish and shellfish receptors.
Paragraph 4.47: The Marine Acts (see Table 9.1 and Table 9.2) place a duty on all regulators to ensure that there is no significant risk of hindering the achievement of the conservation objectives of an MPA before giving consent to an activity. Where an ongoing activity presents a significant risk of hindering the achievement of the conservation objectives of an MPA there will be a management intervention. This intervention will be practical and proportionate, utilising the most appropriate statutory mechanism to reduce the risk.	Section 9.11 presents assessments of the significance of the effects of the development on fish and shellfish receptors, including on the features of the relevant designated sites such as MPAs.
GEN5 Climate Change: Marine planners and decision makers must act in the way best calculated to mitigate, and adapt to, climate change.	The impact of climate change on the baseline environment and how this may influence the assessment of effects is considered as part of the future baseline in section 9.7.4.

Summary of Relevant Legislation	How and Where Considered in the Offshore EIA Report
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.	Section 9.11 presents assessments of the significance of the effects of the development on diadromous fish species separately from marine species.
Offshore Wind and Marine Renewable Energy Policies	
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.	The maximum design scenario for cables is shown in Table 9.15 and the cumulative effect of these cables along with the cables from other projects in the area is assessed in section 9.12. Further information on the route selection process for the Proposed Development export cable corridor is presented in volume 1, chapter 4.

Table 9.5: Summary of Scottish Priority Marine Features (NatureScot, 2020) Relevant to Fish and Shellfish Ecology

Summary of Relevant Legislation	How and Where Considered in the Offshore EIA Report
Fish and Shellfish Species	
PMFs are habitats and species that have been identified as being conservation priorities in Scottish waters. These include 30 species of fish and shellfish, including elasmobranch species and one decapod crustacean.	Relevant PMFs are identified in Table 9.14. Section 9.11 assesses the significance of the effect of the Proposed Development on all fish and shellfish receptors, including PMFs within the Proposed Development northern North Sea fish and shellfish ecology study area, where an impact pathway exists.

Table 9.6: Summary of The Sectoral Marine Plan for Offshore Wind Energy 2020 Relevant to Fish and Shellfish Ecology

Summary of Relevant Policy Framework	How and Where Considered in the Offshore EIA Report
General Policies	
Minimise the potential adverse effects on other marine users, economic sectors and the environment resulting from further commercial scale offshore wind development.	The potential for adverse effects on the identified environmental (i.e. fish and shellfish) receptors are considered fully in section 9.11, with consequent effects on other environmental receptors (e.g. marine mammals and offshore birds) and marine users (e.g. commercial fisheries) considered in volume 2, chapters 10, 11 and 12 respectively. The cumulative effects of the Proposed Development alongside others in the region are assessed in section 9.12.
Offshore Wind and Marine Renewable Energy Policies	
Regional cumulative effects include the potential for adverse effects on bird populations, benthic habitats, cetaceans, navigational safety, seascape/landscape and commercial fisheries. The Sectoral Marine Plan includes measures to mitigate potential impacts at various scales.	The cumulative effects of the Proposed Development alongside others in the region are assessed in section 9.12.

Table 9.7: Summary of the UK Marine Policy Statement Relevant to Fish and Shellfish Ecology

Summary of Relevant Policy Framework	How and Where Considered in the Offshore EIA Report
General Policies	
Ensure a sustainable marine environment which promotes healthy, functioning marine ecosystems and protects marine habitats, species and our heritage assets.	The magnitude of impacts and the sensitivity of fish and shellfish receptors are analysed in section 9.11 to determine if the relevant impacts represent a significant effect on the relevant fish and shellfish receptors.
The marine environment plays an important role in mitigating climate change.	The impact of climate change on the baseline environment and how this will influence the predictions made in the effects assessment is considered as part of the future baseline in section 9.7.4.
Biodiversity is protected, conserved and where appropriate recovered and loss has been halted.	The significance of effects on fish and shellfish receptors is considered, as well as mitigation measures where appropriate, in section 9.11.
Offshore Wind and Marine Renewable Energy Policies	
Marine businesses are acting in a way which respects environmental limits and is socially responsible.	Section 9.11 presents assessments of the significance of the effects of the development on fish and shellfish receptors, with mitigation presented, as necessary, to reduce effects to an acceptable level.

9.5. CONSULTATION

12. The Fish and Shellfish Ecology Road Map was a 'live' document which has been used as a tool to facilitate early engagement with stakeholders and subsequent engagement throughout the pre-application phase of the Proposed Development including on reaching points of agreement on scoping impacts out of the assessment, and/or agreeing the level of assessment which will be presented for impacts, so that the focus in the EIA Report is on likely significant environmental effects as defined by the EIA Regulations.

13. The Fish and Shellfish Ecology Road Map (up to date at the point of Application) is presented as volume 3, appendix 8.2 and documents meetings and discussion points. At the request of MS-LOT[1] an audit document (the Berwick Bank Wind Farm Audit Document for Post-Scoping Discussions (volume 3, appendix 5.1) has been produced and submitted alongside the application to document discussions on key issues, post-receipt of the Berwick Bank Wind Farm Scoping Opinion (MS-LOT, 2022).

14. A summary of the key issues raised during consultation activities undertaken to date specific to fish and shellfish ecology is presented in Table 9.8, together with how these issues have been considered in the production of this Fish and Shellfish Ecology EIA Report chapter. Further detail is presented within volume 1, chapter 5.

[1] Meeting on 26 April 2022 between MS-LOT, RPS and the Applicant

Table 9.8: Summary of Key Consultation of Relevance to Fish and Shellfish Ecology

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this Chapter
Relevant Consultation to Date			
March 2021	Marine Scotland – Licensing Operations Team (MS-LOT) – Scoping Opinion on 2020 Berwick Bank	MS-LOT agree and are content with the two Proposed Development fish and shellfish ecology study areas.	The agreed study areas for the fish and shellfish ecology assessment are presented in Section 9.3 and applied to the assessment of likely significant effects.
March 2021	MS-LOT – Scoping Opinion on 2020 Berwick Bank	Request for diadromous fish to be considered separately from marine fish.	Diadromous fish species have been considered separately within the assessment of effects in section 9.11.
March 2021 (Q4 2020)	MS-LOT – Scoping Opinion on 2020 Berwick Bank, highlighting the representations of Marine Scotland Science (MSS) (19 November 2020); NatureScot (7 October 2020), the Scottish Fishermen's Federation (SFF) (10 December 2020) and North and East Coast Regional Inshore Fisheries Group (NECRIFG) (7 October 2020)	Highlight concerns raised by NatureScot, MSS, SFF and NECRIFG regarding characterisation of the baseline using current and relevant data. A literature review must be completed to include the studies, reports and data detailed in the representations (e.g. Aires *et al*. (2014) (for probability of presence and aggregations), Coull *et al*. (1998), Ellis *et al*. (2012), González-Irusta and Wright (2016) and (2017) (for spawning areas of cod, haddock and whiting); also Boyle and New (2018) for ORJIP study on 'Impacts on fish from piling at offshore wind farm sites).	See Table 9.9 for details of up to date data and literature used to inform the characterisation of the baseline. Consideration has been given by the Applicant to all sources of data identified by consultees in the 2020 Berwick Bank Scoping representations.
March 2021 (Q4 2020)	MS-LOT – Scoping Opinion on 2020 Berwick Bank, highlighting representations of NatureScot (7 October 2020) and FMS (26 October 2020) and the MSS (19 November 2020)	Recommend the use of the proposed 'Road Map' process to agree the scope of the assessment, including agreement on the characterisation of the baseline.	The 'Road Map' process (reported in full in volume 3, appendix 8.2) was used to agree the relevant species (Table 9.14 and impacts (Table 9.15) assessed. Key migration times are presented in the baseline characterisation reported in volume 3, appendix 9.1.
March 2021 (Q4 2020)	MS-LOT – Scoping Opinion on 2020 Berwick Bank supported by the representations of MSS (November and December 2020), the SFF (10 December 2020) and NECRIFG (7 October 2020).	Advised that the developer must undertake survey work of suitable habitat and substrate type for *Nephrops* norvegicus (hereafter referred to as *Nephrops*) and their spawning grounds to establish their existence within the Proposed Development fish and shellfish ecology study area.	Substrate types and suitable habitat investigated through site-specific surveys (e.g. trawl surveys, combined grab and Drop Down Video (DDV) sampling) and biotope mapping. Baseline characterisation for *Nephrops* presented in section 9.7 with full details in volume 3, appendix 9.1.
March 2021 (Q4 2020)	NatureScot (7 October 2020) and MSS (19 November 2020 and 10 December 2020) Scoping Representations on 2020 Berwick Bank	Epibenthic beam trawl surveys will go some way to update the existing baseline, but further review required for identification of suitable habitat for sandeel *Ammodytes sp*. and herring *Clupea harengus* spawning/nursery grounds. Sediment analysis coupled with literature on habitat preferences can inform spawning areas. For Herring in particular, the Applicant should take cognisance of ICES advice.	In addition to epibenthic beam trawl surveys, habitat characterisation was undertaken using Particle Size Analysis (PSA) of sediment types to identify herring spawning sites, in conjunction with contemporary literature identified in further review (including ICES reports). Sandeel habitat characterisation was completed in a similar way. Baseline characterisation for sandeel and herring presented in section 9.7 with full details in volume 3, appendix 9.1.
March 2021 (Q4 2020)	MS-LOT – Scoping Opinion on 2020 Berwick Bank citing representations of NatureScot (7 October 2020); SFF (10 December 2020); NECRIFG (7 October 2020) and MSS (19 November 2020 and 10 December 2020)	Agree with receptors and potential impacts scoped in however advise that the representations stakeholders regarding habitat loss/disturbance, Electromagnetic Field (EMF) effects, underwater noise, particle motion and increased suspended sediments, must be fully addressed.	Effects fully assessed, with each impact assessed within its own section (underwater noise and particle motion assessed within the same section) in section 9.11.
March 2021	MS-LOT – Scoping Opinion on 2020 Berwick Bank	In relation to underwater noise, the Scottish Ministers advise that the EIA Report must consider the hearing ability of the fish species when assessing impacts and therefore consideration must be given to sound pressure and particle motion. In addition, consideration must be given to the physiological and behavioural impacts of underwater noise on fish.	Underwater noise effects, including hearing ability, sound pressure and particle motion are assessed in section 9.11.
March 2021	MS-LOT – Scoping Opinion on 2020 Berwick Bank	Advise that impacts to key prey species and supporting habitats throughout all phases of the Proposed Development, both alone and cumulatively in the Forth and Tay area, are scoped in.	Impacts to prey species are considered as part of the assessment alone in section 9.11 and cumulatively in section 9.12.
March 2021 (Q4 2020)	MS-LOT – Scoping Opinion on 2020 Berwick Bank citing representations of NatureScot (7 October 2020) and MSS (19 November 2020 and 10 December 2020)	Consideration of physiological and behavioural impacts of underwater noise (including unexploded ordnance (UXO) clearance) on fish. For fish, impact thresholds must be applied however the impact on shellfish will require to be considered qualitatively.	Noise impacts on fish are considered in section 9.11 including UXO.
March 2021 (Q4 2020)	MS-LOT – Scoping Opinion on 2020 Berwick Bank citing representations of NatureScot (7 October 2020) and MSS (19 November 2020 and 10 December 2020)	Not in agreement with Applicant's decision to scope out colonisation of hard structures. Impacts from this must be assessed in the EIA Report.	Colonisation of hard structures has been scoped in and assessed in section 9.11.
March 2021 (Q4 2020)	MS-LOT – Scoping Opinion on 2020 Berwick Bank supported by representations of MSS (19 November 2020) SFF (10 December 2020) and FMS (7 October 2020)	Agree that the impact pathways detailed in the Scoping Report are scoped out.	See Table 9.16 for the agreed scoped out impacts.

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this Chapter
March 2021 (Q4 2020)	MS-LOT – Scoping Opinion on 2020 Berwick Bank, supported by MSS (November and December 2020), NatureScot (October 2020) and SFF (December 2020) representations	Advise requirement to quantitatively describe the impact of habitat loss or disturbance, both temporary and permanent, alone and cumulatively.	Quantitative temporary and permanent habitat loss or disturbance, alone and cumulatively is presented in section 9.11 and in section 9.12.3.
March 2021 (Q4 2020)	MS-LOT – Scoping Opinion on 2020 Berwick Bank in agreement with NatureScot (October 2020) and MSS (November 2020)	EIA Report must include an assessment quantifying the likely impacts on key PMFs, considering whether this could lead to a significant impact on the PMFs affected.	Effects on key PMFs are assessed in section 9.11.
March 2021 (Q4 2020)	MS-LOT – Scoping Opinion on 2020 Berwick Bank in agreement with NatureScot (October 2020) and MSS (November 2020).	Advise the full range of mitigation techniques and published guidance must be discussed in the EIA Report for the impact pathways identified and scoped in. The likely efficacy of the mitigation proposed should be explained with reference to residual effects.	Best practice guidance has been used to inform the EIA and associated baseline characterisation as set out in sections 9.6 and 9.9. Mitigation proposed is presented in Table 9.20 and follows industry best practice, where relevant and available. Appropriate and proportionate mitigation measures have been identified to minimise impacts on fish and shellfish receptors, based on the assessment of effects conclusions presented in section 9.11.
March 2021 (Q4 2020)	MS-LOT – Scoping Opinion on 2020 Berwick Bank in agreement with NatureScot (October 2020) and MSS (November 2020).	Advise that the proposed mitigation in the Scoping Report applies to marine fish as well as diadromous fish and highlight the potential need for strategic monitoring provided in the NatureScot December representation and the MSS December advice.	Monitoring commitments (including strategic monitoring) are presented in section 9.11 and Table 9.30.
March 2021 (Q4 2020)	MS-LOT – Scoping Opinion on 2020 Berwick Bank, highlighting representations of NatureScot (7 October 2020) and FMS (26 October 2020) and the MSS (19 November 2020)	Highlight comments regarding the relevance and age of the literature review relative to local migration of salmon *Salmo salar* and sea trout *Salmo trutta* together with the concerns regarding how the timing of fish migration will be established and used, in particular for both Atlantic salmon smolts and adult Atlantic salmon.	Most up to date literature regarding diadromous species is presented in Table 9.9 and has been used for the assessment of these species. Full details are provided in volume 3, appendix 9.1.
March 2021	MS-LOT – Scoping Opinion on 2020 Berwick Bank	Advise that Atlantic salmon will be considered within the HRA however potential effects on sea lamprey *Petromyzon marinus* and river lamprey *Lampetra fluviatilis* should be assessed within the EIA Report.	Atlantic salmon and lamprey species are assessed in section 9.11 where necessary, full details in volume 3, appendix 9.1. Furthermore, Atlantic salmon is considered within the HRA/RIAA (SSER, 2022c).
March 2021 (Q4 2020)	Combined response NatureScot, NECRIFG and SFF - Scoping Opinion on 2020 Berwick Bank	A further review of published literature is needed to capture more up to date data and include all species likely to be impacted.	See Table 9.9 for details of up to date data and literature used to inform the characterisation of the baseline.
October 2020	NatureScot representation on Scoping for 2020 Berwick Bank (October 2020)	Protected sites/features with fish/shellfish interests that overlap with the Proposed Development fish and shellfish ecology study area where there is reasonable likelihood of connectivity. Turbot Bank MPA should be screened out due to distance. Advise that PMFs should be considered.	Protected sites/features presented in Table 9.12 and discussed in section 9.11. Turbot Bank MPA is screened out due to distance. Effects on key PMFs are assessed in section 9.11.
October 2020	NatureScot representation on Scoping for 2020 Berwick Bank (October 2020)	EIA Report should consider those fish species which provide an important function as a key prey resource, noting many of these are PMFs, further discussion is needed to agree relevant species and assessment process.	PMFs and prey resources identified in baseline characterisation and in volume 3, appendix 9.1.
October 2020	NatureScot representation on Scoping for 2020 Berwick Bank (October 2020)	Diadromous fish species are assumed to be present within the Proposed Development fish and shellfish ecology study area during key migration periods. The timing of 'fish migration' is referred to in the scoping report as an important element of the baseline characterisation – we seek further clarification on this statement as we are unclear whether the Applicant is proposing to ascertain the timing of Atlantic salmon smolt migration from relevant rivers. The assessment should also reflect the behavioural characteristics of adult fish whilst in the marine environment. Noting, for example, adult Atlantic salmon can enter rivers at any time of the year.	A key focus of impacts within the assessment (section 9.11) for diadromous fish was the potential presence of barrier effects. Where such a potential existed, the seasonality and timing of migrations (of both smolts and adults) could inform mitigations, where required.
October 2020	NatureScot representation on Scoping for 2020 Berwick Bank (October 2020)	Agreement that most of the existing data on fish and shellfish resources have been included, advise that the Applicant refers to Aires *et al*. (2014).	Details of up to date data and literature used to inform the characterisation of the baseline is presented in volume 3, appendix 9.1. The literature reviewed includes Aires *et al*. (2014).
November 2020	MSS (November Advice) Scoping representation for 2020 Berwick Bank	Advise referencing ORJIP Boyle and New (2018) study.	Details of up to date data and literature used to inform the characterisation of the baseline is presented in volume 3, appendix 9.1. These include the Boyle and New (2018) study (ORJIP Impacts from Piling on Fish at Offshore Wind Sites).
November 2020	MSS (November Advice) Scoping representation for 2020 Berwick Bank	Recommend further consideration given to the impact of increased suspended sediment and the potential for it to smother fish eggs and larvae during critical spawning periods. Agree that EMF should be scoped in and recommend that consideration is given to elasmobranch species as studies have shown that they are capable of detecting EMF and showing behavioural responses to them (Hutchison *et al.*, 2018).	Effects on eggs and larvae and elasmobranch species are assessed in section 9.11.
November 2020	MSS (November Advice) Scoping representation for 2020 Berwick Bank	MSS are content with underwater noise from wind turbine operations, and the introduction of contaminants from foundations, being scoped out of the EIA. Recommend that these topics are considered for strategic monitoring.	As agreed, see Table 9.16 for scoped out impacts, and Table 9.30 for monitoring commitments, including strategic monitoring which are targeted specifically at areas of uncertainty and knowledge gaps.

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this Chapter
November 2020	MSS (November Advice) Scoping representation for 2020 Berwick Bank	Advise focusing on herring for proposed mitigation for marine fish as they are the most sensitive to noise impacts and there are herring spawning and nursery grounds in the area. Mitigation measures that are used for marine mammals will go some way towards mitigating noise impacts for fish.	Designed in measures are outlined in Table 9.20. No further mitigation was considered necessary for noise impacts on herring. Mitigation measures utilised for marine mammals will also reduce any effects on fish and shellfish receptors, including herring (see volume 2, chapter 10 for marine mammal mitigation).
November 2020	MSS (November Advice) Scoping representation for 2020 Berwick Bank	Agree with impacts proposed to be scoped in for fish and shellfish and agree that these are also appropriate to diadromous fish. Advise that piling ramp up and soft start are unlikely to be effective mitigation for salmon and sea trout (see previous comment). UXO clearance may also be a major concern in relation to noise. Appropriate timing of the operations may be important. With regard to EMF, note that there are potential effects on migrating diadromous fish which are navigating using geomagnetic cues which will need consideration.	The effects of noise and EMF on salmon and sea trout are assessed in section 9.11. With respect to effectiveness of soft starts for fish species, as discussed in paragraph 195, the paper provided by stakeholders (i.e. Harding *et al*., 2016) the experiments failed to produce physiological or behavioural responses in Atlantic salmon when subjected to noise similar to piling. However, the noise levels tested were estimated at <160 dB re 1 µPa Root Mean Square (RMS), below the level at which injury or behavioural disturbance would be expected for Atlantic salmon and other fish species. At elevated noise levels in close proximity to piling, strong avoidance reactions would be observed and therefore soft starts are considered effective mitigation to minimise risk of injury.
November 2020	MSS (November Advice) Scoping representation for 2020 Berwick Bank	Potential reef effects of the structures, including the direct effect on numbers or behaviour of migrating or foraging diadromous fish or on numbers and behaviour of bird, mammal and fish predators, which may subsequently impact on migrating or foraging diadromous fish.	The colonisation of foundations, scour protection and cable protections (which could lead to reef effects) is presented in section 9.11 (paragraph 259).
November 2020	MSS (November Advice) Scoping representation for 2020 Berwick Bank	Need for improved information on the spatial and temporal distribution of diadromous fish, including particularly salmon and sea trout, in the vicinity of the Proposed Development fish and shellfish ecology study area. Applicant and MS-LOT to consider how to contribute to address knowledge gaps.	Available information on diadromous fish species is presented in volume 3, appendix 9.1. The Applicant has made a commitment to engaging in discussions with Marine Scotland and the SNCBs post consent to identify opportunities for contributing to proportionate and appropriate strategic monitoring of diadromous fish species which would contribute to this knowledge gap (see Table 9.30). This may include research priorities identified by ScotMER steering group.
December 2020	MSS (December Advice) Scoping representation for 2020 Berwick Bank	A further review of herring spawning and nursery grounds has been proposed which will help to confirm if herring spawning ground is still in use or has been abandoned.	Information on herring spawning and nursery grounds presented in volume 3, appendix 9.1.
December 2020	MSS (December Advice) Scoping representation for 2020 Berwick Bank	Updates of spawning and nursery grounds reports could form part of the scoping or mitigation. Advise a *Nephrops* survey to validate the claims of non-existence.	*Nephrops* spawning and nursery details are presented in volume 3, appendix 9.1.
December 2020	SFF (December Advice) Scoping representation for 2020 Berwick Bank	Studies have found that EMF can have negative impacts on Lobsters and their fecundity, so should be scoped in.	The effects on shellfish are assessed in section 9.11.
October 2020	NECRIFG - Scoping representation for 2020 Berwick Bank	Scientific information and learning from previous developments should be drawn on.	Information from previous developments utilised as part of the assessment in section 9.11 and in volume 3, appendix 9.1.
October 2020	NECRIFG - Scoping representation for 2020 Berwick Bank	Concern raised with regard to the impact of construction on shellfish, juveniles and sprat. Request survey work is undertaken on the Proposed Development fish and shellfish ecology study area to measure the impact.	Information on site specific surveys presented in volume 3, appendix 9.1.
October 2020	NECRIFG - Scoping representation for 2020 Berwick Bank	Ensure that all aspects of impact are considered including noise and those receptors which are particularly sensitive to noise.	The effects on fish and shellfish assessed in section 9.11 (paragraph 152).
Consultation on the Proposed Development			
December 2021	MSS Scoping representation for Berwick Bank Wind Farm	It is very difficult to simply define everything from statistics, the project Fisheries Liaison Officer (FLO)/Fishing Industry Representative (FIR) relationship should be utilised to access stakeholder knowledge.	Baseline presented in section 9.7 with full details in volume 3, appendix 9.1. The project Fisheries Liaison Officer (FLO) coordinated a programme of consultation with fisheries stakeholders, which was grounded on the FLO/Fisheries Industry Representative (FIR) relationship. The outcomes of this process are reported in volume 2, chapter 12. This information was considered in the production of the baseline and used to inform to EIA.
December 2021	SFF Scoping representation for Berwick Bank Wind Farm	Given the predominance of scallops in the area, the Applicant needs to be checking that spawning will not be affected.	Effects of the Proposed Development on scallops are assessed in section 9.11 and volume 3, appendix 9.1.
December 2021	SFF Scoping representation for Berwick Bank Wind Farm	EMF assessment of effects needs to be cognisant of recent science which appears to show that EMF is impacting on crustacean breeding behaviour, which is probably more important than the predator/prey link.	EMF effects, including effects on crustacean species, are assessed in section 9.11.
December 2021	SFF Scoping representation for Berwick Bank Wind Farm	With respect to colonisation of foundations, scour protection and cable protection, the Applicant should ensure the life cycle of the colonisers, as studies in Belgium seem to show that this can have an unhealthy side effect.	The potential implications on the immediate and wider ecosystem of the colonisation of Project foundations, cable protection and scour protection are assessed in section 9.11. This is with respect to the potential introduction/spread of new species and/or their long-term establishment and the life characteristics of potential colonisers. The implications of the removal of encrusted growth from infrastructure during operation and the potential loss of established communities at decommissioning are addressed in volume 2, chapter 8.
December 2021	NatureScot, MS-LOT	Stakeholders content with content with the two study areas.	The study areas for the fish and shellfish ecology assessment of effects are presented in section 9.3.
December 2021	NatureScot, MSS and MS-LOT	NS Support the screening out of the Turbot Bank MPA, based on the lack of connectivity and distance of 96.2 km from the Proposed Development.	Designated sites are identified within section 9.7.2. The Turbot Bank MPA has been screened out of the assessment.

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this Chapter
December 2021	NatureScot and MS-LOT	Atlantic salmon is also a feature of the River Teith Special Area of Conservation (SAC) and should be included.	Designated sites and features are identified within section 9.7.2. Atlantic salmon is included as a qualifying feature for the River Teith SAC.
December 2021	NatureScot	It is not clear whether sparling and Allis and twaite shad will be included in the Berwick Bank revised design assessment of effects.	Sparling discussed as part of the baseline in volume 3, appendix 9.1 but scoped out of assessment as agreed with stakeholders in Road Map Meetings 1 and 2. Shad species assessed in section 9.11 and volume 3, appendix 9.1.
December 2021	NatureScot	NS advise that species which have the greatest potential to be present within the vicinity of the development are likely to be Atlantic salmon, sea trout, European eel, river and sea lamprey.	Atlantic salmon, sea trout, European eel, river and sea lamprey have been assessed in section 9.11 and described as part of the baseline in volume 3, appendix 9.1.
December 2021	NatureScot	The EIA Report must utilise language that is accurate and reflective of the ecology of all relevant diadromous fish species and note differences between migration behaviours between diadromous species.	The ecology of relevant diadromous fish species, including their migration behaviours, has been considered in the assessment of effects in section 9.11 and described as part of the baseline in volume 3, appendix 9.1. This assessment accounts for the specific ecology and behaviours of the individual species assessed and does not generalise as to 'relevant periods' that it is acknowledged, may not apply in each case.
December 2021	NatureScot	NS expect justification, based on available evidence, on the exclusion of sparling and the two shad species to be provided in the EIA Report.	Sparling discussed as part of the baseline in volume 3, appendix 9.1 but scoped out of assessment as agreed with stakeholders in Road Map Meetings 1 and 2. Shad species assessed in section 9.11 and volume 3, appendix 9.1 and has not been scoped out.
December 2021	NatureScot	NS agree that the timing of fish migration is a crucial element of the data that will require careful consideration in the assessment of effects and in what mitigation may be necessary and when it should be applied (e.g. Atlantic salmon stocks comprise a number of distinct temporal components (spring, summer and autumn multi-sea-winter fish and grilse) and this means that adult Atlantic salmon may enter Scotland's rivers at all times of the year).	Timing of migration assessed is considered as part of the assessment detailed in section 9.11 and described as part of the baseline in volume 3, appendix 9.1. Proposed mitigation measures and monitoring commitments are detailed in Table 9.20 and Table 9.30, respectively.
December 2021	NatureScot	See Smith and Smith (1997), Hedger *et al*. (2008) and Dempson *et al*. (2011) for further info on Atlantic salmon migration behaviour/timings.	Studies used to inform the baseline in volume 3, appendix 9.1 and the assessment in section 9.11 include the named studies. Smith and Smith (1997) was cited on Atlantic salmon migration as it may relate to tidal phase and time of day. Hedger et al. (2008) and Dempson et al. (2011) were referenced with respect to nocturnal/daytime migration activity.
December 2021	NatureScot	In addition to being qualifying features of European sites, Atlantic salmon, sea lamprey and river lamprey are PMFs. European eel, sea trout and sparling are also PMFs.	PMFs, including Atlantic salmon, sea lamprey and river lamprey, European eel, sea trout and sparling are discussed section 9.7, and assessed in section 9.11.
December 2021	NatureScot	European eel is a conservation priority due to a dramatic drop in its population over the last 20 years; it is listed as 'critically endangered' on the International Union for Conservation of Nature (IUCN) Red list. See Malcolm *et al*. (2010) for a review of available data in relation to migration routes and behaviour of European eel.	This study was used to inform the baseline in volume 3, appendix 9.1 and the assessment of effects in section 9.11.
December 2021	NatureScot	See Gill & Bartlett (2010) for a review of effects of noise and EMF on European eel.	Study used to inform volume 3, appendix 9.1 and assessed in section 9.11.
December 2021	NatureScot	Sea trout can also be a host species for freshwater pearl mussel (FWPM) (as well as Atlantic Salmon) and indirect effects on FWPM need to be considered within the EIA Report.	Indirect impacts of Proposed Development on fresh water pearl mussel (via salmonid hosts) are assessed in section 9.11 and as part of the baseline in volume 3, appendix 9.1.
December 2021	NatureScot	See Malcolm *et al*. (2010) for a review of available data in relation to sea trout migration routes and behaviour.	Study used to inform the baseline in volume 3, appendix 9.1 and assessed in section 9.11.
December 2021	NatureScot	See Gill and Bartlett (2010) for a review of effects of noise and EMF on sea trout.	Study used has been used to inform the assessment of effects in section 9.11.
December 2021	NatureScot	Given sparling primarily utilise coastal and estuarine environments, this species is less likely to be present in the offshore development area, however, may be present in the export cable corridor. However due to the temporary nature of cable laying activities, NatureScot advise sparling can be scoped out from further assessment.	Sparling discussed as part of the baseline in volume 3, appendix 9.1 but scoped out of assessment following stakeholder advice at Road Map Meetings 1 and 2 (see volume 3, appendix 8.2).
December 2021	NatureScot	NatureScot welcome the approach to consider the importance of fish species (such as herring, sandeel, mackerel and sprat) as key prey species to better inform the assessment of effects for seabirds and marine mammals (noting many are PMFs).	The effects on key prey species assessed in section 9.11.
December 2021	NatureScot	The EIA report should acknowledge a number of other PMF fish species, including anglerfish, cod and whiting, with ling also likely to be found in the vicinity of the proposed development.	PMFs identified, including those raised by NatureScot (namely anglerfish, cod, whiting and ling) are listed in Table 9.14.
December 2021	NatureScot	NatureScot is content with the relevant species described in the Scoping Report.	Table 9.14 includes all relevant species identified.
December 2021	NatureScot	NatureScot welcome the intention that a further review of the herring spawning and nursery grounds will be undertaken to support the fish and shellfish ecology assessment as per the guideline in Boyle and New (2018).	A review of the herring spawning and nursery grounds has been included as part of the baseline in volume 3, appendix 9.1. The effects on herring spawning and nursery grounds are assessed in section 9.11.

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December 2021	NatureScot	There is no mention of potential impacts of the proposed development on ocean quahog aggregations or of cumulative impacts from the Seagreen projects (Seagreen 1, Seagreen 1A Project and Seagreen 1A Export Cable) or any proposed mitigation measures to minimise damage to this protected species. NatureScot expect a detailed assessment of impacts on this protected feature which is also an Oslo and Paris Conventions (OSPAR) threatened and/or declining species.	The effects on ocean quahog are assessed within volume 2, chapter 8, which also considers cumulative impacts from neighbouring projects.
December 2021	NatureScot and MS-LOT	The Applicant needs to fully include all appropriate pre-construction seabed preparation works.	Seabed preparation works are listed in Table 9.15 and have been considered as part of the assessment of effects in section 9.11.
December 2021	NatureScot	NatureScot is content with the inclusion of particle motion and sound pressure as outlined in the approach to assessment.	The effects (injury and or disturbance) of sound pressure and particle motion from underwater noise on relevant species are assessed in section 9.11 (paragraph 152).
December 2021	NatureScot	With respect to Atlantic salmon, recent research by Harding *et al*. (2016) should be considered which found that soft-start and ramp-up procedures associated with piling activity may be ineffective as mitigation to protect Atlantic salmon from noisy activities, as fish did not show immediate avoidance behaviour in the presence of piling noise.	The research presented by Harding *et al.* (2016) has been considered in the assessment of potential effects from underwater noise on relevant species in section 9.11. With respect to effectiveness of soft starts for fish species, as discussed in paragraph 195, the experiments in Harding *et al.* (2016) failed to produce physiological or behavioural responses in Atlantic salmon when subjected to noise similar to piling. However, the noise levels tested were estimated at <160 dB re 1 µPa RMS, which is far below the level at which injury or behavioural disturbance would be expected for Atlantic salmon and other fish species. At elevated noise levels in close proximity to piling, strong avoidance reactions would be observed and therefore soft starts are considered effective mitigation to minimise risk of injury and have been applied in the assessment of effects in this chapter.
December 2021	NatureScot	Available research on Atlantic salmon behaviour at sea (see above) indicates that ceasing relevant noisy activities (such as piling) during the hours of darkness could help to mitigate potential impacts from noise. Consideration should be given to limiting or ceasing relevant noisy activities during daylight hours including during periods when high numbers of young Atlantic salmon could be migrating through these waters, depending on the findings of the assessment of potential impacts from sound pressure and particle movement.	The Applicant assumes that the reference to 'daylight hours' was intended to be 'hours of darkness'. The effects from underwater noise on relevant species are assessed in section 9.11, with appropriate and proportionate mitigation measures included to minimise impacts on fish and shellfish receptors set out in section 9.10. Further restrictions (e.g. limiting piling in hours of darkness) were not considered necessary following the conclusion of the assessment of effects.
December 2021	NatureScot	UXO clearance should be explicitly considered in the assessment.	The effects from underwater noise from UXO on relevant species are assessed in section 9.11.
December 2021	NatureScot	Disturbance from construction-related noisy activities should be assessed depending on the foundation type/installation method.	The effects from underwater noise during the construction phase are assessed on relevant species in section 9.11.
December 2021	NatureScot	Impacts from EMF from subsea electromagnetic cabling must consider all relevant fish species, including elasmobranch species, *Nephrops* and diadromous fish.	EMF effects on all relevant species, including elasmobranch species, *Nephrops* and diadromous fish are assessed in section 9.11.
December 2021	NatureScot	Recent research on EMF effects from underwater cables concluded that we are still not that knowledgeable on the effects of EMF on fish and benthic species. This is likely to be addressed further through a strategic project via ScotMER in the longer term.	EMF effects on relevant species are assessed in section 9.11. Proposed monitoring commitments including potential contribution to ScotMER projects is detailed in Table 9.30.
December 2021	NatureScot	The EIA Report should detail expected concentrations of sediment, their distribution and duration within the context of species-specific behaviour to enable assessment of potential impacts and their significance.	Changes to the concentration and distribution of suspended solids in the marine environment and the estimated duration of any such changes are considered in volume 3, appendix 7.1. The effects of suspended sediment on relevant species are assessed in section 9.11.
December 2021	NatureScot	There is limited information on critical levels of exposure to suspended solids, and behavioural responses of the relevant fish species to high sediment levels. Diadromous species pass through these environments as they migrate to feeding or spawning areas. While we expect that fish are likely to move away from or avoid areas of high suspended solids, this should be informed by the expected concentrations of sediment, distribution and duration and an assessment of this in light of fish avoidance behaviour.	Suspended solids are considered in volume 3, appendix 7.1. The potential effects of suspended sediment on relevant species, with a particular focus on diadromous fish species, are assessed in section 9.11.
December 2021	NatureScot	NatureScot is content that the colonisation of hard structures has been scoped into the fish and shellfish assessment.	The potential implications of the colonisation of hard structures in the marine environment are assessed in section 9.11. with respect to Project foundations, cable protection and scour protection components.
December 2021	NatureScot	Ensure that impacts to key prey species (such as sandeel, herring, mackerel and sprat) and their habitats are considered across all development phases for Berwick Bank alone and cumulatively.	The effects on key prey species (including sandeel, herring, mackerel and sprat) across all development phases are assessed in section 9.11.

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December 2021	NatureScot	NatureScot recognise most EIA Reports concentrate on receptor specific impacts, however increasingly the need to understand the impacts at the ecosystem scale. Consideration across key trophic levels will enable better understanding of the consequences (positive or negative) of any potential changes in prey distribution and abundance on marine mammal (and other top predator) interests and how this may influence population level impacts. Therefore, consideration of how this loss/disturbance may affect the recruitment of key prey (fish) species through impacts to these important spawning and or nursery ground habitats should also be assessed.	Consideration of linkages between trophic levels has been included in the assessments for the Project alone throughout section 9.11 and cumulatively in section 9.12. Other ecosystem related elements are included in other topic chapters, including marine mammal and ornithology. Cross references to these chapters are provided, where relevant. Inter-related effects are addressed for the project in volume 2, chapter 20, supported by volume 3, appendix 20.1.
December 2021	NatureScot	NatureScot welcome the inclusion of habitat suitability assessment for sandeel and herring spawning/nursery grounds using data from the benthic ecology surveys.	Habitat characterisation was undertaken using PSA of sediment types to identify herring spawning sites, in conjunction with contemporary literature identified in further review. Sandeel habitat was identified in a similar way. Sandeel and herring habitat/spawning has been included as part of the baseline in volume 3, appendix 9.1 and is assessed in section 9.11.
December 2021	NatureScot and MS-LOT	NatureScot expect that the assessment will quantify, where possible, the likely impacts to key PMFs and consider whether this could lead to a significant impact on the national status of the PMFs being considered.	PMFs identified in Table 9.14 and assessed in section 9.11. Significance conclusions are presented throughout section 9.11 for all fish and shellfish receptors, including PMFs.
December 2021	NatureScot	The EIA Report must consider the cumulative effect of key impacts such as habitat loss/change from Berwick Bank revised design wind farm in combination with the neighbouring wind farms in the Forth/Tay area especially in relation to diadromous fish. This may differ depending on the life stage being considered.	Cumulative effects are assessed in section 9.12.
February 2022	MSS	MSS welcome the use of low order unexploded ordinance (UXO) clearance techniques for the clearance of UXO that cannot be removed or avoided.	Underwater noise effects from UXO are assessed in section 9.11.
February 2022	MSS and MS-LOT	MSS recommend a further review of sandeel spawning grounds which should identify suitable habitat for sandeel to inform the assessment of effects and the need for mitigation (see Mazik *et al.* (2015) and Lancaster *et al.* (2014)).	Sandeel spawning grounds were identified through comprehensive desktop study, supplemented by site-specific fish ecology surveys (as reported in volume 3, appendix 9.1) Data from epibenthic beam trawl sampling, DDV and PSA data obtained from grabs was used alongside literature (including Mazik *et al.* (2015) to identify suitable habitat for sandeel as part of the baseline in volume 3, appendix 9.1, and to inform the assessment in section 9.11.
February 2022	MSS	MSS recommend further consideration of the overlap of the development area, particularly the cables, with *Nephrops* grounds in terms of habitat loss, disturbance and the potential impacts of EMF from cables.	The potential effects of the Proposed Development, including the cables on *Nephrops* grounds, including habitat loss, disturbance and the potential impacts of EMFs are assessed in section 9.11.
February 2022	MSS and MS-LOT	MSS note that the development area is a high intensity nursery ground for herring. The report states that, 'a further review of the herring spawning and nursery grounds will be undertaken to support the fish and shellfish ecology assessment following guidelines set out by Boyle and New (2018) considering seabed sediment type and records of herring larvae from the International Herring Larval Survey (IHLS) over the past decade'. This review will be important to confirm and refine spawning areas within the study area and inform the EIA. MSS would appreciate having sight of this review and the findings when they are available.	The effects of the Proposed Development on herring habitat/spawning are assessed in section 9.11. A summary of the herring spawning mapping was presented in Road Map Meetings 1 and 2 and recapped in Road Map Meeting 3.
February 2022	MSS	MSS recommend including fish spawning periods to consider peak spawning periods in comparison with the proposed construction timetable. This might help to avoid conflict and any impacts on spawning fish.	Fish spawning periods included in the baseline in volume 3, appendix 9.1 as part of the assessment of effects in section 9.11. Appropriate and proportionate mitigation measures have been considered within the assessment of effects to minimise impacts on fish and shellfish receptors set out in section 9.10. Following conclusions of the assessment of effects (section 9.11), seasonal restrictions on construction activities were not deemed necessary.
February 2022	MSS	In terms of proposed mitigation, it appears that mitigation will only be considered for the potential for disturbance or disruption to diadromous fish for underwater noise, increased sediment concentrations and associated sediment deposition and EMF and not marine fish. MSS seek clarification that mitigation will also be considered for these impacts for marine fish.	Designed in measures (Table 9.20) have been included as part of assessment in section 9.11 and have been designed with both marine and diadromous fish and shellfish receptors in mind.
February 2022	MSS and MS-LOT	MSS suggest that a key consideration for the environmental impacts of underwater noise on fish should be on herring, as this species is sensitive to noise impacts and there are known herring spawning and nursery grounds in the area. Sound abatement measures that are used for marine mammals may go some way towards mitigating noise impacts for fish. MSS recommend the avoidance of loud, impulsive noise generating activities (e.g. pile driving and UXO clearance), during important fish peak spawning periods.	The potential effects of the Proposed Development on herring are assessed in section 9.11. Spawning periods are described in volume 3, appendix 9.1. In view of the conclusions of the assessment of effects (section 9.11) for underwater noise, neither seasonal restrictions or sound abatement measures (other than soft start piling procedures in relation to construction activities) have been identified as being required.

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this Chapter
February 2022	MSS and MS-LOT	MSS recommend that the developer provides evidence for either predicted or known EMF emissions from their cables to predict the range of EMF emissions from the cable. This range can then be considered against background levels of geomagnetism. MSS also recommend further consideration of the potential impacts of EMF on elasmobranchs and marine invertebrates such as lobster, *Nephrops* and crabs while taking into account recent scientific evidence, for example, papers by Scott *et al*. (2018, 2021) and Hutchison *et al*. (2020, 2021).	EMF effects are assessed in section 9.11.
February 2022	MSS	MSS would welcome the development of a strategic project to measure and monitor EMF, and would encourage the involvement of this developer in any future strategic projects to contribute to the evidence base and improve assessments of EMF impacts. This work will also be important in helping to improve our understanding of the potential for population level effects on fish and invertebrates.	Monitoring commitments detailed in Table 9.30.
February 2022	MSS	MSS advise that the Developer should refer to a report which provides a modelled spatial representation of the probability of the presence of 0 age group fish (fish in the first year of their life) and the probability of aggregations of 0 age group fish (Aires *et al*. 2014). It is recommended these data are presented visually in conjunction with the Coull *et al*. (1998) and Ellis *et al*. (2012) nursery maps, as there are certain limitations with the data.	This study has been used to inform the baseline in volume 3, appendix 9.1.
February 2022	MSS	MSS recommend that in addition to the Coull *et al*. (1998), Ellis *et al*. (2010) and Aires *et al*. (2014) data, new information is available regarding the spawning areas of cod, haddock and whiting (González-Irusta and Wright 2016; González-Irusta and Wright 2017).	This study has been used to inform the baseline in volume 3, appendix 9.1 and the assessment in section 9.7.
February 2022	MSS	MSS also recommend reference to the ORJIP study on 'Impacts on fish from piling at offshore wind farm sites: collating population information, gap analysis and appraisal of mitigation options' which was published in 2018 (Boyle and New, 2018).	This study has been used to inform the baseline in volume 3, appendix 9.1 and the assessment in section 9.7.
February 2022	MSS	A recent study has also been published on 'A verified distribution model for the lesser sandeel *Ammodytes marinus'* by Langton *et al*. (2021). MSS recommend that the developer considers this new research in the EIA.	This study has been used to inform the baseline in volume 3, appendix 9.1 and the assessment in section 9.7.
February 2022	MSS	MSS would like to highlight that 2020 landings data is now available, although MSS would urge careful interpretation of these most recent data due to the impacts of the Covid 19 Pandemic on the commercial fishing industry.	Commercial fisheries baseline described in volume 3, appendix 12. 2020 landings data not included due to the potential influence of the COVID-19 pandemic.
February 2022	MSS	MSS advise that MS-LOT should consider how developers might contribute to addressing knowledge gaps regarding the distribution and conservation of diadromous fish at sea.	Monitoring commitments are detailed in Table 9.30.
February 2022	MSS and NatureScot	With respect to noise, MSS advise that piling ramp up and soft start are unlikely to be effective mitigation for salmon and sea trout. Harding *et a*l. (2016) found that salmon did not show immediate avoidance behaviour in the presence of piling noise, although the sound level was greatly above that which salmon can detect.	The research presented by Harding *et al.* (2016) has been considered in the assessment of potential effects from underwater noise on relevant species in section 9.11. With respect to effectiveness of soft starts for fish species, the experiments in Harding *et al.* (2016) failed to produce physiological or behavioural responses in Atlantic salmon when subjected to noise similar to piling. However, the noise levels tested were estimated at <160 dB re 1 µPa RMS, which is far below the level at which injury or behavioural disturbance would be expected for Atlantic salmon and other fish species. At elevated noise levels in close proximity to piling, strong avoidance reactions would be observed and therefore soft starts are considered effective mitigation to minimise risk of injury and have been applied in the assessment of effects in this chapter.
February 2022	MSS	In regard to EMF, MSS would note that there are potential effects on migrating diadromous fish which are navigating using geomagnetic cues which will need consideration in the EIA.	EMF effects are assessed in section 9.11 (paragraph 232 *et seq.*). Advice given has been considered within the assessment.
February 2022	MSS	UXO clearance may be a major source of impulsive noise with potential impacts on diadromous fish. Appropriate timing of the operations may be important and should be considered within the EIA. Emigrating salmon smolts are potentially a very sensitive life stage and are likely to pass through the development area in May and possibly early June.	The effects of underwater noise from UXO on diadromous fish are assessed in section 9.11 (paragraph 152 *et seq*.). In view of the conclusions of the assessment of effects (section 9.11) for underwater noise, seasonal restrictions on construction activities were not deemed necessary.
February 2022	MSS	With regard to the colonisation of hard structures, MSS would note that the potential reef effects of the structures include the direct effect on numbers or behaviour of migrating or foraging diadromous fish, and also on the abundance and behaviour of predators such as seabirds, marine mammals and fish, which may subsequently impact on migrating or foraging diadromous fish.	Potential impacts on diadromous fish species from the colonisation of structures assessed in section 9.11 (paragraph 259 *et seq.)*. Includes consideration of the reef effect and associated changes to behaviour, migration, distributions, foraging and predator/prey dynamics.

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this Chapter
February 2022	MSS	MSS recommend that the applicant considers the resilience of salmon and sea trout populations to loss of fish, in any population impact modelling for diadromous fish.	The effects of the Proposed Development on diadromous species assessed in section 9.11. Population impact modelling was not undertaken or considered necessary for the assessment of effects as mortality of individuals due to the Proposed Development are not anticipated in any significant numbers, with mitigation measures designed to avoid injury to fish wherever possible.
February 2022	MSS	It is stated that the River South Esk, River Dee and River Spey SACs have primarily been designated as SACs due to the presence of the freshwater pearl mussel. This should instead say that they are designated as SACs with freshwater pearl mussel as a species that are a primary reason for selection of the site, and Atlantic salmon and in some cases lamprey species are also primary species interests.	European sites and features updated in Table 9.12 to incorporate feedback from MSS. Freshwater pearl mussel now cited as primary reason for the designation of River South Esk SAC, River Dee SAC and River Spey SAC; Atlantic salmon cited as primary reason for the designation of River South Esk SAC, River Dee SAC, River Tay SAC and River Tweed SAC.
February 2022	MS-LOT	MS-LOT have stated that from hereon in, diadromous fish will be considered separately from marine fish.	Effects of the Proposed Development on diadromous species assessed in section 9.11, separately from marine fish, as requested by MS-LOT.
February 2022	MS-LOT	Impacts from pre-construction noise, including UXO clearance, must be considered and assessed. With regards to UXO clearance, the Scottish Ministers advise that fish impact thresholds must be applied however the impact on shellfish will require to be considered qualitatively. The Scottish Ministers advise that this must include a worst case of high order detonation in terms of impact and mitigation, unless there is robust supporting evidence that can be presented to show the consistent performance of the preferred low order or deflagration method.	Pre-construction noise, including underwater noise effects from UXO assessed in section 9.11. Fish impact thresholds are applied, and a qualitative assessment provided for shellfish in this section. Underwater noise modelling (see volume 3, appendix 10.1) models accidental high order detonation which have been incorporated in the pre-construction noise assessment.
February 2022	MS-LOT	MS-LOT highlight NatureScot's December representation regarding the consideration of impacts to the offshore subtidal sands and gravels feature of the ncMPA as spawning habitat and furthermore the importance of a clear assessment of the specific impacts of the Proposed Development in itself and cumulatively against all designated features of the ncMPA, including ocean quahog.	Cumulative effects assessed in section 9.12. Impacts to ocean quahog are assessed within volume 2, chapter 8. Impacts to all features of the Firth of Forth Banks Complex MPA are considered in the MPA Assessment for the Proposed Development (Marine Protected Area Assessment (SSER, 2022b)).
February 2022	MS-LOT	MS-LOT advises that the EIA Report must consider the cumulative effect of key impacts from the Proposed Development in combination with the neighbouring consented wind farms in the Forth and Tay area, especially in relation to the Firth of Forth Banks Complex ncMPA. This must include the cumulative effect of key impacts such as habitat loss or change especially in relation to key fish and shellfish species that contribute ecological importance as a prey resource.	Cumulative effects assessed in section 9.12.
February 2022	MS-LOT	MS-LOT advises that the proposed mitigation in the Scoping Report applies to marine fish as well as diadromous fish. Furthermore, the Scottish Ministers highlight the advice provided in the NatureScot December representation and the MSS December advice regarding the potential need for strategic monitoring.	Mitigation measures included as part of assessment in section 9.11 and list of proposed monitoring commitments in Table 9.30.
February 2022	MS-LOT	MS-LOT advises that should sparling, Allis shad and twaite shad not be considered for further assessment, the justification for this, based on available evidence, must be provided in the EIA Report. The Scottish Ministers advise that the timing of fish migration is a crucial element of the data that will require careful consideration in the assessment of effects. Mitigation that may be necessary and when it should be applied in respect of fish migration should also be carefully considered.	Sparling discussed in volume 3, appendix 9.1 but scoped out of assessment on advice from stakeholders at Road Map Meeting 1 and Road Map Meeting 2. Shad species assessed in section 9.11 and volume 3, appendix 9.1. Appropriate and proportionate designed in measures have been considered within the assessment to minimise impacts on fish and shellfish receptors, as set out in section 9.10. Following conclusions of the assessment of effects (section 9.11), secondary mitigation designed to minimise impacts on fish migration was not considered necessary.
February 2022	MS-LOT	MS-LOT suggest the need to bring in a range of available information in the absence of site specific surveys and noting that epibenthic trawls provide little information on salmon and sea trout, as well as the NatureScot December representation concerning the utilisation of accurate and reflective language as regards diadromous fish species.	Information used to support the baseline is presented in volume 3, appendix 9.1. This information comprises comprehensive desktop study and data from site-specific fish ecology surveys. Effects of the Proposed Development on diadromous species assessed in section 9.11. The language applied is sensitive to the specific ecology and behaviours of the individual species assessed and does not generalise as to 'relevant periods' that it is acknowledged, may not apply in each case.
February 2022	MS-LOT	MS-LOT advises that the Developer must fully implement both the NatureScot December representation and MSS December advice with regards to the SAC sites for diadromous fish, including identification of sites, potential impact mechanisms and determination of likelihood of significant effect. In relation to those diadromous fish which are also PMFs, the Scottish Ministers advise that their PMF status and associated importance should be acknowledged in the EIA Report and draw attention to the NatureScot December representation which contains further detail and references regarding these species and associated migration routes.	The Berwick Bank Wind Farm Offshore HRA Screening Report (SSER, 2021b) and RIAA (SSER, 2022c) detail how the specified advice has factored in the identification and assessment of European sites for diadromous species. Effects on SACs for diadromous fish which are also PMFs are assessed in section 9.11, with detail on migration routes provided in the baseline report (volume 3, appendix 9.1).

Date	Consultee and Type of Consultation	Issue(s) Raised	Response to Issue Raised and/or Where Considered in this Chapter
February 2022	MS-LOT	MS-LOT agree with the impacts to be scoped in for diadromous fish, however, advise that the NatureScot December representation and the MSS December advice, regarding underwater noise, change in prey species availability, EMF (including potential effects on migrating diadromous fish which are navigating using geomagnetic cues), increased suspended sediments and colonisation of hard structures must be fully addressed.	Effects of the Proposed Development on diadromous species assessed in section 9.11, including those regarding underwater noise, change in prey species availability, EMF, increased suspended sediments and colonisation of hard structures.
February 2022	MS-LOT	MS-LOT advise that the EIA Report must consider the cumulative effect of key impacts from the Proposed Development in combination with the neighbouring consented wind farms in the Forth and Tay area, in relation to diadromous fish. This view is supported by the NatureScot December representation. In addition, the Scottish Ministers highlight the MSS December advice regarding consideration of cross border impacts from the Proposed Development.	Cumulative effects assessed in section 9.12.
February 2022	MS-LOT	MS-LOT advise that all the points raised in respect of indirect impacts upon freshwater pearl mussels and underwater noise impacts must be fully addressed from the NatureScot December representation.	Effects of the Proposed Development in relation to potential indirect impacts upon freshwater pearl mussels and underwater noise impacts (i.e. due to disruption of salmonid migration) assessed in section 9.11.
Consultation on the Proposed Development: Road Map Meetings			
September 2021	Marine Scotland – Road Map Meeting 1	Request to scope in the potential reef effect of the structures from the viewpoint of potentially increasing number of predators that may predate upon migratory fish species.	Reef effects scoped in through colonisation of hard substrate impact, including consideration of predation, which is assessed in section 9.11.
September 2021	Marine Scotland – Road Map Meeting 1	Marine Scotland to issue the charts mentioned in relation to diadromous fish. If possible, also the most recent annual reports for the individual rivers/Special Areas of Conservation (SACs).	Reports not provided however see Table 9.9 and volume 3, appendix 9.1 for details of literature used to inform the characterisation of the baseline. However, the lack of diadromous fish charts has not affected the robustness of the assessment.
September 2021	Marine Scotland – Road Map Meeting 1	Ensure consultation with fisheries to gain their specific knowledge on local and surrounding areas.	Fisheries information from desktop studies presented in Table 9.9 and volume 3, appendix 9.1. Information on commercial fisheries consultation is included in volume 2, chapter 12 and volume 3, appendix 12.1.
September 2021	Marine Scotland – Road Map Meeting 1	Sandeel – see Langton, *et al*. (2021) publication to inform impacts to sandeel habitat.	This study has been used to inform the baseline in section 9.7. For further detail see volume 3, appendix 9.1.
September 2021	Marine Scotland – Road Map Meeting 1	Consider additional report from Newton *et al*. (2017) regarding salmon movements.	This study has been used to inform the baseline in section 9.7. For further detail see volume 3, appendix 9.1.
September 2021	Marine Scotland – Road Map Meeting 1	Consider additional report from Newton *et al.* (2019) also regarding salmon movements.	This study has been used to inform the baseline in section 9.7. For further detail see volume 3, appendix 9.1.
December 2021	Marine Scotland – Road Map Meeting 2	Query regarding behavioural responses of Atlantic salmon to noise impacts. Little scientific evidence of response to noise and soft start piling.	Sensitivity of salmon is considered as part of the assessment of noise on this species in section 9.11. The research presented by Harding *et al*. (2016) was considered (see section 9.11). On balance, soft starts are considered effective mitigation to minimise risk of injury and have been applied in the assessment of effects in this chapter.
December 2021	Marine Scotland – Road Map Meeting 2	Note that FeAST Fish should be available in March which will support the assessment.	FeAST is a Sensitivity Tool developed by the Scottish Government. Baseline characterisation is presented in section 9.7. For further detail see volume 3, appendix 9.1
February 2022	Marine Scotland – Road Map Meeting 3	Road Map Meeting 3 presented a recap of info presented in Road Map Meetings 1 and 2. It then outlined the early findings of the EIA presenting impacts on specific key impacts including subtidal habitat loss, underwater noise impacts, and colonisation of hard structures. This focused on key species including sandeel and herring. The magnitude, sensitivity and significance for these impacts on key receptors was presented to the stakeholder. The early findings of the Cumulative Effects Assessment (CEA) were presented, alongside some potential monitoring methods for the stakeholders to comment on.	Road Map Meeting 3 was a presentation based on information contained within this chapter and therefore is considered throughout this chapter. No queries have been received following Road Map Meeting 3.
February 2022	Marine Scotland – Road Map Meeting 3	Presented rationale for scoping out intertidal impacts, based on the baseline characterisation showing low importance of this area for the fish and shellfish and minimal impacts on intertidal habitats.	Intertidal impacts on fish and shellfish receptors have been scoped out of the EIA (see Table 9.16).
June 2022	Marine Scotland – Road Map Meeting 4	Road Map Meeting 4 resulted in several papers being recommended to review regarding EMF effects on fish and shellfish receptors.	Additional studies sent through by stakeholders have been reviewed and included where relevant. Recommendations within these papers have been taken into account including cable burial which reduces effects of EMF (see designed in mitigation measures; Table 9.20), discussion of uncertainties around EMF and provision of information on likely EMFs from cable infrastructure (see section 9.11).

9.6. METHODOLOGY TO INFORM BASELINE

9.6.1. DESKTOP STUDY

15. Information on fish and shellfish ecology within the Proposed Development fish and shellfish ecology study area and Proposed Development northern North Sea fish and shellfish ecology study area was collected through a detailed desktop review of existing studies and datasets. These are summarised in Table 9.9 with full details presented in the technical report. Other studies considered as part of the baseline characterisation, although not included in this table, are fully detailed and discussed in volume 3, appendix 9.1.

Table 9.9: Summary of Key Desktop Reports Identified in Scoping Report and Scoping Opinion

Title	Source	Year	Author
Seagreen Phase 1 (Seagreen Alpha/Bravo): Natural Fish and Shellfish Resource Environmental Statement chapter for the original project	Chapter 12, Seagreen Environmental Statement Volume 1	2012	Seagreen
Sandeel Surveys in the east coast	Marine Scotland	2019	Marine Scotland
Seagreen Phase 1 (Seagreen Alpha/Bravo): Natural Fish and Shellfish Resource Environmental Statement chapter for the optimised project	Chapter 9, Seagreen Environmental Statement Volume 1	2018	Seagreen
International Bottom Trawl Surveys	ICES	2021	ICES
Scallop Stock Assessment	MS	2018b	MS
Neart na Gaoithe Proposed Offshore Wind Farm Fish and Shellfish Ecology	Chapter 7, Neart na Gaoithe EIA Fish and Shellfish Ecology	2018	GoBe Consultants Ltd.
2018 landings data by the International Council for the Exploration of the Sea (ICES) rectangle	Marine Scotland	2018	Marine Scotland
International Herring Larvae Survey	Wageningen Marine Research, Ijmuiden	2015	Wageningen Marine Research, Ijmuiden
Mapping the spawning and nursery grounds of selected fish for spatial planning	Centre for Environment, Fisheries and Aquaculture Science (CEFAS)	2012	Ellis *et al*.
Review of migratory routes and behaviour of Atlantic salmon, sea trout and European eel in Scotland's coastal environment: implications for the development of marine renewables	Scottish Marine and Freshwater Science	2010	Malcolm *et al*.
Marine renewables Strategic Environmental Assessment (SEA) environmental report. Section C7 Fish and shellfish	Scottish Government	2007	Faber Maunsell
British sea fishes	Underwater World Publications Ltd	2001	Dipper
Fisheries sensitivity maps in British waters	United Kingdom Offshore Operators Association (UKOOA) Ltd	1998	Coull *et al*.
Fish and shellfish sensitivity reports	https://www.marlin.ac.uk/activity/pressures_report	Not Applicable (N/A)	Various
Salmon fishery statistics, including rod catch data	Marine Scotland	2021 (latest dataset)	Marine Scotland
Salmon smolt trawl surveys in Moray Firth and Firths of Forth and Tay	Marine Scotland	2018	Marine Scotland
Creel Fishing Effort Study	Marine Scotland	2017	Marine Scotland
Landings Data by ICES Rectangle (see volume 3, appendix 12.1 for further detail)	Marine Management Organisation (MMO)	2010 - 2019	ICES

9.6.2. IDENTIFICATION OF DESIGNATED SITES

16. All relevant designated sites within the northern North Sea fish and shellfish ecology study area and qualifying interest features that could be affected by the construction, operation and maintenance, and decommissioning phases of the Proposed Development were identified using the three-step process described here:

- Step 1: All designated sites of international, national and local importance within the Proposed Development northern North Sea fish and shellfish ecology study area were identified using a number of sources. These sources included Joint Nature Conservation Committee (JNCC), MPA mapper, and the Marine Scotland National Marine Plan Interactive (NMPI) maps.
- Step 2: Information was compiled on the relevant features for each of these sites (e.g. species listed as features of the relevant designated sites, information on habitat usage, migration information etc.).
- Step 3: Using the above information and expert judgement, sites were included for further consideration if:
  - a designated site directly overlaps with the Proposed Development;
  - sites and associated features were located within the potential Zone of Influence (ZoI) for impacts associated with the Proposed Development; and
  - sites which are designated to protect mobile features (e.g. diadromous fish) and where the range of those features has the potential to overlap with either the Proposed Development and/or the ZoI of impacts associated with the development (e.g. fish migrating through or close to the Proposed Development at particular life history stages).

17. Identified designated sites are listed in Table 9.12.

9.6.3. SITE-SPECIFIC SURVEYS

18. A site specific benthic sub-tidal survey was completed in 2020. Data collected as part of this survey has been used to inform this Fish and Shellfish Ecology EIA Report chapter, as agreed with MS-LOT, MSS and NatureScot via the Road Map process (see Table 9.10 and volume 3, appendix 9.1 for further details). Further information about this site specific survey is provided in Table 9.10 below.

Table 9.10: Summary of Site-Specific Survey Data

Title	Extent of Survey	Overview of Survey	Survey Contractor	Date	Reference to Further Information
Benthic subtidal survey	Across the Proposed Development fish and shellfish ecology study area	Grab samples, DDV sampling and epibenthic trawls	Ocean Ecology Ltd	2020	Survey Ltd, 2020

9.7. BASELINE ENVIRONMENT

9.7.1. OVERVIEW OF BASELINE ENVIRONMENT

19. The baseline environment has been described in detail within volume 3, appendix 9.1. The fish and shellfish receptors that could be potentially impacted by the Proposed Development have been determined by the desktop review of available data/information as detailed in Table 9.9, and through site-specific surveys, as detailed in Table 9.10 (see volume 3, appendix 9.1 for further detail regarding baseline data collection and site specific surveys). Through this process a number of demersal, pelagic, elasmobranch and diadromous fish species were identified, along with shellfish species. The baseline environment was described for the Proposed Development northern North Sea fish and shellfish ecology study area and for the Firth and Tay SMR. Spawning and nursery areas within the vicinity of the Proposed Development fish and shellfish ecology study area were also described, followed by detailed characterisations of particularly sensitive fish and shellfish species, including sandeel, herring (focussing on spawning habitats) and diadromous fish species.

20. Species identified as likely to be found within the Proposed Development northern North Sea fish and shellfish ecology study area include:

- **demersal species** – sandeel, whiting *Merlangius merlangus*, lemon sole *Microstomus kitt*, ling *Molva molva*, plaice *Pleuronectes platessa*, saithe *Pollachius virens* and cod *Gadus morhua*;
- **pelagic species** – herring, mackerel *Scomber scombrus* and sprat *Sprattus sprattus*;
- **elasmobranch species** – spotted ray *Raja montagui*, spurdog *Squalus acanthias*, tope *Galeorhinus galeus* common skate *Dipturus batis*, and thornback ray *Raja ecommi*. Basking sharks *Cetorhinus maximus* are likely to pass through the vicinity of the Proposed Development fish and shellfish ecology study area but infrequently and in low numbers;
- **diadromous species** – Atlantic salmon, European eel *Anguilla ecommis*, sea trout, river lamprey, sea lamprey, Allis shad, *Alosa alosa*, twaite shad *Alosa fallax*, sparling/European smelt *Osmerus eperlanus*; and freshwater pearl mussel *Margaritifera margaritifera* (included here due to reliance on Atlantic salmon and sea trout at specific life stages); and
- **shellfish species** – *Nephrops*, European lobster *Homarus ecommis*, crab (edible (brown) crab *Cancer pagarus* and velvet swimming crab *Necora puber*), king scallop *Pecten maximus*, and squid *Loligo sp*.

21. The spawning and nursery habitats present in the Proposed Development fish and shellfish ecology study area are summarised in Table 9.11 based on Ellis *et al*. (2012) and Coull *et al*. (1998). Nursery and spawning habitats were categorised by Ellis *et al. (*2012) as either high or low intensity dependent on the level of spawning activity or abundance of juveniles recorded. Spawning grounds identified by Coull *et al. (*1998) are classified as low, high or undetermined, again based on the level of spawning activity. Intensity of nursery grounds were not specified by Coull *et al*. (1998). Further detail on nursery and spawning grounds is presented in volume 3, appendix 9.1.

22. However, due to the particular sensitivities of herring and sandeel to offshore wind development (including underwater noise and seabed disturbance), a summary of the baseline characterisation presented in volume 3, appendix 9.1 has been included in the following section.

Table 9.11: Species Known to Have Spawning and Nursery Areas that Overlap with the Proposed Development Fish and Shellfish Ecology Study Area and Spawning Periods (Coull *et al.*, 1998, Ellis *et al.*, 2010) (see volume 3, appendix 9.1)

Common Name	Scientific name	Proposed Development Array Area		Proposed Development Export Cable Corridor	
		Spawning	Nursery	Spawning	Nursery
Anglerfish	*Lophius piscatorius*		✓		✓
Blue whiting	*Micromesistius poutassou*		✓		✓
Cod	*Gadus morhua*	✓	✓	✓ (partial)	✓
European hake	*Merluccius merluccius*		✓		✓ (partial)
Herring	*Clupea harengus*		✓	✓ (partial)	✓
Ling	*Molva molva*		✓		✓
Mackerel	*Trachurus trachurus*		✓		✓
Plaice	*Pleuronectes platessa*	✓	✓	✓	✓
Sandeel	*Ammodytidae*	✓	✓	✓ (partial)	✓
Spotted ray	*Raja montagui*		✓		✓
Spurdog	*Squalus sp.*		✓		✓ (partial)
Tope shark	*Galeorhinus galeus*		✓		✓ (partial)
Common skate	*Dipturus batis*		✓		✓
Whiting	*Merlangius merlangus*	✓	✓	✓	✓
Haddock	*Melanogrammus aeglefinus*		✓		
Sprat	*Sprattus sprattus*	✓	✓	✓ (partial)	✓
Lemon sole	*Microstomus kitt*	✓	✓	✓	✓

Herring

23. Herring utilise specific benthic habitats during spawning, which increases their vulnerability to activities impacting the seabed. Further, as a hearing specialist, herring are vulnerable to impacts arising from

underwater noise. Herring spawning grounds have been identified by Coull *et al*. (1998) as being present within the Proposed Development fish and shellfish ecology study area. However, data presented by Coull *et al*. (1998) is relatively broad scale, and therefore, confidence in the presence of spawning grounds can be increased through completing spawning assessments using larval data available from IHLS.

24. The IHLS conducts monitoring where larvae numbers are recorded around the UK coastline and the North Sea. Herring larvae are identified as being recently hatched by their size, and therefore small herring larvae can be assumed to have been spawned recently and therefore in close proximity to the area where they are recorded. The IHLS present larval data by size per m^2, with larvae under 10 mm long used as a cut off point for recently spawned larvae. Recently spawned larvae will not have drifted far from the location where eggs were spawned on the seabed and high abundances of these larvae are therefore a good indication of recent spawning activity local to where these were sampled.

25. Figure 9.2 provides a composite of the individual years of herring larval data from the IHLS for the years 2007 to 2016 (see volume 3, appendix 9.1 for individual years). This shows where highest numbers of herring larvae were consistently recorded over a ten-year period, using a cut off of 100 larvae <10 mm in length per m^2. Areas marked with darker blue patches indicate where spawning evidence (i.e. high abundances of larvae) was most regularly recorded and therefore indicates the core spawning habitat for the Buchan herring spawning stock. As shown in Figure 9.2, there is a large patch of darker blue to the north of the Proposed Development which corresponds with the annual herring larval data high density areas. The Proposed Development fish and shellfish ecology study area and the area to the south is marked as lighter blue which reflects less consistent, more variable spawning activity.

26. The larval density data supports the Coull *et al*. (1998) data, showing significant spawning areas to the north of the Proposed Development fish and shellfish ecology study area, and also to the far south. However, it also slightly contradicts Coull *et al*. (1998) as the spawning areas identified which overlap the Proposed Development export cable corridor have not been demonstrated to have consistently high herring spawning activity (this area was characterised by muddy sediments which are unsuitable for herring spawning). This is further supported by results from detailed site specific survey PSA data (see volume 3, appendix 9.1 for full results) which found that the majority of the Proposed Development fish and shellfish ecology study area has unsuitable sediment for herring spawning, with only small patches of suitable habitat in the north-west section of the Proposed Development array area. By contrast, the core herring spawning area shown in Figure 9.2 coincided with areas of suitable herring spawning habitat (i.e. coarse, gravelly sediments) which is shown in Figure 9.3; see volume 3, appendix 9.1 for full details).

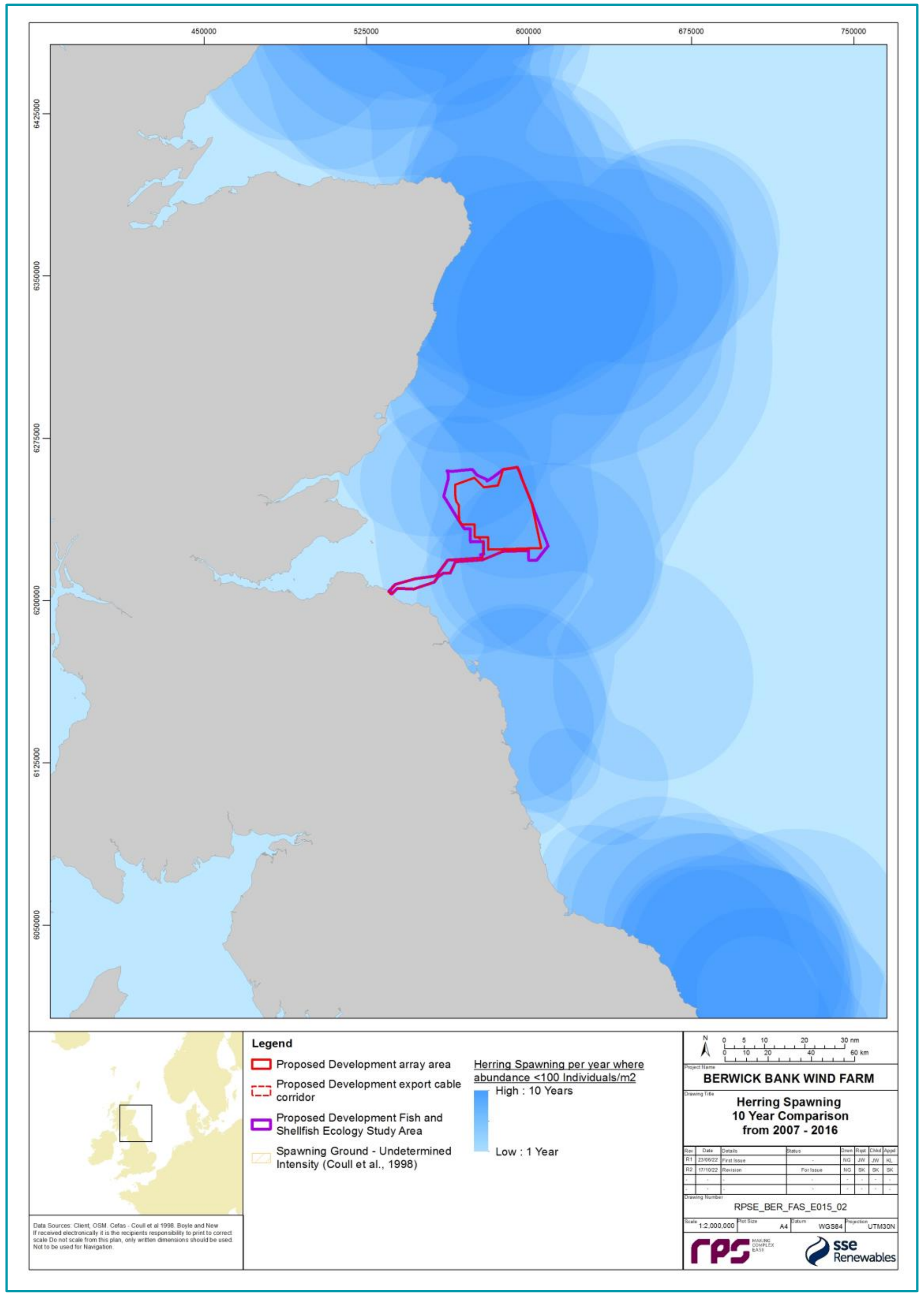

Figure 9.2: Herring Larval Density of over 100 per m^2 per Year from 2007 to 2016

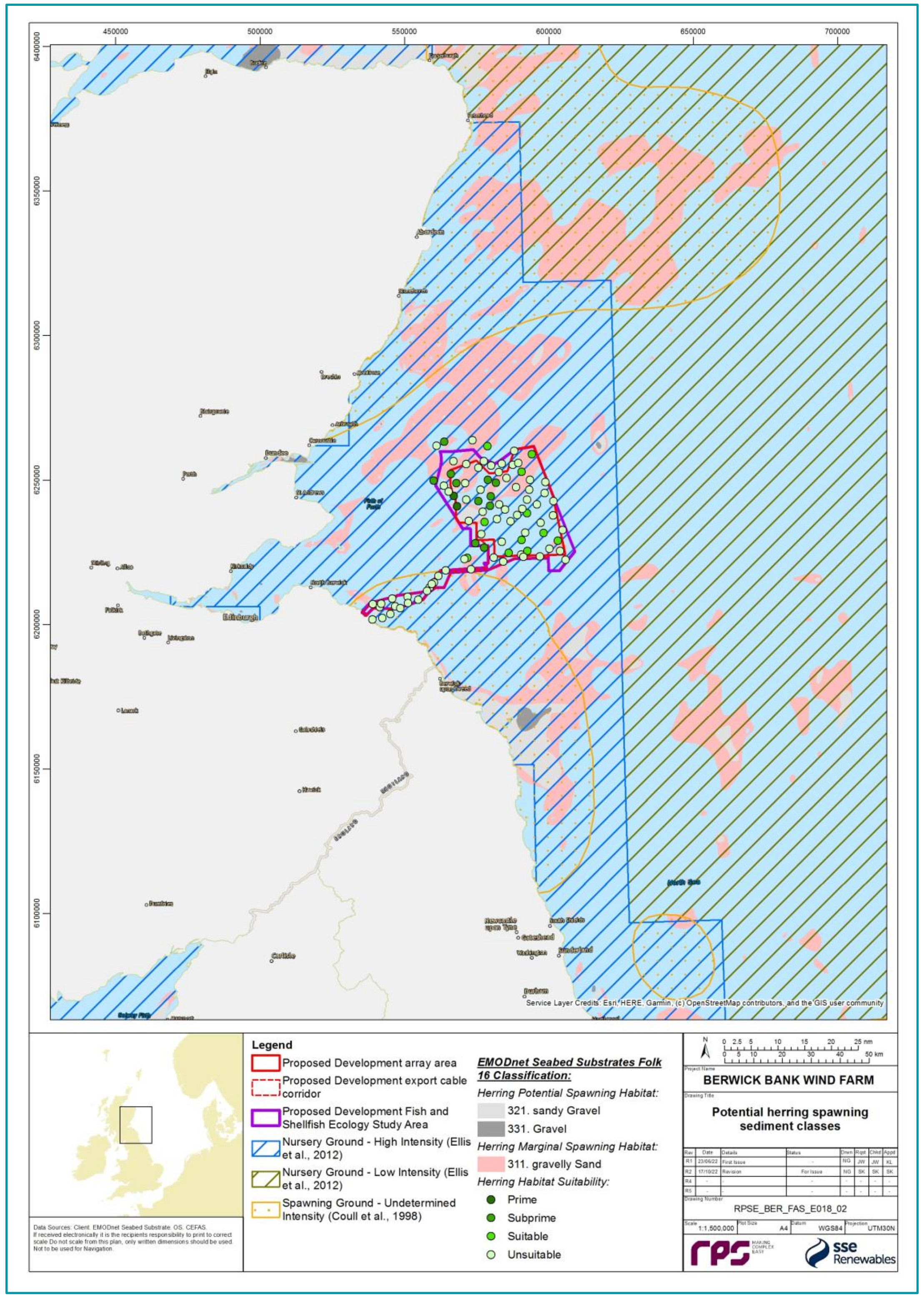

Figure 9.3: Herring Spawning Habitat Preference Classifications from EMODnet and Site-Specific Survey Data Covering the Buchan Stock Herring Spawning Habitats

Sandeel

27. Sandeel high intensity spawning grounds have been identified by Ellis *et al.* (2012) as being present throughout the Proposed Development fish and shellfish ecology study area. However, data presented by Ellis *et al*. (2012) is relatively broad scale, and therefore, confidence in the presence of spawning grounds can be increased through completing analysis on site specific surveys and drawing on more recently published data which can provide increased data resolution.

28. Figure 9.4 presents the results of site-specific PSA survey data alongside European Marine Observation and Data Network (EMODnet) seabed substrate data which can be used to assess habitat suitability for sandeel. For the purposes of considering sandeel habitat, suitability across the Proposed Development fish and shellfish ecology study area and surrounding areas, gravelly sand, (gravelly) sand, and sand in the EMODnet data were classified as preferred habitat and sandy gravel as marginal habitat (see volume 3, appendix 9.1 for further details). Where no shading is present, the habitat in that area is unsuitable for sandeel. Results of PSA were categorised into prime, subprime, suitable and unsuitable, dependant on the proportion of sand and mud in grab samples. On the whole, there is good alignment between the results of site-specific surveys and EMODnet seabed substrate data with the Proposed Development array area containing mostly preferable habitat with a few patches of marginal habitat. The Proposed Development export cable corridor has a significant patch of unsuitable habitat, which matches PSA points of unsuitable habitat, although there are some misalignments within the Proposed Development export cable corridor, where the EMODnet data suggests suitable habitat, but the PSA data indicates the opposite. PSA data is of higher resolution and therefore supersedes the EMODnet data. The Proposed Development export cable corridor has been found to be dominated by muddy sediments, which further supports the site-specific survey results, which determine much of the Proposed Development export cable corridor as unsuitable (see volume 3, appendix 9.1 for further detail). The site-specific survey results provide higher resolution of favourable sandeel habitat, which generally shows that the Proposed Development array area is favourable sandeel habitat, and the Proposed Development export cable corridor is less favourable to unsuitable sandeel habitat.

29. Further work regarding sandeel has been completed by Langton *et al.* (2021) where a predicted distribution model for sandeel was developed, producing predicted density and probability of occurrence for sandeel around the British coastline. This modelling was undertaken based on the dependence of sandeel on particular habitat types, with the four main explanatory variables within the model being silt, depth, sand and slope, and was supported by sandeel fisheries data (e.g. data from Jensen *et al*., 2011). The results were mapped, highlighting areas of importance for sandeel populations in the North Sea, including the Forth and Tay SMR and the Proposed Development fish and shellfish ecology study area. Figure 9.5 presents the outputs of the modelling within the Proposed Development. This identifies a number of areas within the Proposed Development array area where there is a high probability of sandeel presence. However, predicted densities of sandeel are more variable with areas of predicted lower sandeel densities interspersed with discrete patches of predicted higher sandeel density. These areas also correlate to previous studies where marine mammals and birds are known to congregate and feed on sandeel (Langton *et al.*, 2021). This supports results of habitat suitability characterisation from site specific surveys, further depicting the suitability of habitat within the Proposed Development array area for sandeel and that the Proposed Development export cable corridor is less suitable or unsuitable.

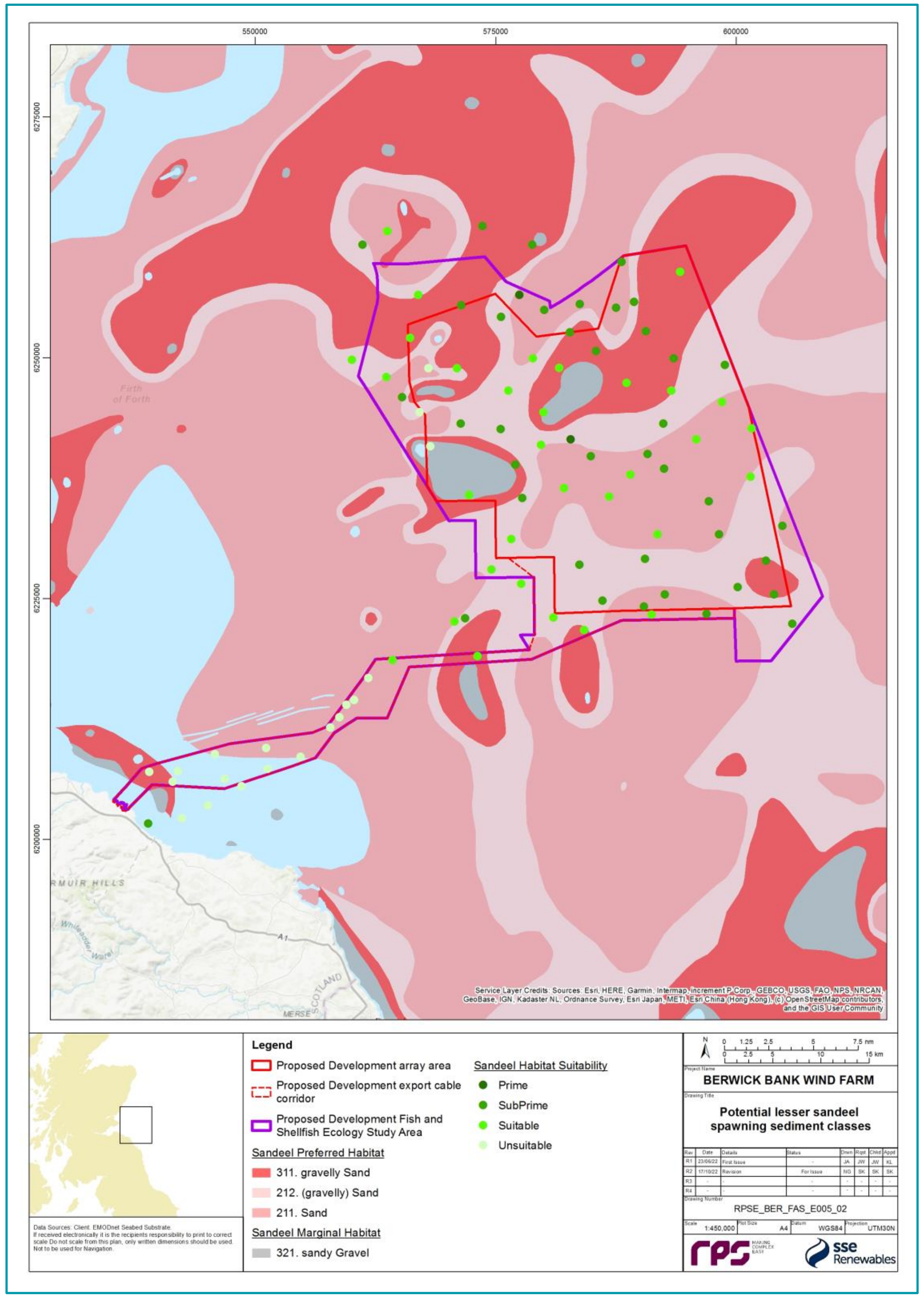

Figure 9.4: Sandeel Habitat Preference Classifications from EMODnet and Site-specific Survey Data

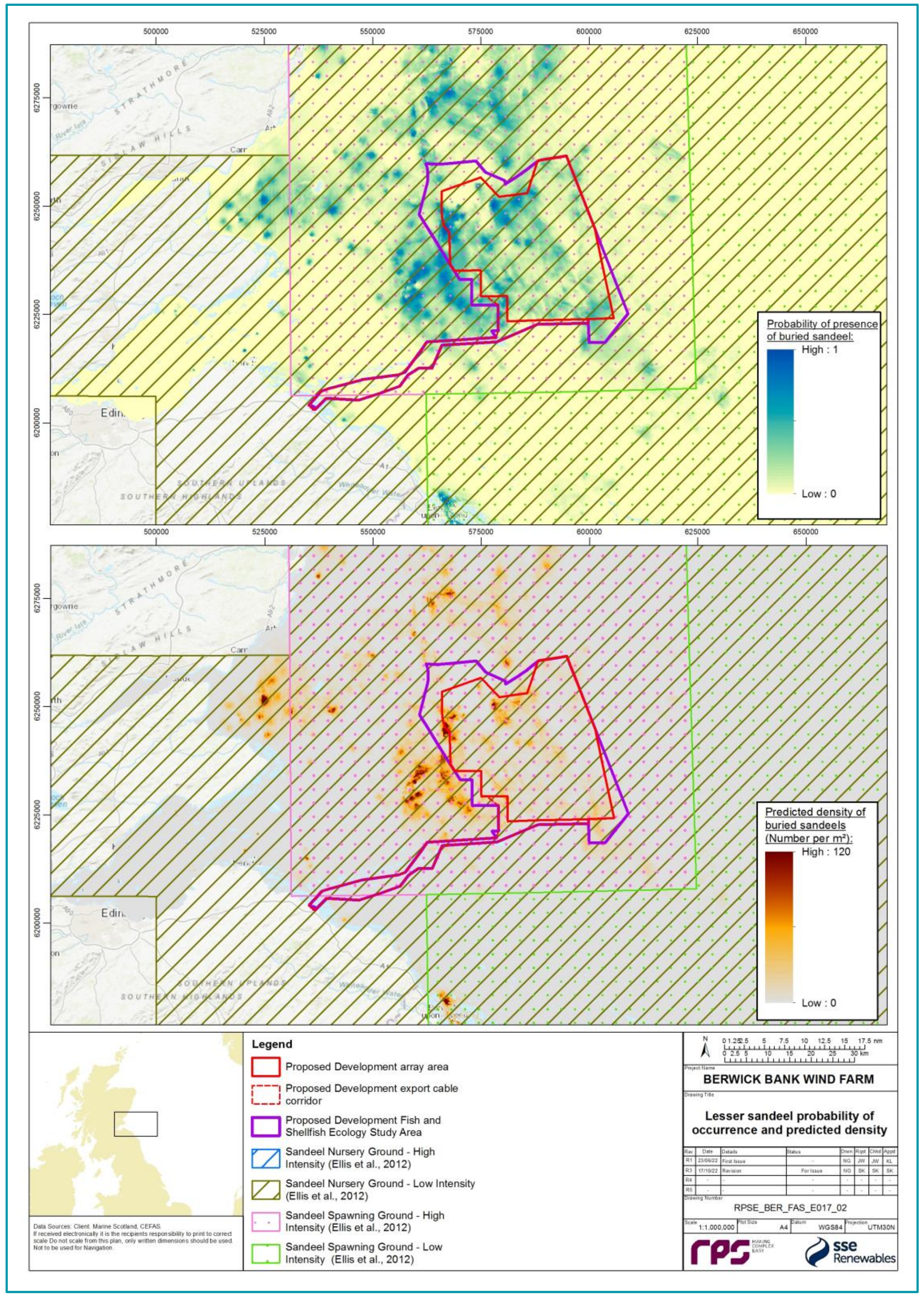

Figure 9.5: Model Derived Predictions of Density and Probability of Presence of Sandeel within the Proposed Development (derived from Langton *et al*. (2021))

9.7.2. DESIGNATED SITES

30. Designated sites identified for consideration within the Fish and Shellfish Ecology EIA Report chapter are described in Table 9.12.

Table 9.12: Designated Sites with Relevant Qualifying Interest Features for the Fish and Shellfish Ecology EIA Report Chapter

Designated Site	Closest Distance to Proposed Development Array Area (km)	Closest Distance to Offshore Cable Corridor (km)	Relevant Qualifying Interest Feature(s)
River Tay SAC	61.3	68.4	• Atlantic salmon present as primary reason for site selection. • Sea lamprey and river lamprey present as a qualifying feature, but not a primary reason for site selection.
River Tweed SAC	48.0	10.5	• Atlantic salmon present as primary reason for site selection. • Sea lamprey and river lamprey present as a qualifying feature, but not a primary reason for site selection.
Tweed Estuary SAC	46.3	27.2	• Sea lamprey and river lamprey present as a qualifying feature, but not a primary reason for site selection.
River Teith SAC	127.1	94.8	• Sea lamprey and river lamprey present as primary reason for site selection. • Atlantic salmon present as a qualifying feature, but not a primary reason for site selection.
River South Esk SAC	50.1	74.6	• Atlantic salmon and freshwater pearl mussel present as primary reason for site selection.
River Dee SAC	70.6	99.8	• Atlantic salmon and freshwater pearl mussel present as primary reason for site selection.
Turbot Bank Nature Conservation MPA	96.1	132.3	• Sandeel are listed as a protected feature.

9.7.3. IMPORTANT ECOLOGICAL FEATURES

31. IEFs are habitats, species, ecosystems and their functions/processes that are considered to be important and potentially impacted by the Proposed Development. As agreed by stakeholders, guidance from the Chartered Institute of Ecology and Environmental Management (CIEEM) (2019) was used to assess IEFs. IEFs can be attributed to individual species (such as plaice) or species groups (for example other flat fish species). Each IEF is assigned a value or importance rating which is based on commercial, ecological and conservation importance. In particular, and following stakeholder responses to the Scoping Report (see Table 9.8), IEF importance ratings have considered whether fish and shellfish IEFs have been identified as PMFs in Scottish waters and/or whether these are qualifying features of SACs. Table 9.13 details the criteria used for determining IEFs and Table 9.14 presents the defining characteristics for classification of IEFs, providing justifications for importance rankings for the key species likely to occur within the Proposed Development fish and shellfish ecology study area. Specific reference is made to each species' commercial, conservation and ecological importance, where this is known. These species will be taken forward for assessment. Diadromous species refer to specific species that migrate between fresh water and the marine environment (see Table 9.14). Marine fish and shellfish species refer to all other IEF species identified within this chapter (Table 9.14). Within the individual assessments of effects, diadromous fish and marine fish are considered separately following stakeholder feedback (see Table 9.8).

Table 9.13: Defining Criteria for IEFs

Value of IEF	Defining Criteria
International	Internationally designated sites. Species protected under international law (i.e. Annex II species listed as qualifying interests of SACs).
National	Nationally designated sites. Species protected under national law. Annex II species which are not listed as qualifying interests of SACs in the Proposed Development fish and shellfish ecology study area. OSPAR List of Threatened and/or Declining Species, and IUCN Red List species that have nationally important populations within the Proposed Development fish and shellfish ecology study area, particularly in the context of species/habitat that may be rare or threatened in Scottish waters. Species that are listed as PMFs as they have been deemed features characteristic of the Scottish marine environment and are likely to be one of the characteristic species and or have spawning or nursery grounds within the Proposed Development northern North Sea fish and shellfish ecology study area. Species that have spawning or nursery areas within the Proposed Development fish and shellfish ecology study area that are important nationally (e.g. may be primary spawning/nursery area for that species).
Regional	OSPAR List of Threatened and/or Declining Species, and IUCN Red List species that have regionally important populations within the Proposed Development fish and shellfish ecology study area (i.e. are locally widespread and/or abundant). Species that are of commercial value to the fisheries which operate within the Proposed Development fish and shellfish ecology study area. Species that form an important prey item for other species of conservation or commercial value and that are key components of the fish assemblages within the Proposed Development fish and shellfish ecology study area. Species that are listed as PMFs but are not a key contributing species to the characterisation of the Proposed Development northern North Sea fish and shellfish ecology study area. Species that have spawning or nursery areas within the Proposed Development fish and shellfish ecology study area that are important regionally (i.e. species may spawn in other parts of Scottish waters but this is a key spawning/nursery area within the Proposed Development fish and shellfish ecology study area).

Value of IEF	Defining Criteria
Local	Species that are of commercial importance but do not form a key component of the fish assemblages within the Proposed Development fish and shellfish ecology study area (e.g. they may be exploited in deeper waters outside the Proposed Development fish and shellfish ecology study area). The spawning/nursery area for the species are outside the Proposed Development fish and shellfish ecology study area. The species is common throughout Scottish waters but forms a component of the fish assemblages in the Proposed Development fish and shellfish ecology study area.

Table 9.14: IEF Species and Representative Groups within the Proposed Development Fish and Shellfish Ecology Study Area

IEF	Scientific Name/Representative species	Importance	Justification
Marine Fish IEF Species			
Plaice	*Pleuronectes platessa*	Regional	• Low intensity nursery and spawning grounds identified throughout Proposed Development fish and shellfish ecology study area. It is an important commercial species, but not in the local area.
Lemon Sole	*Microstomus kitt*	Regional	• Low intensity nursery and spawning grounds identified throughout Proposed Development fish and shellfish ecology study area. It is an important commercial species, but not in the local area.
Other flatfish species		Local	• Other flatfish species including common dab, turbot and long rough dab are likely to occur within the Proposed Development fish and shellfish ecology study area. • These species either have no known spawning or nursery grounds or low intensity/undetermined nursery and spawning grounds.
Cod	*Gadus morhua*	Regional	• Listed as a PMF. Listed by OSPAR as threatened and/or declining and listed as vulnerable on the IUCN Red List. • High intensity nursery grounds and low intensity spawning grounds are present throughout the Proposed Development fish and shellfish ecology study area. • It is an important commercial species, but not in the local area.
Haddock	*Melanogrammus aeglefinus*	Regional	• Spawning ground of unspecified intensity marginally overlaps the Proposed Development fish and shellfish ecology study area. • Listed as vulnerable on the IUCN Red List.
Whiting	*Merlangius merlangus*	Regional	• High intensity nursery grounds and low intensity spawning grounds identified throughout the Proposed Development fish and shellfish ecology study area. • It is an important commercial species, but not in the local area.
Saithe	*Pollachius virens*	Regional	• Partial overlap with the Proposed Development fish and shellfish ecology study area of unspecified nursery grounds. • It is an important commercial species, but not in the local area.
Other demersal species		Local	• Species including pollack Pollachius pollachius and European hake are common throughout Scottish waters and are likely to be in the Proposed Development fish and shellfish ecology study area. They are important commercial species, but not in the local area.
Other PMF species		Regional	• Species listed as PMFs including anglerfish and ling may be present within the Proposed Development fish and shellfish ecology study area however there are no spawning grounds present.
Sandeel species		National	• There are 5 species of sandeel found in Scottish waters with lesser sandeel Ammodytes tobianus and Raitt's sandeel Ammodytes marinus being the most commonly found species, particularly in the vicinity of the Proposed Development fish and shellfish ecology study area. • Important prey species for fish, birds and marine mammals. • High intensity spawning grounds and low intensity nursery grounds present throughout the Proposed Development fish and shellfish ecology study area. • Identified as likely to be present in the Proposed Development fish and shellfish ecology study area based on historic data and habitat preference. • Lesser sandeel and Raitt's sandeel are listed as PMFs and listed as protected features within the Turbot Bank Nature Conservation MPA, which occurs within the Proposed Development northern North Sea fish and shellfish ecology study area.

IEF	Scientific Name/Representative species	Importance	Justification
Herring	*Clupea harengus*	Regional	• Important prey species for larger fish, birds and marine mammals. • High intensity nursery grounds within the Proposed Development fish and shellfish ecology study area. Known to have spawning grounds in the vicinity of the Proposed Development fish and shellfish ecology study area, with core spawning habitats to the north and south of the Proposed Development fish and shellfish ecology study area. • It is an important commercial species, but not in the local area.
Mackerel	*Scomber scombrus*	Regional	• Important prey species for larger fish, birds and marine mammals. • Low intensity nursery grounds throughout Proposed Development fish and shellfish ecology study area. No spawning grounds in the vicinity. • It is an important commercial species, but not in the local area.
Sprat	*Sprattus sprattus*	Regional	• Important prey species for larger fish, birds and marine mammals. • Unspecified intensity spawning and nursery grounds within the Proposed Development fish and shellfish ecology study area. • It is an important commercial species, but not in the local area.
Basking Shark	*Cetorhinus maximus*	National	• The north-east Atlantic population are classed as Endangered on the IUCN Red List. They are listed under Convention on International Trade in Endangered Species (CITES) Appendix II and classified as a Priority Species under the UK Post-2010 Biodiversity Framework. Protected in the UK under the Wildlife and Countryside Act. Listed as a PMF, however only likely to be present in low abundances if present at all.
Tope	*Galeorhinus galeus*	Regional	• Listed as Vulnerable by the IUCN Red List and is a Priority Species under the UK Post-2010 Biodiversity Framework. Low intensity nursery grounds within the Proposed Development fish and shellfish ecology study area.
Spurdog	*Squalus acanthias*	Regional	• Listed as Vulnerable by the IUCN Red List and is a Priority Species under the UK Post-2010 Biodiversity Framework. Low intensity nursery grounds within the Proposed Development fish and shellfish ecology study area.
Common skate	*Dipturus batis*	Regional	• Listed as Critically Endangered on the IUCN Red List. It is a Priority Species under the UK Post-2010 Biodiversity Framework. Low intensity nursery grounds within the Proposed Development northern North Sea fish and shellfish ecology study area.
Rays		Regional	• Ray species including spotted ray and thornback ray. These species either have low intensity nursery grounds or no known nursery grounds.
Shellfish IEF Species			
Edible crab	*Cancer pagurus*	Regional	• Commercially important species. Identified as being likely to be present within the Proposed Development fish and shellfish ecology study area.
Norway lobster	*Nephrops norvegicus*	Regional	• Commercially important species. Identified as being likely to be present within the Proposed Development export cable corridor. • Spawning and nursery grounds present throughout the majority of Proposed Development fish and shellfish ecology study area.
European lobster	*Homarus gammarus*	Regional	• Commercially important species. Identified as being likely to be present within the Proposed Development fish and shellfish ecology study area.
King Scallop	*Pecten maximus*	Regional	• Commercially important species. Identified as being likely to be present within the Proposed Development fish and shellfish ecology study area.
Velvet swimming crab	*Necora puber*	Regional	• Commercially important species. Identified as being likely to be present within the Proposed Development fish and shellfish ecology study area.
Other crustaceans		Local	• Other crustaceans including, swimming crabs, spider crabs and shrimp have been identified as being likely to occur within the Proposed Development fish and shellfish ecology study area. They are all important commercial species, but not in the local area.
Freshwater Pearl Mussel	*Margaritifera margaritifera*	International	• Listed in Annexes II and V of the European Union (EU) Habitats and Species Directive and Appendix III of the Bern Convention. Listed as Endangered on the IUCN Red List. • Annex II species and listed as qualifying features of a number of SACs in the vicinity of the Proposed Development fish and shellfish ecology study area. • Freshwater pearl mussel are included due to their dependency on Atlantic salmon and sea trout.
Diadromous Fish IEF Species			
Sea trout	*Salmo trutta*	National	• Likely to migrate through the Proposed Development fish and shellfish ecology study area. • Listed as OSPAR threatened/declining species. Not a feature of any designated sites in the vicinity of the Proposed Development fish and shellfish ecology study area.

IEF	Scientific Name/Representative species	Importance	Justification
European eel	*Anguilla anguilla*	National	• Likely to migrate through the Proposed Development fish and shellfish ecology study area. • Listed as an OSPAR threatened/declining species and listed as critically endangered on the IUCN Red List. Not a feature of any designated sites in the vicinity of the Proposed Development fish and shellfish ecology study area.
Sea lamprey	*Petromyzon marinus*	International	• Likely to migrate through the Proposed Development fish and shellfish ecology study area. Annex II species and listed as qualifying features of a number of SACs in the vicinity of the Proposed Development fish and shellfish ecology study area.
River lamprey	*Lampetra fluviatilis*	N/A	• Scoped out: These are estuarine species and are therefore unlikely to have any interaction with the Proposed Development fish and shellfish ecology study area. As such, these are not considered further as agreed with MS-LOT, MSS and NatureScot via the consultation Road Map (see section 9.5).
Twaite shad	*Alosa fallax*	National	• Likely to migrate through the Proposed Development fish and shellfish ecology study area. Annex II species although not listed as qualifying features of any SACs in the vicinity of the Proposed Development fish and shellfish ecology study area.
Allis Shad	*Alosa alosa*	National	• Likely to migrate through the Proposed Development fish and shellfish ecology study area. Annex II species although not listed as qualifying features of any SACs in the vicinity of the Proposed Development fish and shellfish ecology study area.
Atlantic salmon	*Salmo salar*	International	• Likely to migrate through the Proposed Development fish and shellfish ecology study area. Annex II species and listed as qualifying features of a number of SACs in the vicinity of the Proposed Development fish and shellfish ecology study area.
Sparling/ European smelt	*Osmerus eperlanus*	N/A	• Scoped out: These are estuarine species and are therefore unlikely to have any interaction with the Proposed Development fish and shellfish ecology study area. As such, these are not considered further as agreed with MS-LOT, MSS and NatureScot via the consultation Road Map (see section 9.5).

9.7.4. FUTURE BASELINE SCENARIO

32. The EIA Regulations ((The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017, The Marine Works (Environmental Impact Assessment) (Scotland) Regulations 2017; The Marine Works (Environmental Impact Assessment) Regulations 2007; and The Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations, 2017)), require that a "*a description of the relevant aspects of the current state of the environment (baseline scenario) and an outline of the likely evolution thereof without development as far as natural changes from the baseline scenario can be assessed with reasonable effort ,on the basis of the availability of environmental information and scientific knowledge*" is included within the Offshore EIA Report.

33. In the event that the Proposed Development does not come forward, an assessment of the future baseline conditions has been carried out and is described within this section.

34. The baseline environment is not static and will exhibit some degree of natural change over time, even if the Proposed Development does not come forward, due to naturally occurring cycles and processes and additionally any potential changes resulting from climate change. Therefore, when undertaking assessments of effects, it will be necessary to place any potential impacts into the context of the envelope of change that might occur over the timescale of the Proposed Development.

35. 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).

36. Scottish and UK waters are facing an increase in sea surface temperature. The rate of increases is varied geographically, but between 1985 and 2009, the average rate of increase in Scottish waters has been greater than 0.2 °C per decade, with the south-east of Scotland having a higher rate of 0.5°C per decade (Marine Scotland, 2011). A study completed over a longer period of time showed Scottish waters (coastal and oceanic) have warmed by between 0.05 and 0.07 °C per decade, calculated across the period 1870 – 2016 (Hughes *et al*., 2018). Changes in temperature will have an effect on fish at all biological levels (cellular, individual, population, species, community and ecosystem) both directly and indirectly. As sea temperatures rise, species adapted to cold water (e.g. cod and herring) will begin to disappear while warm water adapted species will become more established. It is also predicted that due to changes in weather patterns, for example increased numbers of spring storms, changes in stratification of water columns and plankton production may occur (Morison *et al.,* 2019). This may cause knock on impacts on fish and shellfish species due to changes in food availability for prey species. Climate change presents many uncertainties as to how the marine environment will change in the future; therefore, the future baseline scenario is difficult to predict with accuracy.

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

9.7.5. DATA LIMITATIONS AND ASSUMPTIONS

38. The data sources used in this chapter are detailed in Table 9.9 and volume 3, appendix 9.1. The desktop data used are the most up to date publicly available information which can be obtained from the applicable data sources as cited. Data that have been collected is based on existing literature, consultation with stakeholders and identification of habitats to inform likely fish and shellfish species.

39. Site-specific surveys were carried out for benthic ecology requirements (volume 2, chapter 8), 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. As such, this additional information will have filled any gaps missed through site-specific survey. 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 regional study area (i.e. the Proposed Development northern North Sea fish and shellfish ecology study area), it is unlikely that key species have been omitted from the assessment.

9.8. KEY PARAMETERS FOR ASSESSMENT

9.8.1. MAXIMUM DESIGN SCENARIO

40. The maximum design scenarios identified in Table 9.15 have been selected as those having the potential to result in the greatest effect on fish and shellfish IEFs. These scenarios have been selected from the details provided in volume 1, chapter 3 of the Offshore EIA Report. Effects of greater adverse significance are not predicted to arise should any other development scenario, based on details within the Project Design Envelope (PDE) (e.g. different infrastructure layout), to that assessed here, be taken forward in the final design scheme.

Table 9.15: Maximum Design Scenario Considered for Each Impact as Part of the Assessment of Likely Significant Effects on Fish and Shellfish Ecology

Potential Impact	Phase[2] C	O	D	Maximum Design Scenario	Justification
Temporary habitat loss/disturbance	✓	✓	✓	**Construction Phase** Up to 113,974,700 m^2 of temporary subtidal habitat loss/disturbance due to: • up to 1,268,000 m2 of disturbance from the use of jack-up vessels during foundation installation, with up to 4 jack-up events per wind turbine and 4 jack-up events per Offshore Substation Platform (OSP/Offshore convertor substation platform)/Offshore convertor station platform; • up to 42,948,000 m^2 of disturbance from installation of cables comprising up to 24,500,000 m^2 disturbance from installation of up to 1,225 km of inter-array cables, up to 1,880,000 m^2 disturbance from installation of up to 94 km of interconnector cable and up to 16,568,000 m^2 disturbance from installation of up to 872 km of offshore export cables with seabed disturbance width of: up to 25 m for sand wave clearance, up to 25 m for boulder clearance and up to 15 m for cable burial; • sand wave clearance may be required for up to 20% of the Proposed Development export cable corridor length, up to 30% of inter-array cables and OSP/Offshore convertor substation platform/Offshore convertor substation platform interconnector cables; • boulder clearance may be required for up to 20% of offshore export cable length, inter-array cables and OSP/Offshore convertor substation platform/Offshore convertor substation platform interconnector cables; • up to 69,320,500 m^2 of habitat disturbance associated with the deposition of 12,860,250 m3 of sand wave clearance material dredged within the Proposed Development array area and 21,800,000 m3 of sand wave clearance material dredged within the Proposed Development export cable corridor; • up to 438,200 m^2 from a 100 m^2 anchor placed every 500 m during array, OSP/Offshore convertor substation platform interconnector and offshore export cables installation; • offshore export cables installation at the landfall via trenchless burial techniques; • up to 8 exit punches out, each 20 m x 5 m, for up to 8 cable ducts due to trenchless cable installation in the intertidal; • exit punches out located up to 488 m from the MHWS mark; • clearance of up to 14 UXOs; and • maximum duration of the offshore construction phase is up to 96 months. **Operation and Maintenance Phase** Up to 989,000 m^2 of temporary habitat loss/disturbance due to: • up to 245 major component replacements (7 per year) for wind turbines and 7 major component replacements (one every 10 years) for OSP/Offshore convertor substation platforms and 10 access ladder replacements for wind turbines and 7 access ladder replacements for OSP/Offshore convertor substation platforms using jack-up vessel over the lifetime of the Proposed Development; • inter-array and OSP/Offshore convertor substation platform interconnector cables: up to 450,000 m^2 for repair events and up to 150,000 m^2 for reburial events (assuming 15 m width seabed disturbance for repair and remedial burial); • offshore and intertidal export cables: up to 60,000 m^2 for repair and up to 60,000 m^2 reburial events (assuming 15 m width seabed disturbance for repair and remedial burial); and • operation and maintenance phase up to 35 years. **Decommissioning Phase** Up to 34,571,200 m^2 of temporary subtidal habitat loss/disturbance due to:	Maximum footprint which would be affected during the construction, operation and maintenance and decommissioning phases. The maximum design scenario for disturbance from offshore export cables is based on the installation of up to 8 offshore export cables. The maximum design scenario for disturbance associated with activities for the OSP/Offshore convertor substation platforms is based on up to 10 OSP/Offshore convertor substation platforms. Based on the assumption that the width of disturbance for sand wave and boulder clearance also includes subsequent burial as repeat disturbance. As such, up to 60% of the length of offshore export cables, and up to 50% of the length of inter-array cables will need burial only. Based on the assumption that sand wave clearance will occur to an average depth of 1.3 m. The area of seabed affected by the placement of sand wave clearance material has been calculated based on the maximum volume of sediment to be placed on the seabed, assuming all this sediment is coarse material (i.e. is not dispersed through tidal currents; see "Increased suspended sediment concentrations" assessment of effects in section 9.11). The total footprint of seabed affected has been calculated, for the purposes of the maximum design scenario, assuming a mound of uniform thickness of 0.5 m height. Temporary loss of benthic habitat is assumed beneath this. The maximum design scenario assumes that cable installation in the intertidal will involve trenchless techniques only (e.g. Horizontal Directional Drilling (HDD)). It is assumed that the footprint of the exit punches out associated with the trenchless technique within the subtidal area are within the width of disturbance assumed for offshore export cable installation. The maximum design scenario for the exit punches out is based on up to 8 offshore export cables. The exits punches out will be located

[2] C = Construction, O = Operation and maintenance, D = Decommissioning

Potential Impact	Phase[2] C	O	D	Maximum Design Scenario	Justification
				• up to 1,268,000 m^2 of disturbance from the use of jack-up vessels during foundation decommissioning, with up to 4 jack-up events per wind turbine and 4 jack-up events per OSP/Offshore convertor substation platform; • up to 32,865,000 m^2 of disturbance from removal of cables comprising of up to 18,375,000 m^2 from decommissioning of up to 1,225 km of inter-array cables, up 1,410,000 m^2 disturbance from decommissioning of up to 94 km of interconnector cable and up to 13,080,000 m^2 disturbance from decommissioning of up to 872 km of buried offshore export cables with seabed disturbance width of 15 m for cable deburial; • up to 438,200 m^2 from a 100 m^2 anchor placed event every 500 m during inter-array, OSP/Offshore convertor substation platform interconnector and offshore export cables removal; and • up to 8 exit punches out, each 20 x 5 m, for removal of up to 8 cables from the landfall.	between 488 m and 1,500 m from the MHWS mark. However, the maximum design scenario for impact to nearshore habitats considers the minimum punch out distance (i.e. 488 m from the MHWS mark) as this results in the greatest impact to nearshore receptors. The maximum design scenario assumes that UXO clearance would occur within the footprint of other seabed clearance works, cable burial activities and/or foundation footprints and therefore will not lead to additional habitat disturbance, such that the maximum footprint associated with this impact would be increased. Maximum design scenario for habitat disturbance associated with offshore export cable maintenance includes repairs/reburial of both subtidal and intertidal cables. Parameters for decommissioning are expected to be similar to those in the construction phase as it is expected that cables, cable protection and scour protection will be removed where possible and appropriate to do so. This will be determined at the time of decommissioning following the most up to date and best available guidance. Removal of all infrastructure has been assessed as a maximum design scenario. If any infrastructure is left *in situ* this will result in a lower area of temporary habitat disturbance during decommissioning.
Increased suspended sediment concentrations (SSC) and associated sediment deposition	✓	✓	✓	**Construction Phase** Wind turbines and OSP/Offshore convertor substation platforms installed on piled jacket foundations: • drilling of foundations associated with 179 wind turbine structures, with 2 x 5.5 m piles per leg and 4 legs per foundation; • drilling undertaken for 20% of total 80 m depth (estimated at 16 m) with a rate of 0.5 m/h; • modelling undertaken for drilling events at locations across the area encompassing a range of dispersion characteristics with 2 concurrent drilling events; and • drilling of foundations associated with up to 5 OSP/Offshore convertor substation platforms for up to 4 piles of 3.5 m diameter associated with each of the 8 legs, with 4 per foundation requiring drilling to 20% depth (i.e. 12 m), and drilling at 2 OSP/Offshore convertor substation platforms for 4 piles of 4 m diameter are associated with each of the 8 legs, with 4 per foundation requiring drilling to 20% depth (i.e. 12 m). Installation of inter-array and offshore export cables (maximum trench width of 2 m and maximum trench depth of 3 m): • inter-array cables length up to 1,225 km; • buried offshore export cable length up to 872 km; • OSP/Offshore convertor substation platform Interconnector cable length up to 94 km; • sand wave clearance over 30% of inter-array and OSP/Offshore convertor substation platform interconnector cables (395.7 km) and 20% of offshore export cables (174.4 km); • boulder clearance over 20% of inter-array, OSP/Offshore convertor substation platform interconnector cables (263.8 km) and offshore export cables (174.4 km); • installation using jet trenching which mobilises material from a depth of up to 3 m deep 2 m wide trench; and	Greatest volume of sediment released into the water column. See volume 2, chapter 7. Maximum design scenario assumed complete removal of all infrastructure, if any infrastructure is left *in situ* this will result in reduced levels of suspended sediment and associated deposition during decommissioning.

Potential Impact	Phase[2] C	O	D	Maximum Design Scenario	Justification
				• modelling assumes that the offshore cable routes extend over areas of sand suitable for jetting (i.e. which mobilises the greatest volume of sediment throughout the water column). **Operation and Maintenance Phase** Cable repair/reburial activities: • inter-array: up to 30,000 m of cable for repair events and up to 10,000 m of cable for cable reburial events; and • offshore export cables and OSP/Offshore convertor substation platform interconnector cables: Up to 4,000 m of cable for repair events and up to 4,000 m of cable for reburial events over 35-year lifetime. **Decommissioning Phase** • piled substructures will be cut at an agreed depth below the level of the seabed for partial removal, suction caisson foundations will be removed; • decommissioning of inter-array and offshore export cables: - inter-array cables length up to 1,225 km; - offshore export cable length up to 872 km; and - OSP/Offshore convertor substation platform interconnector cable length up to 94 km. • decommissioning using jet dredging which mobilises material from up to 3 m deep, 2 m wide trench; and • modelling assumes that the offshore cable routes extend over areas of sand suitable for jetting (i.e. which mobilises the greatest volume of sediment throughout the water column).	
Injury and/or disturbance to fish and shellfish from underwater noise and vibration	✓	×	×	**(Pre-)Construction phase** • clearance of up to 14 UXOs within the inter-array area or offshore export cable route. • absolute maximum assessed of 300 kg UXO; • low order clearance of all UXOs using low order techniques (subsonic combustion) with a single donor charge of up to 80 g Net Explosive Quantity (NEQ) for each clearance event; • up to 500 g NEQ clearance shot for neutralisation of residual explosive material; • small risk of potential for unintended consequence of low order techniques to result in high order detonation of UXO; • up to 2 detonations within 24 hours; and • clearance during daylight hours only. **Construction Phase** • wind turbines: - up to 179 piled jacket foundations, with up to 4 legs per foundation and up to 2 x 5.5 m diameter piles per leg (1,432 piles). - maximum hammer energy up to 4,000 kJ, with realistic maximum hammer energy of 3,000 kJ (based on average of up to 75% maximum hammer energy); - two concurrent piling events with 2 vessels for wind turbine foundations and/or OSP/Offshore convertor substation platforms; - minimum 900 m and maximum 49.3 km distance between concurrent piling events; - up to 10 hours absolute maximum piling per pile (9 hours realistic maximum); - total duration of piling for wind turbines only = 14,320 hours (absolute max) to 12,888 hours (realistic max); and - maximum piles installed within 24 hours (concurrent piling) = 5. • OSPs/Offshore convertor substation platforms: - up to 8 jacket foundations with up to 6 legs per foundation and 4 x 3.0 m diameter piles per leg (192 piles) and up to 2 jacket foundations with up to 8 legs per foundation and 4 x 4.0 m diameter piles per leg (64 piles); - maximum hammer energy up to 4,000 kJ;	Maximum number and maximum size of UXOs encountered in the Proposed Development based on UXO Hazard Assessment undertaken for Seagreen. Maximum number of UXOs will lead to greatest potential impact. Donor charge is maximum required to initiate low order detonation. Assumption of a clearance shot of up to 500 g at all locations will lead to the greatest potential impact, however it should be noted that this may not always be required. Maximum design scenario is for the maximum number of piles, the maximum possible duration of piling and the greatest hammer energy (leading to the greatest propagation of noise into the water column). Note that maximum design scenario assumes concurrent piling for wind turbine foundations as the maximum design scenario but it may occur as a combination of wind turbines and OSPs/Offshore convertor station platforms. See volume 2, chapter 7.

Potential Impact	Phase[2] C	O	D	Maximum Design Scenario	Justification
				- up to 8 hours absolute maximum (7 hours realistic maximum) piling per pile; - total duration of piling = 1,792 hours (realistic maximum) to 2,048 hours (absolute maximum); and - maximum piles installed within 24 hours (single piling) = 3. • The maximum scenario for concurrent piling is maximum of two2 piling events at any one time. Number of days when piling may occur within piling phase (OSPs/Offshore convertor station platforms and wind turbines) = 372 days. Total piling phase of 52 months over a construction period of 96 months.	
Long-term subtidal habitat loss	✓	✓	✓	**Construction, and Operation and Maintenance Phase** Up to 7,798,856 m^2 of long term habitat loss due to: • presence of up to 179 wind turbine foundations on suction caisson foundations and 10 OSP/Offshore convertor substation platform foundations on suction caisson jacket foundations with associated scour protection; • presence of cable protection associated with up to 1,225 km of inter-array cables, 94 km of OSP/Offshore convertor substation platform interconnector cable and up to 872 km of offshore export cables. Assumes up to 15% of inter-array, interconnector cables and Propose Development export cable corridor may require protection; • presence of cable protection for cable crossings, 78 cable crossings for inter-array and interconnector cables and 16 crossings for the offshore export cables (each cable will cross each of the Neart na Gaoithe offshore export cables once); and • operation and maintenance phase up to 35 years. **Decommissioning Phase** Habitat loss of up to 7,562,609 m^2 due to: • presence of cable protection for 1,225 km of inter-array cables, 94 km of OSP/Offshore convertor substation platform interconnector cables and 872 km of offshore export cables which may be left in situ after decommissioning; • presence of cable protection for cable crossings, 78 cable crossings for array and OSP/Offshore convertor substation platform interconnector cables and 16 crossings for the offshore export cables which may be left in situ after decommissioning; and • scour protection for up to 179 wind turbines and 10 OSP/Offshore convertor substation platforms which may be left *in situ* after decommissioning.	Largest wind turbine and OSP/Offshore convertor substation platform foundation type and associated scour protection, maximum length of cables and cable protection resulting in greatest extent of habitat loss. Mud mats will be completely underneath the scour protection therefore will not create additional long-term habitat loss. Maximum design scenario assumes removal of foundations only. Cables and cable protection will be removed where possible and appropriate; if any additional infrastructure is decommissioned, this will result in a reduced area of long-term habitat loss. Greatest amount of cable and scour protection resulting in the largest area of infrastructure, assumed to be left *in situ* after decommissioning.
EMFs from subsea electrical cabling	×	✓	×	**Operation and Maintenance Phase** Presence of inter-array and offshore export cables: • up to 1,225 km of 66 kV inter-array cables; • up to 872 km of 275 kV offshore export cables; • minimum burial depth 0.5 m; • up to 15% of inter-array cables and offshore export cable route may require cable protection; and • cables will also require cable protection at asset crossings (up to 78 crossings for inter-array cables and up to 16 crossings for offshore export cables). Operation and maintenance phase of up to 35 years.	Maximum length of cables across the Proposed Development array area and offshore export cable route and minimum burial depth (the greater the burial depth, the more the EMF is attenuated). The maximum design scenario for EMF is based on the greatest cable length and as this provides the greatest potential for EMF effects on fish and shellfish IEFs.

Potential Impact	Phase[2]			Maximum Design Scenario	Justification
	C	O	D		
Colonisation of foundations, scour protection and cable protection	×	✓	✓	**Operation and Maintenance Phase** Long term habitat creation of up to 10,198,971 m^2 due to: • presence of up to 307 wind turbines and 10 OSP/Offshore convertor substation platforms on jacket foundations; • presence of scour protection associated with wind turbines and OSP/Offshore convertor substation platforms; • presence of cable protection associated with up to 1,225 km of inter-array cables, up to 94 km of interconnector cables and up to 872 km of offshore export cables. Assumes up to 15% of inter-array, OSP/Offshore convertor substation platform interconnector and offshore export cables may require cable protection; • presence of cable protection for cable crossings, 78 cable crossings for array and OSP/Offshore convertor substation platform interconnector cables and 16 crossings for the offshore export cables; and • operation phase of up to 35 years. **Decommissioning Phase** Habitat creation of up to 7,493,186 m^2 due to: • presence of cable protection for 1,225 km of inter-array cables, 94 km of interconnector cables and 872 km of offshore export cables which may be left *in situ* after decommissioning; • presence of cable protection for cable crossings, 78 crossings for array and OSP/Offshore convertor substation platform interconnector cables and 16 crossings for the offshore export cables which may be left in situ after decommissioning; and • scour protection for up to 307 wind turbines and 10 OSP/Offshore convertor substation platforms which may be left in situ after decommissioning.	Maximum number of wind turbines and OSP/Offshore convertor substation platform foundations and associated scour protection, maximum length of cables and cable protection resulting in greatest surface area for colonisation. The estimate of habitat creation from the presence of foundations has been calculated as if the foundations were a solid structure. This is, therefore, a conservative estimate of habitat creation on the basis that the jacket foundations will have a lattice design rather than a solid surface, as has been assumed. Maximum design scenario assumes removal of foundations only. If any additional infrastructure is decommissioned, this will result in a reduced area of long-term habitat loss. Greatest amount of cable and scour protection resulting in the largest area of infrastructure, assumed to be left *in situ* after decommissioning.

9.8.2. IMPACTS SCOPED OUT OF THE ASSESSMENT

41. The Fish and Shellfish Ecology Road Map (volume 3, appendix 8.2), the Berwick Bank Wind Farm Offshore Scoping Report (SSER, 2021a) and the Berwick Bank Wind Farm Scoping Opinion (MS-LOT, 2022) (see section 9.5), have been used to facilitate stakeholder engagement on topics to be scoped out of the assessment.

42. On the basis of the baseline environment and the project description outlined in volume 1, chapter 3 of the Offshore EIA Report, a number of impacts are proposed to be scoped out of the assessment for fish and shellfish ecology. These have been agreed with key stakeholders through consultation as discussed in volume 1, chapter 5. Otherwise, these impacts were proposed to be scoped-out in The Berwick Bank Wind Farm Offshore Scoping Report (SSER, 2021a) and no concerns were raised by key consultees. Where discussions with consultees took place after the publication of the Berwick Bank Wind Farm Scoping Opinion (MS-LOT, 2022), these are audited in the Berwick Bank Wind Farm Audit Document for Post-Scoping Discussions (volume 3, appendix 5.1).

43. Following consultation with stakeholders and advice received within the Offshore EIA Scoping Opinion (Marine Scotland, 2021), it has been agreed to scope these impacts out for further consideration within the EIA for fish and shellfish ecology.

44. These impacts are outlined, together with a justification for scoping them out, in Table 9.16.

Table 9.16: Impacts Scoped Out of the Assessment for Fish and Shellfish Ecology (tick confirms the impact is scoped out)

Potential Impact	Phase[3]			Justification
	C	O	D	
Accidental pollution during construction, operation and maintenance and decommissioning.	✓	✓	✓	There is a risk of pollution being accidentally released during the construction phases from sources including vessels/vehicles and equipment/machinery. However, the risk of such events is managed by the implementation of measures set out in standard post consent plans, (e.g. Environmental Management Plans (EMP), including Marine Pollution Contingency Plans (MPCP)). These plans include planning for accidental spills, address all potential contaminant releases and include key emergency contact details. It will also set out industry good practice and OSPAR, International Maritime Organisation (IMO), MARPOL (International Convention for the Prevention of Pollution from Ships) guidelines for preventing pollution at sea. Therefore, the likelihood of an accidental spill occurring is very low and in the unlikely event that such events occur, the magnitude of these will be minimised through measures such as marine pollution contingency planning.
Underwater noise from wind turbine operation.	N/A	✓	N/A	Noise generated by operation wind turbines is of a very low frequency and low sound pressure level (Andersson *et al.,* 2011). Studies have found that sound levels are only high enough to possibly cause a behavioural reaction within metres from a wind turbine (Sigray and Andersson, 2011), and therefore such levels are not considered to have potentially adverse effects on fish and shellfish IEFs.
Underwater noise from vessels.	✓	✓	✓	Operation underwater noise generated from vessels, including geophysical and geotechnical surveys, is likely to be low and effects would only occur if fish species remained within immediate vicinity of the vessel (i.e. within metres) for a number of hours, which is highly unlikely.
Impacts on intertidal areas.	✓	✓	✓	Due to minimal works associated with the Proposed Development boundary in intertidal areas (i.e. all cables will be installed via trenchless technology, avoiding direct impacts on the intertidal) which may be utilised by fish and shellfish IEFs, and the relatively low importance of this area for the fish and shellfish IEFs, impacts on intertidal habitats have been scoped out and will not be assessed further. This approach was agreed at Road Map Meeting 3.

[3] C = Construction, O = Operation and maintenance, D = Decommissioning

9.9. METHODOLOGY FOR ASSESSMENT OF EFFECTS

9.9.1. OVERVIEW

45. The fish and shellfish ecology assessment of effects has followed the methodology set out in volume 1, chapter 6 of the Offshore EIA Report. Specific to the fish and shellfish ecology EIA, the following guidance documents have also been considered:

- Guidelines for Ecological Impact Assessment (EcIA) in the UK and Ireland. Terrestrial, Freshwater and Coastal (CIEEM, 2019);
- Guidance on Environmental Considerations for Offshore Wind Farm Development (OSPAR, 2008); and
- Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects (Judd, 2012).

46. In addition, the fish and shellfish ecology assessment of effects has considered the legislative framework as set out in volume 1, chapter 2 of the Offshore EIA Report.

9.9.2. CRITERIA FOR ASSESSMENT OF EFFECTS

47. The process for 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 describes 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 1, chapter 6 of the Offshore EIA Report.

48. The criteria for defining magnitude in this chapter are outlined in Table 9.17. In determining magnitude within this chapter, each assessment considered the spatial extent, duration, frequency and reversibility of impact and these are outlined within the magnitude section of each assessment of effect (e.g. a duration of hours or days would be considered for most receptors to be of short term duration, which is likely to result in a low magnitude of impact).

Table 9.17: Definition of Terms Relating to the Magnitude of an Impact

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

49. The definitions of sensitivities of fish and shellfish IEFs have been informed by the Marine Evidence based Sensitivity Assessment (MarESA) (MarLIN, 2021) and Feature Activity Sensitivity Tool (FeAST) (NatureScot, 2021). The MarESA defines sensitivity as a product of the likelihood of damage (resistance) due to a pressure and the rate of recovery (recoverability) once the pressure has been removed. Recoverability is the ability of a habitat to return to the state of the habitat that existed before the activity or event which caused change. Full recovery does not necessarily mean that every component species has returned to its prior condition, abundance, or extent but that the relevant functional components are present, and the habitat is structurally and functionally recognisable as the initial habitat of interest. The FeAST is another web based application which allows users to investigate the sensitivity of marine features in Scotland's seas, to pressures arising from human activities (noting that this has been developed for features of low/limited mobility, so may not be relevant to fish and shellfish ecology). The FeAST sensitivity assessment considers feature tolerance (ability to absorb or resist change or disturbance) to a pressure and its ability to recover once the pressure stops. Both the MarESA and the FeAST define pressures by a benchmark which describes the extent and duration of the pressure but does not consider the intensity, frequency of pressures or any cumulative impacts. The FeAST tool has been utilised to identify pressures where possible, however, it is only available for a small number of fish and shellfish species at the time of writing.

50. The sensitivities of fish and shellfish IEFs presented within this EIA Report have therefore been defined by an assessment of the combined vulnerability (i.e. resistance, following MarESA, or tolerance following FeAST) of the receptor to a given impact and the likely rate of recoverability to pre-impact conditions (consistent with both MarESA and FeAST). Here, vulnerability is defined as the susceptibility of a species to disturbance, damage or death, from a specific external factor. Recoverability is the ability of the same species to return to a state close to that which existed before the activity or event which caused change. Recoverability is dependent on an IEFs ability to recover or recruit subject to the extent of disturbance/damage incurred. Information on these aspects of sensitivity of the fish and shellfish IEFs to given impacts has been informed by the best available evidence following environmental impact or experimental manipulation in the field and evidence from the offshore wind industry and analogous activities such as those associated with aggregate extraction, electrical cabling, and oil and gas industries. These assessments have been combined with the importance of the relevant IEFs as defined in section 9.7.3 and as presented in Table 9.14 for the fish and shellfish IEFs considered in this assessment.

51. The criteria for defining sensitivity in this chapter are outlined in Table 9.18.

Table 9.18: Definition of Terms Relating to the Sensitivity of the Receptor

Value (Sensitivity of the Receptor)	Description
Very High	Nationally and internationally important receptors with high vulnerability and low to no recoverability.
High	Regionally important receptors with high vulnerability and no ability to recover.
Medium	Nationally and internationally important receptors with medium vulnerability and medium recoverability. Regionally important receptors with medium to high vulnerability and low recoverability. Locally important receptors with high vulnerability and no ability to recover.
Low	Nationally and internationally important receptors with low vulnerability and high recoverability. Regionally important receptors with low vulnerability and medium to high recoverability.

Value (Sensitivity of the Receptor)	Description
	Locally important receptors with medium to high vulnerability and low recoverability.
Negligible	Locally important receptors with low vulnerability and medium to high recoverability. Receptor is not vulnerable to impacts regardless of value/importance.

52. 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. The particular method employed for this assessment is presented in Table 9.19.

53. In cases where a range is suggested for the significance of effect, there remains the possibility that this may span the significance threshold (e.g. the range is given as minor to moderate). In such cases the final significance conclusion is based upon the author's professional judgement as to which outcome delineates the most likely effect. Where professional judgement is applied to quantify final significance from a range, the assessment will set out the factors that result in the final assessment of significance. These factors may include the likelihood that an effect will occur, data certainty and relevant information about the wider environmental context.

54. For the purposes of this assessment:

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

55. Effects of moderate significance or above are therefore considered important in the decision-making process, whilst effects of minor significance or less warrant little, if any, weight in the decision-making process.

Table 9.19: Matrix Used for the Assessment of the Significance of the Effect

		Magnitude of Impact			
Sensitivity of Receptor		**Negligible**	**Low**	**Medium**	**High**
	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

9.9.3. DESIGNATED SITES

56. Where Natura 2000 sites (i.e. nature conservation sites in Europe designated under the Habitats or Birds Directives[4]; or sites in the UK that comprise the National Site Network (collectively termed 'European sites') are considered, this chapter makes an assessment of the likely significant effects in EIA terms on the qualifying interest feature(s) of these sites as described within section 9.7.2 of this chapter. The assessment of the of the potential impacts on the site itself are deferred to the RIAA (SSER, 2022c) for the Proposed Development. A summary of the outcomes reported in the RIAA is provided in section 9.15 of this chapter.

57. With respect to locally designated sites and national designations (other than European sites), where these sites fall within the boundaries of a European site and where qualifying interest features are the same, only the features of the European site have been taken forward for assessment. This is because potential impacts on the integrity and conservation status of the locally or nationally designated site are assumed to be inherent within the assessment of the features of the European site (i.e. a separate assessment for the local or national site features is not undertaken). However, where a local or nationally designated site falls outside the boundaries of a European site, but within the Proposed Development northern North Sea fish and shellfish ecology study area, an assessment of the likely significant effects on the overall site is made in this chapter using the EIA methodology.

9.10. MEASURES ADOPTED AS PART OF THE PROPOSED DEVELOPMENT

58. 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 9.20). As there is a commitment to implementing these measures, they are considered inherently part of the design of the Proposed Development and have therefore been considered in the assessment presented in section 9.11 (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 9.20: Designed In Measures Adopted as Part of the Proposed Development

Designed In Measures Adopted as Part of the Proposed Development	Justification
Implementation of piling soft start and ramp up measures. During piling operations, soft starts will be used. This will involve the implementation of lower hammer energies (i.e. approximately 15% of the maximum hammer energy; see paragraph 152 *et seq.)* at the beginning of the piling sequence before energy input is 'ramped up' (increased) over time to required higher levels.	This measure will minimise the risk of injury to fish species in the immediate vicinity of piling operations, allowing individuals to flee the area before noise levels reach a level at which injury may occur. Comments regarding the effectiveness of soft start procedures provided at Scoping are addressed in Table 9.8 and the assessments of effects in section 9.11.

[4] Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora) and Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds.

Designed In Measures Adopted as Part of the Proposed Development	Justification
Low order disposal of UXOs	Low order techniques will be adopted wherever practicable (e.g. deflagration and clearance shots) as mitigation to minimise noise levels and thereby injury and disturbance to fish and shellfish receptors. However, as noted in paragraph 169, there is a small risk that low order could unintentionally arise in a high order detonation and therefore this scenario has also been considered in the assessment of effects.
Development of, and adherence to, an EMP, including MPCP	To reduce the potential for release of pollutants from construction, operation and maintenance, and decommissioning plant as far as reasonably practicable. These will likely include designated areas for refuelling where spillages can be easily contained, storage of chemicals in secure designated areas in line with appropriate regulations and guidelines, double skinning of pipes and takes containing hazardous substances, and storage of these substances in impenetrable bunds. The MPCP will require, in the unlikely event that a pollution even occurs, that plans are in place to respond quickly and effectively to ensure any spillage is reduced as far as reasonably practicable and effects on the environment are ideally avoided or reduced as far as reasonably practicable. Implementation of these measures will reduce the accidental release of contaminants from vessels as far as reasonably practicable, thus providing protection for marine life across all phases of the Project Development (see section 9.8.2).
Development of, and adherence to, an appropriate Code of Construction Practice (CoCP)	These measures have been identified during the design of the offshore and intertidal elements of the Project as part of the EIA process. They include strategies, control measures and monitoring procedures for managing the potential environmental impacts of constructing the Project and limiting disturbance from construction activities as far as reasonably practicable (*see* section 9.8.2*)*.
Preparation and implementation of a Cable Plan (CAP), including a cable burial risk assessment (CBRA) to inform cable burial depth	A CAP will be prepared prior to the construction phase and will include a detailed cable laying plan, including geotechnical data, cable laying techniques and a CBRA which will include details on target and minimum burial depths. While the sediments in which cables are buried will not reduce the strength of EMF, the burial of cables does increase the distance between cables and fish and shellfish IEFs, with greater attenuation of EMFs with greater distance from the cable, thereby potentially reducing the effect of EMFs on those IEFs (see paragraph 233 *et seq*.).
Development of, and adherence to, a 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 Proposed Development, the maximum design scenario for the decommissioning phase has been considered in each of the assessments of effects presented in section 9.11.

9.11. ASSESSMENT OF SIGNIFICANCE

59. The potential effects arising from the construction, operation and maintenance and decommissioning phases of the Proposed Development are listed in Table 9.15, along with the maximum design scenario against which each impact has been assessed. An assessment of the likely significance of the effects of the Proposed Development on fish and shellfish ecology IEFs caused by each identified impact is given below.

TEMPORARY SUBTIDAL HABITAT LOSS/DISTURBANCE

60. Direct temporary habitat loss/disturbance of subtidal seabed habitats within the Proposed Development array area and offshore export cable corridor during the construction, operation and maintenance, and decommissioning phases will occur as a result of a range of activities including use of jack-up vessels during foundation installation/maintenance, installation and maintenance of inter-array and offshore export cables (including seabed clearance operations prior to cable installation) and anchor placements associated with these activities. Disturbance to these habitats has the potential to affect identified fish and shellfish IEFs directly (e.g. removal or injury of individuals) and indirectly (e.g. loss of important fish and shellfish habitats, such as spawning grounds).

61. Seabed preparation activities, including sand wave clearance and boulder clearance, will occur in advance of installation of inter-array cables and offshore export cables. Dredged material resulting from seabed preparations will be disposed of within the Proposed Development. The assessment therefore includes habitat loss/disturbance associated with disposal of dredged material from this activity, (i.e. habitat loss/disturbance due to placement of large volumes of coarse sediments on the seabed (see Table 9.15)). Effects on areas of seabed which have been subject to seabed preparation activities prior to foundation installation have been assessed under long term subtidal habitat loss as the area of seabed affected by seabed preparation will be the same area on which foundations (and potentially scour protection) will be placed for the lifetime of the Proposed Development.

Construction Phase

Magnitude of Impact

62. The installation of infrastructure within the Proposed Development fish and shellfish ecology study area may lead to temporary subtidal habitat loss/disturbance. The maximum design scenario is for up to

113,974,700 m² of temporary habitat loss/disturbance during the construction phase (Table 9.15). This equates to 9.7% of the Proposed Development, representing a relatively small proportion of the Proposed Development fish and shellfish ecology study area. It should be noted that only a small proportion of the total footprint will be affected at any one time during the 96 months construction phase, with recovery of seabed habitats commencing immediately following installation of infrastructure.

63. Temporary habitat loss of up to 42,948,000 m² will also occur as a result of the installation of up to 1,225 km of inter-array cables, 94 km of OSP/Offshore convertor substation platform interconnector cables and up to 872 km of offshore export cables. Sand wave clearance may be required for up to 20% of the Proposed Development export cable corridor length and up to 30% of inter-array cables and OSP/Offshore convertor substation platform interconnector cables. Boulder clearance may be required for up to 20% of offshore export cables length, inter-array cables and OSP/Offshore convertor substation platform interconnector cable (Table 9.15). The maximum width of seabed preparation is greater than the disturbance associated with the cable installation itself to allow enough space to operate the tool (i.e. 15 m for cable burial, 25 m for boulder clearance and 25 m for sand wave clearance). Cable burial will therefore occur within the area previously disturbed via sand wave or boulder clearance resulting in localised repeat disturbance within a 15 m wide corridor, within the wider 25 m corridor disturbed during sand wave and boulder clearance.

64. A recent review commissioned by The Crown Estate (TCE) reviewed the effects of cable installation on subtidal sediments and habitats (RPS, 2019), drawing on monitoring reports from over 20 UK offshore wind farms. This review showed that sandy sediments recover quickly following cable installation, with trenches infilling quickly following cable installation and little or no evidence of disturbance in the years following cable installation. It also presented evidence that in some settings, remnant cable trenches in coarse and mixed sediments and muddy sediments were conspicuous for several years after installation. However, these shallow depressions were of limited depth (i.e. tens of cm) relative to the surrounding seabed, over a horizontal distance of several metres and therefore did not represent a large shift from the baseline environment (RPS, 2019).

65. As set out in Table 9.15, the maximum design scenario assumes the removal of up to 14 UXO from the Proposed Development. These clearance activities would however occur within the footprint of other seabed clearance works (i.e. sand wave and boulder clearance), cable burial activities and/or foundation footprints and therefore will not lead to additional habitat disturbance. Any craters created during detonation are expected to backfill by natural processes, the speed of which would depend on the sediment transport regimes in the area.

66. Anchor footprints from cable installation vessels will also result in habitat disturbance. Typically, one anchor reposition per 500 m of cable may be required, with individual anchors associated with cable installation vessels having a footprint of approximately 100 m². This area of seabed disturbance will depend on the precise vessel used and in some cases anchor placements may not be required at all (e.g. where the vessel uses dynamic positioning). The maximum design scenario accounts for up to 438,200 m² of temporary disturbance from a 100 m² anchor placed every 500 m during inter-array, OSP/Offshore convertor substation platform interconnector and offshore export cables installation.

67. Jack-up footprints associated with foundation installation will result in compression of seabed sediments beneath spud cans where these are placed on the seabed. These will infill over time, although may remain on the seabed for a number of years, as demonstrated by monitoring studies of UK offshore wind farms (BOWind, 2008; EGS, 2011). Monitoring at the Barrow offshore wind farm showed depressions were almost entirely infilled 12 months after construction (BOWind, 2008). Monitoring at Lynn and Inner Dowsing offshore wind farm also showed some infilling of the footprints, although the depressions (i.e. of the order of tens of centimetres) were still visible a couple of years post construction (EGS, 2011). In areas where mobile sands and coarse sediments are present such as in the majority of the Proposed Development fish and shellfish ecology study area (see volume 2, chapter 8), jack-up depressions are likely to be temporary features which will only persist for a period of months to a small number of years.

68. Activities resulting in the temporary subtidal habitat loss/disturbance will occur intermittently throughout the construction phase. The offshore construction phase which includes activities resulting in temporary habitat loss/disturbance will occur over a period of up to 96 months. Once construction in a local area (for example, a section of offshore export cable) has been completed, this area will not be disturbed further during the construction phase. This area will start to recover immediately following cessation of construction activities in the vicinity allowing mobile species, such as sandeel and other fish and shellfish species, to repopulate the areas of previous disturbance (see paragraph 78 *et seq.* for further discussion of recovery of species).

69. The impact is predicted to be of local spatial extent (i.e. limited to the Proposed Development fish and shellfish ecology study area), medium term duration (although only a small proportion of the total area will be affected at any one time with individual elements of construction having much shorter durations), intermittent and high reversibility. It is predicted that the impact will affect the receptor directly or indirectly, dependent on species' life strategies. The magnitude is therefore considered to be low.

<u>Sensitivity of the Receptor</u>

Marine species

70. In general, mobile fish species are able to avoid areas subject to temporary habitat disturbance (EMU, 2004). The most vulnerable species are likely to be shellfish which are much less mobile than fish. For example, egg bearing lobster are thought to be more restricted to an area based on a mark and recapture study in Norway which showed that 84% of berried female lobster remained within 500 m of their release site (Agnalt *et al*., 2007). Evidence from other stocks around the world are less clear, with limited movement recorded for some stocks and long distance migrations documented for other stocks (e.g. Campbell and Stasko,1985; Comeau and Savoie, 2002).

71. Indirect effects on fish and shellfish species also include loss of feeding habitat and prey items. For example, crabs and other crustaceans and small benthic fish species (as well as other benthic species; see volume 2, chapter 8) are considered important prey species for larger fish. However, since this impact is predicted to affect only a small proportion of seabed habitats in the Proposed Development fish and shellfish ecology study area at any one time, with similar habitats (and prey species) occurring throughout the Forth and Tay SMR and the wider Proposed Development northern North Sea fish and shellfish ecology study area, these effects are likely to be limited and highly reversible. Conversely, habitat disturbance during the construction phase will also expose benthic infaunal species from the sediment (see volume 2, chapter 8), potentially offering foraging opportunities to some fish and shellfish species (e.g. opportunistic scavenging species) immediately after completion of works. The implications of changes in fish and shellfish prey species are also discussed for higher trophic level receptors (i.e. marine mammals and birds) in volume 2, chapter 10 and chapter 11.

72. A number of commercially important shellfish species such as edible crab, lobster, *Nephrops,* scallop and velvet swimming crab are known to inhabit the Proposed Development fish and shellfish ecology study area. Habitat loss in this area will represent a relatively small temporary disturbance to these habitats (e.g. during cable laying and seabed preparation), with relatively rapid recovery of sediments (RPS, 2019), and following this, recovery of associated communities (see volume 2, chapter 8) including shellfish populations into these areas. The recoverability and rate of recovery of an area after large scale seabed disturbance (e.g. dredging or trawling activities) is linked to the substrate type (Newell *et al*., 1998; Desprez, 2000). Mud or sand habitats, similar to those found in the Proposed Development fish and shellfish ecology study area, have been shown to return to baseline species abundance after approximately one to two years (Newell *et al*., 1998; Desprez, 2000). Harder gravely and rocky substrate takes proportionally longer to re-establish: up to ten years for boulder coastlines (Newell *et al*., 1998).

73. Larger crustacea (e.g. *Nephrops*, 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. The sensitivity of these fish and shellfish IEFs is therefore higher than for smaller benthic organisms which move in and colonise new substrate immediately after the effect. Therefore, although recovery of benthic assemblages may occur over relatively fast timescales (e.g. within one to two years; see volume 2, chapter 8), recovery of the equilibrium species may take up to ten years in some areas of coarse sediments (Phua *et al*., 2002).

74. Construction operations (including cable installation) within the Proposed Development fish and shellfish ecology study area may also impact on spawning and nursery habitats for *Nephrops*, as these areas overlap and have been mapped (i.e. broadscale mapping by Coull *et al*., 1998) as coinciding with the Proposed Development fish and shellfish ecology study area (volume 3, appendix 9.1). However, site-specific surveys showed that *Nephrops* were only recorded along the Proposed Development export cable corridor and therefore would only be affected by a relatively small proportion of the proposed construction operations. Further, larval settlement will also increase the rate of recovery in an area (Phua *et al*., 2002), with shellfish (*Nephrops*) spawning and nursery habitats in the vicinity of the Proposed Development fish and shellfish ecology study area (see volume 3, appendix 9.1) potentially increasing the rate of recovery into disturbed areas. A recent study undertaken during construction of the Westermost Rough Offshore Wind Farm located on the north-east coast of England, within a European lobster fishing ground, found that the size and abundance of lobster individuals increased following temporary closure or the area for construction of the wind farm. This study shows that the activities associated with construction of the wind farm, which included installation of wind turbines and cables, did not impact on resident lobster populations and instead allowed some respite from fishing activities for a short time period before reopening following construction (Roach *et al*., 2018).

75. Scallop are likely to be present within the Proposed Development fish and shellfish ecology study area and are targeted by commercial fisheries activities (see volume 2, chapter 12). Scallop are predominantly sessile organisms, however, they do have the ability to swim, which is ordinarily used as an escape response, although limited in distance (Marshall and Wilson, 2008). It has been documented the scallop have been able to move up to 30 m from a release site during a tagging study (Howell & Fraser, 1984). This response may allow improved resilience to temporary habitat loss/disturbance than other sessile organisms, by being able to avoid areas of disturbance and relocate to areas nearby. Scallop tend to occur in aggregations as their larval distribution is reliant on hydrographic features (Brand, 1991), therefore assuming scallop populations continue to spawn outside the boundary of the Proposed Development fish and shellfish ecology study area and within unimpacted areas of the Proposed Development, and suitable habitat for settlement remains, it is likely that scallop will continue to be recruited into the Proposed Development fish and shellfish ecology study area. Therefore, scallop will recover well from any disturbance due to short term habitat loss. This is supported by the MarLIN sensitivity assessment (Marshall and Wilson, 2008) which concluded scallops have a high recovery potential (i.e. recovery within months, with full recovery in a small number of years).

76. The fish species within the Proposed Development fish and shellfish ecology study area which are likely to be most sensitive to temporary habitat loss are those species which spawn on or near the seabed sediment (e.g. herring, sandeel and elasmobranchs, including spotted ray). Of the IEF fish species that spawn on or near the seabed, sandeel and herring are known to spawn at varying intensities within the vicinity of the Proposed Development fish and shellfish ecology study area (see volume 3, appendix 9.1). Therefore, seabed disturbance activities carried out during spawning periods may result in some mortality of eggs and reduced opportunity due to removal of suitable habitat. However, the area which will be disturbed is small given the abundance of similar substrate types and the extensive nature of fish spawning grounds across the Proposed Development northern North Sea fish and shellfish ecology study area.

77. Physical disturbance to sandeel habitats may also lead to direct effects on adult and juvenile sandeel (e.g. increased mortality), where individuals are not able to colonise viable sandy habitats in the immediate vicinity, or where habitats may be at carrying capacity (Wright *et al.,* 2000). This is as identified by the FeAST tool as a pressure on sandeel 'sub-surface abrasion/penetration' which has noted that sandeel have high sensitivity to this impact (Wright *et al.,* 2000). Sandeel may also be particularly vulnerable during their winter hibernation period when they bury themselves in the seabed substrates and are therefore less mobile. A large proportion of temporary habitat disturbance (60,342,400 m^2) is related to construction activities within the Proposed Development export cable corridor. The majority of favourable and preferred sandeel habitat within the Proposed Development fish and shellfish ecology study area is located within the Proposed Development array area (as described in section 9.7). Therefore, a significant proportion of temporary habitat disturbance will take place within areas of less favourable habitat within the Proposed Development export cable corridor. The temporary subtidal habitat loss/disturbance in the Proposed Development array area alone equates to up to 53,632,300 m^2. As a proportion of the Proposed Development array area, this accounts for up to 5.3%, which is a relatively small proportion in the context of available habitat in the Proposed Development array area and across the wider Firth and Tay SMR. Further, as noted above, only a small proportion of this maximum footprint of habitat loss/disturbance will be occurring at any one time during the construction phase, with recovery of sediments, and sandeel populations into them.

78. Recovery of sandeel populations would be expected following construction operations, with the rate of recovery dependent on the recovery of sediments to a condition suitable for sandeel recolonisation. Effects of offshore wind farm construction (Jensen *et al*., 2004) and operation (i.e. post-construction) (van Deurs *et al*., 2012) on sandeel populations have been examined through short term and long term monitoring studies at the Horns Rev offshore wind farm in the Baltic Sea, Denmark. These monitoring studies have shown that offshore wind farm construction and operation has not led to significant adverse effects on sandeel populations and that recovery of sandeel occurs quickly following construction operations.

79. The recovery potential of sandeel populations can also be inferred from a study by Jensen *et al*. (2010), which found sandeel populations mix within fishing grounds to distances of up to 28 km. This suggests that some recovery of adult populations is likely following construction operations, with adults recolonising suitable sandy substrates from adjacent un-impacted habitats. Recovery may also occur through larval recolonisation of suitable sandy sediments with sandeel larvae likely to be distributed throughout the Proposed Development fish and shellfish ecology study area during spring months following spawning in winter/spring (see Ellis *et al*., 2012; and volume 3, appendix 9.1).

80. A recent monitoring study conducted at the Beatrice Offshore Wind Farm completed a post construction sandeel survey where sandeel abundance were compared pre and post construction (BOWL, 2021a). The results showed that sandeel abundance either increased or remained at similar levels when comparing abundance from 2014 to 2020, with offshore construction commencing in April 2017. The study concluded that there was no evidence that the construction of Beatrice Offshore Wind Farm resulted in adverse impacts on the local sandeel population. This conclusion should be seen in the context of general increase in sandeel populations in the area surrounding the Beatrice Offshore Wind Farm (using ICES set Total Allowable Catch (TAC) as an indicator), and an increase in bycatch abundance from the sandeel dredging, which may indicate the Beatrice Offshore Wind Farm site was generally healthier in 2020 than it was in 2014 (BOWL, 2021a). This study builds on previous work conducted by Stenberg *et al*. (2011) which concluded that the construction of the Horns Rev 1 Offshore Wind Farm posed neither a threat nor direct benefit to sandeel over a seven-year period.

81. As described in paragraph 68, temporary habitat loss during the construction phase (96 months), will not occur simultaneously across the entire Proposed Development array area, rather only a small proportion of the maximum habitat loss/disturbance footprint will occur at a particular location at any one time. Once construction/infrastructure installation works are complete in a specific area, recovery of sediments and associated communities will begin. Drawing on information from the monitoring studies above, it is highly likely that the displaced individuals will repopulate these previously disturbed areas, with recovery occurring throughout the construction phase rather than once the entire construction phase is completed.

82. As effects on sandeel (and other prey species) are predicted to be limited in extent (particularly in the context of available habitats in the Proposed Development northern North Sea fish and shellfish ecology study area), temporary and reversible, with recovery of sandeel populations occurring post construction, species reliant on sandeel and other small prey species (e.g. sea trout and cod) would similarly not be expected to be significantly affected. The implications of changes in fish and shellfish prey species are also discussed for higher trophic level receptors (i.e. marine mammals and birds) in volume 2, chapter 10 and volume 2, chapter 11.

83. Herring spawning has been demonstrated to take place within the Proposed Development fish and shellfish ecology study area at a low intensity, with higher intensity spawning grounds being present to the north of the Proposed Development fish and shellfish ecology study area (see volume 3, appendix 9.1). Favourable habitat (gravel and sandy gravel) for spawning is present in patches within the Proposed Development fish and shellfish ecology study area, however, the area affected by temporary habitat loss (i.e. within the Proposed Development array area only) is dominated by sediments which are not suitable for herring spawning and therefore the area of herring spawning grounds affected by this impact is expected to be very limited, in the context of available favourable sediments habitat outside the Proposed Development fish and shellfish ecology study area and across the wider Proposed Development northern North Sea fish and shellfish ecology study area.

84. Most fish and shellfish ecology IEFs in the Proposed Development fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and local to national importance. The sensitivity of the receptor is therefore, considered to be low.

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

86. Herring are deemed to be of high vulnerability, medium recoverability and of regional importance. However, the sensitivity of herring to this impact is considered to be low, due to the limited suitable spawning sediments overlapping with the Proposed Development fish and shellfish ecology study area and the core herring spawning ground being located well outside the Proposed Development fish and shellfish ecology study area.

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

Diadromous Species

88. Diadromous fish species are highly mobile and therefore are generally able to avoid areas subject to temporary habitat loss. Diadromous species that are likely to interact with the Proposed Development fish and shellfish ecology study area are only likely to do so by passing through the area during migrations to and from rivers located on the east coast of Scotland, such as to rivers with designated sites, with diadromous fish species listed as qualifying features (see Table 9.12 and volume 3, appendix 9.1). The habitats within the Proposed Development fish and shellfish ecology study area are not expected to be particularly important for diadromous fish species and therefore habitat loss during the construction phase of the Proposed Development fish and shellfish ecology study area is unlikely to cause any direct impact to diadromous fish species and would not affect migration to and from rivers.

89. Indirect impacts on diadromous fish species may occur due to impacts on prey species, for example larger fish species for sea lamprey and sandeel for sea trout. As outlined for marine species above, the majority of large fish species would be able to avoid habitat loss effects due to their greater mobility but would recover into the areas affected following cessation of construction. Sandeel (and other less mobile prey species) would be affected by temporary habitat loss, although recovery of this species is expected to occur quickly as the sediments recover following installation of infrastructure and adults recolonise and also via larval recolonisation of the sandy sediments, which dominate the Proposed Development fish and shellfish ecology study area and are known to recover quickly following cable installation (RPS, 2019). Diadromous fish species are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is therefore, considered to be low.

Significance of the Effect

Marine Species

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

91. For sandeel, the magnitude of the impact is deemed to be low and the sensitivity is considered to be medium. The effect will, therefore, be of **minor** adverse significance which is not significant in EIA terms. Although, the total figure for the area of subtidal habitat loss/disturbance is high, it should be viewed with the following context:

- a large proportion of habitat loss occurs within the Proposed Development export cable corridor, where habitat is less favourable/unsuitable for sandeel; and
- the total habitat loss/disturbance will not occur simultaneously, rather it would be spread across the site over the entire 96 months construction phase, allowing recovery into disturbed areas to begin as soon as construction activity has ceased.

92. For *Nephrops* and European lobster, the magnitude of the impact is deemed to be low and the sensitivity is considered to be medium. The effect will, therefore, be of **minor** adverse significance which is not significant in EIA terms. It should be noted that there is some conservatism in this conclusion, specifically:

- *Nephrops* are distributed across only part of the Proposed Development export cable corridor, with more extensive habitats outside the Proposed Development fish and shellfish ecology study area and therefore would not be affected by the majority of the construction operations, particularly those occurring within the Proposed Development array area which are not suitable habitats for *Nephrops*; and
- similarly, lobster are likely to be targeted in nearshore areas including sections of the offshore export cable route. There is some creeling activity (which targets lobster and crab species) (see volume 3, appendix 12.1) within the Proposed Development array area, however lobster are typically associated with coarser sediments than those found within the Proposed Development fish and shellfish ecology study area and, it is likely that the creeling effort is focused on crab species rather than lobster.

Diadromous Species

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

Secondary Mitigation and Residual Effect

94. No additional fish and shellfish ecology mitigation is considered necessary as recovery of sediments and associated fish and shellfish IEFs will occur naturally without any need for further interventions and the likely effect in the absence of further mitigation (beyond the designed in measures outlined in section 9.10) is not significant in EIA terms.

Operation and Maintenance Phase

Magnitude of Impact

95. Operation and maintenance activities within Proposed Development fish and shellfish ecology study area may lead to temporary subtidal habitat loss/disturbance. The maximum design scenario is for up to 989,000 m^2 of temporary habitat loss/disturbance during the operation and maintenance phase (Table 9.15). This equates to 0.08% of the Proposed Development and therefore this represents a very small proportion of the Proposed Development fish and shellfish ecology study area. It should also be noted that only a small proportion of the total habitat loss/disturbance is likely to be occurring at any one time over the 35-year operation phase of the Proposed Development.

96. Temporary habitat loss will occur as a result of the use of jack-up vessels during any component replacement activities and during any inter-array, OSP/Offshore convertor substation platform interconnector and offshore export cable repair activities. Impacts of jack-up vessel activities will be similar to those identified for the construction phase above and will be restricted to the immediate area around the wind turbine foundation or cable repair site, where the spud cans are placed on the seabed, with recovery occurring following removal of spud cans. Inter-array and offshore export cable repair or reburial activities will also affect habitats in the immediate vicinity of these operations, with effects on seabed habitats also expected to be similar to the construction phase. The spatial extent of this impact is very small in relation to the Proposed Development fish and shellfish ecology study area, although there is the potential for repeat disturbance to the habitats because of these activities (e.g. placement of spud cans on or in close proximity to where these were placed during construction; remedial burial of a length of cable installed during the construction phase, affecting the same area of seabed). Activities resulting in the temporary subtidal habitat loss/disturbance will occur intermittently throughout the 35-year operation and maintenance phase.

97. The impact is predicted to be of local spatial extent, short term duration (individual maintenance operations would occur over the period of days to weeks), intermittent and high reversibility. It is predicted that the impact will affect the receptor directly or indirectly, dependent on species' life strategies. The magnitude is therefore considered to be negligible.

Sensitivity of the Receptor

98. The sensitivity of the fish and shellfish IEFs, for both marine and diadromous species, can be found in the construction phase assessment (see paragraph 70 *et seq.*), ranging from negligible to medium sensitivity.

Significance of the Effect

Marine Species

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

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

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

Diadromous Species

102. Overall, 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** adverse significance, which is not significant in EIA terms.

Secondary Mitigation and Residual Effect

103. No additional fish and shellfish ecology mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond the designed in measures outlined in section 9.10) is not significant in EIA terms.

Decommissioning Phase

Magnitude of Impact

104. Decommissioning activities within the Proposed Development fish and shellfish ecology study area may lead to temporary subtidal habitat loss/disturbance. The decommissioning activities includes jack-up vessels during foundation removal, removal of inter-array, interconnector and offshore export cables, and associated anchor placements during said cables removal. The maximum design scenario is for up to 34,571,200 m^2 of temporary habitat loss/disturbance is during the decommissioning phase (Table 9.15). This equates to 2.9% of the Proposed Development, with only a small proportion of this total area affected at any one time during the decommissioning phase. For the purposes of this assessment, the impacts of decommissioning are predicted to be similar to those for the construction phase (see paragraph 62 *et seq.*), although expected to be considerably less as seabed clearance may not be required.

105. The impact is predicted to be of local spatial extent (within the boundaries of the Proposed Development fish and shellfish ecology study area), medium term duration (although only a small proportion of the total area will be affected at any one time with individual elements of decommissioning having much shorter durations), intermittent and high reversibility. It is predicted that the impact will affect the receptor directly or indirectly, dependent on species' life strategies. The magnitude is therefore considered to be low.

Sensitivity of the Receptor

106. The sensitivity of the fish and shellfish IEFs, for both marine and diadromous species, can be found in the construction phase assessment (see paragraph 70 *et seq.*) ranging from negligible to medium sensitivity.

Significance of the Effect

Marine Species

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

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

109. For *Nephrops* and European lobster, the magnitude of the impact is deemed to be low and the sensitivity is considered to be medium. The effect will, therefore, be of **minor** adverse significance which is not significant in EIA terms. It should be noted that there is some conservatism in this conclusion, specifically:

Diadromous Species

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

Secondary Mitigation and Residual Effect

111. No additional fish and shellfish ecology mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond the designed in measures outlined in section 9.10) is not significant in EIA terms.

INCREASED SUSPENDED SEDIMENT CONCENTRATIONS AND ASSOCIATED SEDIMENT DEPOSITION

112. Increases in SSC and associated sediment deposition are predicted to occur during the construction and decommissioning phases as a result of seabed preparation, the installation/removal of foundations and installation/removal of inter-array, interconnector and offshore export cables. Increases in suspended sediments and associated sediment deposition are also predicted to occur during the operation and maintenance phase due to inter-array and offshore export cable repair and reburial events. Volume 3, appendix 7.1 provides a full description of the physical processes baseline characterisation, including numerical modelling used to inform the predictions made with respect to increases in suspended sediment and subsequent deposition.

Construction Phase

Magnitude of Impact

113. The installation of infrastructure within the Proposed Development fish and shellfish ecology study area may lead to increases SSC and associated sediment deposition. Full details of the modelling undertaken to inform this assessment is presented in volume 3, appendix 7.1, including the individual scenarios considered and assumptions within these and full modelling outputs for suspended sediments and associated sediment deposition. For the purposes of this assessment, the following activities have been considered:

- seabed feature clearance prior to cable installation;
- drilling for foundation installation; and
- inter-array, OSP/Offshore convertor substation platform interconnector, and offshore export cable installation.

114. Sand wave clearance for cable installation would involve disturbance of seabed material within a corridor of up to 25 m width for the 20% the Proposed Development offshore export cables, where it is necessary. Modelling of suspended sediments to quantify the potential increases in SSC and sedimentation during sand wave clearance simulated the use of a suction hopper dredger to remove material from the crest of sand waves and deposit material in the adjacent trough. Modelling associated with the site preparation showed a large variation. SSC reaches its peak in the disposal phase with concentrations reaching 2,500 mg/l at the release site, but the plume is at its most extensive when the deposited material is redistributed on the successive tides, under these circumstance concentrations of 100 mg/l to 250 mg/l have been modelled (see volume 3 appendix 7.1 for further details on modelling assumptions for SSC). The average SSC during the course of the clearance activities is presented in volume 3, appendix 7.1, with values less than 100 mg/l with a plume width of 10 km. Sedimentation of deposited material is focussed within 100 m of the site of release with a maximum depth 0.5 m – 0.75 m (this is considered within temporary habitat loss, see paragraph 62 *et seq.* and Table 9.15) whilst the finer sediment fractions are distributed in the vicinity at much lesser depths circa 5 mm – 10 mm within a range of hundreds of meters to a small number of kilometres. Sedimentation one day following cessation of operation is similar to during operation with a small extension to the area over which sedimentation has occurred but with no increase in maximum sedimentation depth (physical processes modelling detailed in volume 3, appendix 7.1). The dispersion of the released material would continue on successive tides and be incorporated into the baseline sediment transport regime, returning to background levels within a few tides.

115. The maximum design scenario for the inter-array cable sand wave clearance also accounts for up to a 25 m wide corridor. The resulting SSC showed similar characteristics to the offshore export cables clearance. At the Proposed Development array area, the greatest area of increased SSC was also shown to be associated with re-mobilisation of the deposited material on subsequent tides. In this scenario, the plume was found to extend 10 km from the site, with peak concentrations of 100 mg/l – 250 mg/l and average levels are less than 100 mg/l. Again, SSCs were predicted to reach their peak in the dumping phase with concentrations reaching 2,500 mg/l at the release site. The average sedimentation depth is typically half that of the offshore export cable works, with maximum sedimentation of 100 –m - 300 mm, which is only reached in very small areas along the Proposed Development export cable corridor, and almost all within the Proposed Development fish and shellfish ecology study area. The sedimentation one day following the cessation of the clearance operation shows deposited material at the site of release with depth 0.2 m – 0.4 m (this is considered within temporary habitat loss, see paragraph 62 *et seq.* and Table 9.15) whilst in the locality, lower depths, typically less than 5 mm, are present at 50 m distance from the release. The dispersion of the released material would continue on successive tides and be incorporated into the baseline sediment transport regime, returning to background levels within a few tides.

116. The maximum design scenario for foundation installation assumes all wind turbine and OSP/Offshore convertor substation platform foundations will be installed by drilling 5.5 m diameter piles for jacket foundations (Table 9.15). Drilling was modelled for three wind turbines at different locations in the Proposed Development array area. The locations represent the dominant physical environmental conditions experienced in the Proposed Development array area. Modelling of SSCs associated with the foundation installation showed the plume related directly to the sediment releases was less than 5 mg/l and this drops to lower levels within a very short distance, typically less than 500 m. Furthermore, these sediment plumes are predicted to be temporary, returning to background levels within a few tides. The maximum sedimentation depth is typically 0.05 mm to 0.1 mm during pile installation, with that maximum dropping to 0.0005 mm – 0.001 mm one day following cessation of operations. These demonstrate the dispersive nature of the site, dispersing material the full extent of the tidal excursion (12 km), and even using a very small contour interval this settlement would be imperceptible from the background sediment transport activity with plotted sediment depths less than typical grain diameters.

117. The maximum design scenario for the installation of inter-array and OSP/Offshore convertor substation platform interconnector cables assumes installation of all cables through jet trenching, with assumptions (e.g. trench width and depth) summarised in Table 9.15. Modelling was undertaken for installation of inter-array and OSP/Offshore convertor substation platform interconnector cables along a number of paths which connect groups of wind turbines to OSP/Offshore convertor substation platforms or connect two OSP/Offshore convertor substation platforms to each other. Each route would be undertaken as a separate operation and thus a single example has been selected to quantify the potential suspended sediment levels during the installation. The inter-array cabling was modelled along a route with a trench 2 m wide and 3 m in depth. The modelling outputs for SSCs associated with the installation of cabling showed a very wavy plume extending from trenching route, the majority of which sits within the Proposed Development array area. It is clear that the sediment is re-suspended and dispersed on subsequent tides as the plume envelope is most extensive towards the start of the route to the south-east of the site with peak values of 100 mg/l extending hundreds of meters to a small number of kilometres. The volume of material mobilised is relatively large, and elevated tidal currents disperse the material giving rise to concentrations of up to

500 mg/l. The sedimentation is greatest at the location of the trenching and may be up to 30 mm in depth however within close proximity, circa 100 m, the depths reduce significantly.

118. The modelling for offshore export cables also took a precautionary approach, assuming that cable installation would involve disturbance of seabed material up to 2 m wide and up to 3 m deep. Modelling outputs indicated average SSC along the route ranged between 50 mg/l and 500 mg/l. Average sedimentation peaks at 0.5 mm - 1.0 mm during offshore export cable installation and one day after cessation of operations this maximum increased to 10 mm - 30 mm, however this only accounts for a very small area with most of the impacted area displaying deposition depths considerably reduced at distance from the cable trench, returning to background levels within a few tides.

119. The impact is predicted to be of local spatial extent (i.e. largely within the Proposed Development fish and shellfish ecology study area boundaries), short term duration, intermittent during the construction phase and high reversibility. It is predicted that the impact will affect the receptors directly. The magnitude is therefore considered to be low.

Sensitivity of the Receptor

Marine Species

120. In terms of SSC, adult fish species are more mobile than many of the other fish and shellfish IEFs, and therefore may show avoidance behaviour within areas affected by increased SSC (EMU, 2004), making them less susceptible to physiological effects of this impact. Juvenile fish are more likely to be affected by habitat disturbances such as increased SSC than adult fish. This is due to the decreased mobility of juvenile fish and these animals are therefore less able to avoid impacts. Juvenile fish are likely to occur throughout the Proposed Development fish and shellfish ecology study area, with some species using offshore areas as nursery habitats while inshore areas are more important as nurseries for other species (see section 9.7 and volume 3 appendix 9.1). Due to the temporary increases in SSC associated with winter storm events and the occurrence of juveniles in inshore areas (where SSCs are typically higher), it can be expected that most fish juveniles expected to occur in the Proposed Development fish and shellfish ecology study area (see Table 9.11 for species with nursery grounds overlapping the Proposed Development fish and shellfish ecology study area) will be largely unaffected by the low level temporary increases in SSC, as the concentrations are likely to be within the range of natural variability (generally <5 mg/l but can increase to over 100 mg/l during storm events/increased wave heights) for these species and will reduce to background concentrations within a very short period (approximately two tidal cycles).

121. A study by Appleby and Scarratt (1989) found development of eggs and larvae have the potential to be affected by suspended sediments at concentrations of thousands of mg/l. Modelling undertaken of SSC associated with the Proposed Development fish and shellfish ecology study area construction phase identified peak maximum concentrations of 2,500 mg/l predicted in the dumping phase of sand wave clearance activities at the release site. These concentrations of SSC may affect the development of eggs and larvae, however, these concentrations are only expected to be present in the immediate vicinity of the release site with dispersion of the released material continuing on successive tides. Average increases in SSC associated with sand wave clearance activities are predicted to be of the order of less than 100 mg/l. These levels are unlikely to affect the development of eggs and larvae.

122. Many shellfish species, such as edible crab, have a high tolerance to SSC and are reported to be insensitive to increases in turbidity; however, they are likely to avoid areas of increased SSC as they rely on visual acuity during predation (Neal and Wilson, 2008). Berried crustaceans (e.g. European lobster and *Nephrops*) are likely to be more vulnerable to increased SSC as the eggs carried by these species require regular aeration. Increased SSC within the Proposed Development fish and shellfish ecology study area (potential habitat for egg bearing and spawning *Nephrops*, particularly along the Proposed Development export cable corridor) will only affect a small area at any one time and will be temporary in nature, with sediments settling to the seabed quickly following disturbance (see assessment of magnitude above). *Nephrops* are not considered to be sensitive to increases in SSC or subsequent sediment deposition, since this is a burrowing species with the ability to excavate any sediment deposited within their burrows (Sabatini and Hill, 2008).

123. The species likely to be affected by sediment deposition are those which either feed or spawn on or near the seabed. Demersal spawners within the Proposed Development fish and shellfish ecology study area include sandeel. Spawning areas for sandeel occur within the Proposed Development fish and shellfish ecology study area, however sandeel eggs are likely to be tolerant to some level of sediment deposition due to the nature of re-suspension and deposition within their natural high energy environment. Therefore, effects on sandeel spawning populations are predicted to be limited. Sandeel populations are also sensitive to sediment type within their habitat, preferring coarse to medium sands and showing reduced selection or avoidance of gravel and fine sediments (Holland *et al*., 2005). This is as identified by the FeAST tool as the pressure 'siltation changes' (low) which has identified that sandeel have medium sensitivity to this impact (Wright *et al*., 2000). Therefore, any increase in the fine sediment fraction of their habitat may cause avoidance behaviour until such time that currents remove fine sediments from the seabed, although modelled sediment deposition levels are expected to be highly localised and at very low levels (less than 10 mm).

124. With respect to the effects of sediment deposition on herring spawning activity, it has been shown that herring eggs may be tolerant of very high levels of SSC (Mesieh *et al*., 1981; Kiorbe *et al*., 1981). Detrimental effects may be seen if smothering occurs and the deposited sediment is not removed by the currents (Birklund and Wijsmam, 2005), however this would be expected to occur quickly (i.e. within a couple of tidal cycles) with such a small amount of sediment deposition being forecast. Furthermore, the relatively limited amount of suitable sediments for herring spawning and the mapping of the core herring spawning habitats well outside the Proposed Development fish and shellfish ecology study area would also limit the potential for effects on herring spawning.

125. Based on the increase in sensitivity of herring eggs to the smothering effects of increased sediment deposition, herring is deemed to be of medium vulnerability, high recoverability and of regional importance, and therefore the sensitivity of this receptor is considered to be medium.

126. All other fish and shellfish ecology IEFs in the Proposed Development fish and shellfish ecology study area are deemed to be of low to medium vulnerability, high recoverability and local to national importance. The sensitivity of these IEFs is therefore considered to be low.

Diadromous Species

127. Diadromous fish species known to occur in the area are also expected to have some tolerance to naturally high SSC, given their migration routes typically pass through estuarine habitats which have background SSC which are considerably higher than those expected in the offshore areas of the Proposed Development northern North Sea fish and shellfish ecology study area. As it is predicted that construction activities associated with the Proposed Development will produce temporary and short lived increases in SSC, with levels well below those experienced in estuarine environments, it would be expected that any diadromous species should only be temporarily affected (if they are affected at all). Any adverse effects on these species are likely to be short term behavioural effects (i.e. avoidance) and are not expected to create a barrier to migration to rivers or estuaries used by these species in the Proposed Development northern North Sea fish and shellfish ecology study area.

128. Diadromous fish species IEFs in the Proposed Development fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptors is therefore, considered to be low.

Significance of the Effect

Marine Species

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

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

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

Diadromous Species

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

Secondary Mitigation and Residual Effect

133. No additional fish and shellfish ecology mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond the designed in measures outlined in section 9.10) is not significant in EIA terms.

Operation and Maintenance Phase

Magnitude of Impact

134. Operation and maintenance activities within the Proposed Development fish and shellfish ecology study area will lead to an increase in SSCs and associated sediment deposition, including repair and reburial of inter-array, OSP/Offshore convertor substation platform interconnector and offshore export cables using similar methods as those for cable installation activities (e.g. jet trenching), undertaken at intervals during the 35-year operation and maintenance phase (see Table 9.15).

135. Any suspended sediments and associated deposition will be of the same magnitude as, or lower than, the construction phase. Volume 2, chapter 7 predicts the magnitude of SSC to be negligible and therefore, for the purposes of this assessment, the impacts of the operation and maintenance activities (i.e. cable repair and reburial) are predicted to be no greater than those for construction.

136. 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 receptors directly. The magnitude is therefore considered to be low.

Sensitivity of the Receptor

137. The sensitivity of the fish and shellfish IEFs, for both marine and diadromous species, can be found in the construction phase assessment (see paragraph 120).

Significance of the Effect

Marine Species

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

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

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

Diadromous Species

141. 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.

Secondary Mitigation and Residual Effect

142. No additional fish and shellfish ecology mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond the designed in measures outlined in section 9.10) is not significant in EIA terms.

Decommissioning Phase

Magnitude of Impact

143. Decommissioning of the infrastructure within the Proposed Development fish and shellfish ecology study area will lead to increases in SSCs and associated sediment deposition. The maximum design scenario is represented by the cutting and removal of piled substructures at an agreed depth below the level of the seabed for partial removal, removal of suction caisson foundations, removal of inter-array, OSP/Offshore convertor substation platform interconnector and offshore export cables using jet trenching which mobilises material from a depth of up to 3 m deep in a trench of up to 2 m wide.

144. Decommissioning of foundations is predicted to result in increases in suspended sediments and associated deposition that are no greater than those produced during construction, and likely to be smaller as seabed clearance is less likely to be required. For the purpose of this assessment, as described in volume 2, chapter 7, the impacts of decommissioning activities are predicted to be no greater than those for construction (see paragraph 113 *et seq.*).

145. 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.

Sensitivity of the Receptor

146. The sensitivity of the fish and shellfish IEFs, for both marine and diadromous species, can be found in the construction phase assessment (see paragraph 120 *et seq.*).

Significance of the effect

Marine Species

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

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

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

Diadromous Species

150. 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.

Secondary Mitigation and Residual Effect

151. No additional fish and shellfish ecology mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond the designed in measures outlined in section 9.10) is not significant in EIA terms.

INJURY AND/OR DISTURBANCE TO FISH AND SHELLFISH FROM UNDERWATER NOISE AND VIBRATION

Construction Phase

Magnitude of Impact

152. The installation of foundations within the Proposed Development fish and shellfish ecology study area may lead to injury and/or disturbance to fish and shellfish species due to underwater noise during pile driving. The maximum design scenario, as outlined in Table 9.15, considers the greatest effect from underwater noise on fish and shellfish IEFs, considering both the greatest hammer energy. This scenario is represented by the installation of up to 179 piled jacket foundations (1,432 piles) for wind turbines, and up to ten jacket foundations (256 piles) for OSP/Offshore convertor substation platforms, with each pile installed via impact/percussive piling. Two scenarios were modelled with respect to hammer energy: an average maximum hammer energy of 3,000 kJ and an absolute maximum hammer energy of up to 4,000 kJ.

153. For wind turbines, piling was assumed to take place over a period of on average nine hours per pile (maximum duration of up to ten hours per pile) with up to five piles installed in each 24-hour period. OSP/Offshore convertor substation platform foundations will take place over a period of on average seven hours per pile (maximum duration of up to eight hours per pile) with up to three piles installed in each 24-hour period. A maximum duration of 16,368 hours of piling activity, over a maximum 372-day period, may take place during the construction phase, based on the maximum duration of the piling phase.

154. UXO clearance (including detonation) also has the capability to cause injury and/or disturbance to fish and shellfish IEFs. Clearance will be completed prior to the construction phase (pre-construction). Until detailed pre-construction surveys are completed within the Proposed Development fish and shellfish ecology study area, the precise number of potential UXO which will need to be cleared is unknown. Drawing on the experience of UXO at other North Sea sites, the maximum number of UXO that may require clearance is up to 14 for the Proposed Development. The maximum design scenario assumes that each of these will be detonated using low order processes, with the assumption that one high order detonation may occur (see Table 9.15). Many of these may be left *in situ* and microsited around. Detonation of UXO would represent a short term (i.e. seconds) increase in underwater noise (i.e. sound pressure levels and particle motion) which will be elevated to levels which may result in injury or behavioural effects on fish and shellfish species (discussed further in paragraph 159 *et seq.*).

155. To understand the magnitude of noise emissions from piling and UXO clearance during construction activity, underwater noise modelling has been undertaken considering the key parameters summarised above. Full details of the modelling undertaken are presented in volume 3, appendix 10.1.

156. Piling activities were modelled for jacket foundations at six locations within the Proposed Development fish and shellfish ecology study area array area taking into account the varying bathymetry and sediment type across the model areas (see volume 3, appendix 10.1). Underwater noise modelling included the use of 'soft start' mitigation to reduce the potential for injury effects (as set out in Table 9.20). The implications of the modelling for fish and shellfish injury and behaviour are outlined in the following sensitivity section.

157. All other noise sources including cable installation and foundation drilling are non-percussive and will result in much lower noise levels and therefore much smaller injury ranges (in most cases no injury is predicted) than those predicted for piling operations. For further information on other noise sources see volume 3, appendix 10.1.

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

Sensitivity of the Receptor

159. The following sections apply to both marine fish and shellfish species, and diadromous fish species, with a summary for each of these receptor groups in paragraphs 185 to 196.

160. Underwater noise can potentially have an adverse impact on fish species ranging from physical injury/mortality to behavioural effects. Recent peer reviewed guidelines have been published by the Acoustical Society of America (ASA) and provide directions and recommendations for setting criteria (including injury and behavioural criteria) for fish. The Sound Exposure Guidelines for Fishes and Sea Turtles (Popper *et al*., 2014) are considered to be most relevant and best available guidelines for impacts of underwater noise on fish species (see volume 3, appendix 10.1). The Popper *et al*. (2014) guidelines broadly group fish into the following categories according to the presence or absence of a swim bladder and on the potential for that swim bladder to improve the hearing sensitivity and range of hearing (Popper *et al*., 2014):

- Group 1: Fishes lacking swim bladders (e.g. elasmobranchs and flatfish). These species are only sensitive to particle motion, not sound pressure and show sensitivity to only a narrow band of frequencies;
- Group 2: Fishes with a swim bladder but the swim bladder does not play a role in hearing (e.g. salmonids and some Scombridae). These species are considered to be more sensitive to particle motion than sound pressure and show sensitivity to only a narrow band of frequencies;
- Group 3: Fishes with swim bladders that are close, but not connected, to the ear (e.g. gadoids and eels). These fishes are sensitive to both particle motion and sound pressure and show a more extended frequency range than Groups 1 and 2, extending to about 500 Hz; and

- Group 4: Fishes that have special structures mechanically linking the swim bladder to the ear (e.g. clupeids such as herring, sprat and shads). These fishes are sensitive primarily to sound pressure, although they also detect particle motion. These species have a wider frequency range, extending to several kHz and generally show higher sensitivity to sound pressure than fishes in Groups 1, 2 and 3.

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

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

Injury

163. Table 9.21 summarises the fish injury criteria recommended for pile driving based on the Popper *et al. (*2014) guidelines, noting that dual criteria are adopted in these guidelines to account for the uncertainties associated with effects of underwater noise on fish.

Table 9.21: Criteria for Onset of Injury to Fish due to Impulsive Piling (Popper *et al*., 2014)

Group	Type of Animal	Parameter	Mortality and Potential Mortal Injury	Recoverable Injury
1	Fish: no swim bladder (particle motion detection)	SEL, dB re 1 µPa²s	>219	>216
		Peak, dB re 1 µPa	>213	>213
2	Fish: where swim bladder is not involved in hearing (particle motion detection)	SEL, dB re 1 µPa²s	210	203
		Peak, dB re 1 µPa	>207	>207
3 and 4	Fish: where swim bladder is involved in hearing (primarily pressure detection)	SEL, dB re 1 µPa²s	207	203
		Peak, dB re 1 µPa	>207	>207
N/A	Eggs and larvae	SEL, dB re 1 µPa²s	>210	(*Near*) Moderate[a] (*Intermediate*) Low (*Far*) Low
		Peak, dB re 1 µPa	>207	

[a] Relative risk (high, moderate, low) is given for animals at three distances from the source defined in relative terms as near field (N; i.e. 10s of metres), intermediate (I; i.e. 100s of metres), and far field (F; i.e. 1000s of metres); Popper *et al*. (2014).

164. The full results of the underwater noise modelling are presented in volume 3, appendix 10.1. For the purpose of this assessment, a conversion factor range of 0.5 to 4% was applied as this represents an adequately conservative range for which energy from piling is transferred into sound energy. It should be noted that sensitivity analysis was undertaken on other, more conservative conversion factors, which is presented in volume 3, appendix 10.1. In order to inform this assessment, Table 9.22 and Table 9.23 display the predicted injury ranges associated with the installation of one 5.5 m diameter pile, for peak sound pressure levels (SPL_{pk}) and cumulative sound exposure level (SEL_{cum}) respectively. This modelled scenario resulted in the greatest predicted injury ranges and therefore forms the focus of the assessment for injury.

165. For peak pressure noise levels when piling energy is at its maximum (i.e. 4,000 kJ), mortality and recoverable injury to fish may occur within approximately 138 m – 228 m of the piling activity (lower estimate for Group 1 fish species, higher estimate for Group 4 species). The potential for mortality or mortal injury to fish eggs would also occur at distances of up to 228 m (Table 9.22), with a low to moderate risk of recoverable injury to eggs and larvae within the range of hundreds of metres (see Table 9.21 for qualitative criteria). It should be noted that these ranges are the maximum ranges for the maximum hammer energy, and it is unlikely that injury will occur in this range due to the implementation of soft starts during piling operations, which will allow fish to move away from the areas of highest noise levels, before they reach a level that would cause an injury. The initial injury ranges for soft start initiation will be considerably smaller than those maximum ranges presented in Table 9.22 (i.e. of the order of tens of metres, depending on the fish species considered).

166. For cumulative SEL, injury ranges were calculated for piling activities undertaken for the maximum energy scenario and for a realistic hammer energy scenario (i.e. average maximum; Table 9.23). These ranges indicate that with the implementation of soft start initiation, the mortality and recoverable injury ranges are considerably smaller than those predicted for SPL_{pk} (i.e. mortality thresholds were not exceeded and recoverable injury to maximum ranges of 67 m; see Table 9.23). This table also presents ranges of effect for Temporary Threshold Shift (TTS) for all fish groups. As outlined above, TTS is a temporary reduction in hearing sensitivity caused by exposure to intense sound. Normal hearing ability returns following cessation of the noise causing TTS, though the recovery period is variable, during which fish may have decreased fitness due to a reduced ability to communicate, detect predators or prey, and/or assess their environment. Table 9.24 presents the ranges at which TTS in fish may occur as a result of piling for one 5.5 m pile, with TTS predicted to occur to maximum ranges of 4,161 m from piling operations (smaller ranges for basking shark and the realistic maximum hammer energy).

167. The injury ranges presented indicate that injury may occur out to ranges of tens to a few hundred metres, based on the maximum design scenario. However, in reality, the risk of fish injury will be considerably lower due to the hammer energies being lower than the absolute maximum modelled, as demonstrated by the lower injury ranges associated with initiation and soft starts in Table 9.22. The expected fleeing behaviour of fish from the area affected when exposed to high levels of noise and the soft start procedure, which will be employed for all piling (see Table 9.20), mean that it is likely that fish will have sufficient time to vacate the areas where injury may occur prior to noise levels reaching that level.

Table 9.22: Summary of Peak Pressure Injury Ranges for Fish due to Phase of Impact Piling resulting in Maximum Peak Sound Pressure Level, for both Wind Turbine Foundations and OSP/Offshore Convertor Substation Platform Foundations Based on the Peak Pressure Metric

Hearing group	Response	Threshold (SPL_{pk}, dB re 1 µPa)	Range (m)	
			Wind Turbine - Max Energy and OSP/Offshore convertor substation platform	Wind Turbine - Realistic Energy
Group 1 Fish: No swim bladder (particle motion detection)	Mortality	213	138	119
	Recoverable injury	213	138	119
Group 2 Fish: Swim bladder not involved in hearing (particle motion detection)	Mortality	207	228	196
	Recoverable injury	207	228	196
Group 3 and 4 Fish: Swim bladder involved in hearing (primarily pressure detection)	Mortality	207	228	196
	Recoverable injury	207	228	196
Fish eggs and larvae	Mortality	207	228	196

Table 9.23: Injury Ranges for Fish due to Impact Pile Driving for the "Realistic" and "Maximum" Pile Driving for Wind Turbine Jacket Foundations, and for the Piling of the OSP/Offshore Convertor Substation Platform Jackets Based on the Cumulative SEL Metric (N/E Denotes where Thresholds are not Exceeded)

Hearing group	Response	Threshold (SEL, dB re 1 µPa²s)	Range (m)		
			Wind Turbine Max Energy	Wind Turbine Realistic Energy	OSP/Offshore Convertor Substation Platform
Group 1 Fish: No swim bladder (particle motion detection) – [*basking shark ranges shown in square brackets*].	Mortality	219	N/E	N/E	N/E
	Recoverable injury	216	N/E	N/E	N/E
	TTS	186	4,161 [2,219]	3,183 [1,609]	3,900 [2,165]
Group 2 Fish: Swim bladder not involved in hearing (particle motion detection)	Mortality	210	19	N/E	19
	Recoverable injury	203	67	53	67
	TTS	186	4,161	3,183	3,943
Group 3 and 4 Fish: Swim bladder involved in hearing (primarily pressure detection)	Mortality	207	33	26	33
	Recoverable injury	203	6	53	67
	TTS	186	4,161	3,183	3,943
Fish eggs and larvae (static)	Mortality	210	495	4	439

168. Noise modelling was also undertaken for the concurrent piling of wind turbine foundations or wind turbine and OSP/Offshore convertor platform foundations. As outlined in volume 3, appendix 10.1, mortality and recoverable injury ranges were unchanged for the concurrent piling scenario and therefore TTS ranges only are presented in Table 9.24. This indicates that for concurrent piling, TTS ranges may be increased to up to 7.1 km from the piling location and 5.6 km for realistic hammer energy.

Table 9.24: TTS Injury Ranges for Fish due to Impact Pile Driving at Two Locations Concurrently, for the "Realistic" and "Maximum" Pile Driving for Wind Turbine Jacket Foundations Based on the Cumulative SEL Metric

Hearing group	Response	Threshold (SEL, dB re 1 µPa²s)	Range	
			Wind Turbine Max Energy	Wind Turbine Realistic Energy
Group 1 Fish: No swim bladder (particle motion detection) – [*basking shark ranges shown in square brackets*].	TTS	186	7.1 km [4.3 km]	5.6 km [3.3 km]
Group 2 Fish: Swim bladder not involved in hearing (particle motion detection)	TTS	186	7.1 km	5.6 km
Group 3 and 4 Fish: Swim bladder involved in hearing (primarily pressure detection)	TTS	186	7.1 km	5.6 km

169. Underwater noise modelling has also been completed for underwater noise associated with UXO clearance/detonation. Modelling was undertaken for a range of orders of detonation, from a realistic worse case high order detonation to low order detonations (e.g. deflagration and clearance shots) to be used as mitigation to minimise noise levels. Table 9.25 details the injury ranges for fish of all groups in relation to various orders of detonation. The method of low order has been committed to (see Table 9.20) and as such will be the dominant method of UXO clearance, although higher order detonations may also occur if low order is not successful or unintentionally as part of the low order process.

Table 9.25: Injury Ranges for all Fish Groups Relating to Varying Orders of Detonation

Detonation Size (kg)	Mortality		Recoverable Injury	TTS
	Threshold (m)	Range (m)		
0.08 (deflagration)	229 - 234	30 – 45	(*Near*) High (Intermediate) Low (*Far*) Low	(*Near*) High (Intermediate) Moderate-High (*Far*) Low
0.5 (clearance shot)	229 - 234	50 - 80	(*Near*) High (Intermediate) Low (*Far*) Low	(*Near*) High (Intermediate) Moderate-High (*Far*) Low
300 (high order)	229 - 234	410 - 680	(*Near*) High (Intermediate) Low (*Far*) Low	(*Near*) High (Intermediate) Moderate-High (*Far*) Low

170. Of the key shellfish species of the Proposed Development fish and shellfish ecology study area, decapod crustaceans (e.g. European lobster and crab) are believed to be physiologically resilient to noise as they lack gas filled spaces within their bodies (Popper *et al*., 2001). To date no lethal effects of underwater noise have been described for edible crab, European lobster or *Nephrops*, however a number of sub-lethal physiological effects have been reported among *Nephrops* and related species. In a report by Christian *et al*. (2003), no significant difference was found between acute effects of seismic airgun exposure (a similar impulsive high amplitude noise source to piling; >189 dB re 1 µPa (peak–peak) @ 1 m) upon adult snow crabs *Chionoecetes opilio* in comparison with control crabs. Another study investigated whether there was a link between seismic surveys and changes in commercial rock lobster *Panulirus cygnus* based on rates associated with acute to mid-term mortality over a 26-year period. This found no statistically significant correlative link (Parry and Gason, 2006).

171. Sub-lethal physiological effects have been identified from impulsive noise sources including bruised hepatopancreas and ovaries in snow crab exposed to seismic survey noise emissions (at unspecified SPLs) (DFO, 2004). Changes in serum biochemistry and hepatopancreatic cells (Payne *et al*., 2007), increase in respiration in brown shrimp *Crangon crangon* (Solan *et al*., 2016) and metabolic rate changes in green shore crab *Carcinus maenas* have also been identified.

172. In terms of shellfish eggs and larvae there is no direct evidence to suggest they are at risk of direct harm from high amplitude anthropogenic underwater noise such as piling (Edmonds *et al*., 2016). Of the few studies that have focussed on the eggs and larvae of shellfish species, evidence of impaired embryonic development and mortality has been found to arise from playback of seismic survey noise among gastropod and bivalve species (De Soto *et al*., 2013, Nedelec *et al*., 2014). There is limited information on the effect of impulsive sound upon crustacean eggs, and no research has been conducted on commercially exploited decapod species in the UK. Of the evidence that is available all studies focus on the impact of seismic noise. Preliminary findings show that seismic exposure could be implicated in delayed hatching of snow crab eggs, causing resultant larvae to be smaller than controls (DFO, 2004) and Pearson *et al*. (1994) found no statistically significant difference between the mortality and development rates of stage II

Dungeness crab *Metacarcinus magister* larvae exposed to single field-based discharges (231 dB re 1 µPa (zero-peak) @ 1 m) from a seismic airgun.

173. While the evidence described above from species specific studies and primarily laboratory based experiments have shown some effects on shellfish species (although lower level effects compared to fish species), another recent study examined the effects on catch rates of European lobster of a temporary closure of lobster fishing grounds during offshore wind farm construction (including piling) (Roach *et al*., 2018). Monitoring data at the Westermost Rough Offshore Wind Farm located on the north-east coast of England found that the size and abundance of European lobster increased following temporary closure of the area while construction was undertaken. This study shows that the activities associated with construction of the wind farm, which included piling of foundations for 80 wind turbines, did not impact on the resident European lobster populations and instead allowed some respite from fishing activities for a short period time before reopening following construction (Roach *et al*., 2018). The results of this study strongly suggest that population level injury effects on shellfish species will not occur due to piling operations.

Behaviour

174. Behavioural effects in response to construction related underwater noise include a wide variety of responses including startle responses (also known as C-turn responses), strong avoidance behaviour, changes in swimming or schooling behaviour or changes of position in the water column. The Popper *et al*. (2014) guidelines provide qualitative behavioural criteria for fish from a range of noise sources. These categorise the risks of effects in relative terms as "high", "moderate" or "low" at three distances from the source: "near" (i.e. tens of metres), "intermediate" (i.e. hundreds of metres) or "far" (i.e. thousands of metres). The behavioural criteria for piling operations are summarised in Table 9.26 for the four fish groupings.

Table 9.26: Potential Risk for the Onset of Behavioural Effects in Fish from Piling (Popper *et al*., 2014)[a]

Type of fish	Masking[a]	Behaviour[a]
Group 1 Fish: no swim bladder (particle motion detection)	N: Moderate risk I: Low risk F: Low risk	N: High risk I: Moderate risk F: Low risk
Group 2 Fish: swim bladder is not involved in hearing (particle motion detection)	N: Moderate risk I: Low risk F: Low risk	N: High risk I: Moderate risk F: Low risk
Groups 3 and 4 Fish: swim bladder involved in hearing (pressure and particle motion detection)	N: High risk I: High risk F: Moderate risk	N: High risk I: High risk F: Moderate risk
Eggs and larvae	N: Moderate risk I: Low risk F: Low risk	N: Moderate risk I: Low risk F: Low risk

[a] Note: Relative risk (high, moderate, low) is given for animals at three distances from the source defined in relative terms as near field (N; i.e. 10s of metres), intermediate (I; i.e. 100s of metres), and far field (F; i.e. 1000s of metres); Popper *et al*. (2014).

175. Group 1 Fish (e.g. flatfish and elasmobranchs), Group 2 Fish (e.g. salmonids) and shellfish are less sensitive to sound pressure, with these species detecting sound in the environment through particle motion. However, sensitivity to particle motion in fish is also more likely to be important for behavioural responses rather than injury (Hawkins, 2009; Mueller-Blenkle *et al*., 2010; Hawkins *et al*., 2014a). Group 3 (including gadoids such as cod and whiting) and Group 4 fish (sprat) are more sensitive to the sound pressure component of underwater noise and, as indicated in Table 9.26 the risk of behavioural effects in the intermediate and far fields are therefore greater for these species.

176. A number of studies have examined the behavioural effects of the sound pressure component of impulsive noise (including piling operations and seismic airgun surveys) on fish species. Mueller-Blenkle *et al*. (2010) measured behavioural responses of cod and sole to sounds representative of those produced during marine piling, with considerable variation across subjects (i.e. depending on the age, sex, condition etc. of the fish, as well as the possible effects of confinement in cages on the overall stress levels in the fish). This study concluded that it was not possible to find an obvious relationship between the level of exposure and the extent of the behavioural response, although an observable behavioural response was reported at 140 dB to 161 dB re 1 µPa SPL_{pk} for cod and 144 dB to 156 dB re 1 µPa SPL_{pk} for sole. However, these thresholds should not be interpreted as the level at which an avoidance reaction will be elicited, as the study was not able to show this.

177. A study by Pearson *et al*. (1992) on the effects of geophysical survey noise on caged rockfish *Sebastes spp.* observed a startle or "C-turn response" at peak pressure levels beginning around 200 dB re 1 µPa, although this was less common with the larger fish. Studies by Curtin University in Australia for the oil and gas industry by McCauley *et al*. (2000) exposed various fish species in large cages to seismic airgun noise and assessed behaviour, physiological and pathological changes. The study made the following observations:

- a general fish behavioural response to move to the bottom of the cage during periods of high level exposure (greater than RMS levels of around 156 dB to 161 dB re 1 µPa; approximately equivalent to SPL_{pk} levels of around 168 dB to 173 dB re 1 µPa);
- a greater startle response by small fish to the above levels;
- a return to normal behavioural patterns some 14 to 30 minutes after airgun operations ceased;
- no significant physiological stress increases attributed to air gun exposure; and
- some preliminary evidence of damage to the hair cells when exposed to the highest levels, although it was determined that such damage would only likely occur at short range from the source.

178. The authors did point out that any potential seismic effects on fish may not necessarily translate to population scale effect or disruption to fisheries and McCauley *et al*. (2000) show that caged fish experiments can lead to variable results. While these studies are informative to some degree, these, and other similar studies, do not provide an evidence base that is sufficiently robust to propose quantitative criteria for behavioural effects (Hawkins and Popper, 2016; Popper *et al*., 2014) and as such the qualitative criteria outlined in Table 9.26 are proposed.

179. For the purposes of the underwater noise modelling (volume 3, appendix 10.1), an un-weighted sound pressure level of 150 dB re 1 µPa (RMS) was used as the criterion for indicating the extent of behavioural effects due to impulsive piling based on the Washington State Department of Transport Biological Assessment Preparation for Transport Projects Advanced Training Manual (WSDOT, 2011). At sound pressure levels in excess of 150 dB re 1 µPa (RMS) temporary behavioural changes, such as elicitation of a startle response, disruption of feeding, or avoidance of an area may be expected to occur. It is important to note that this threshold is for onset of potential effects, and not necessarily an 'adverse effect' threshold and should be considered alongside other information (including those studies outlined above) in addition to the qualitative criteria set out by Popper *et al*. (2014) in Table 9.26. Using this criterion, site specific modelling indicated that behavioural responses may occur to ranges of approximately 17 km for single pile driving and 23 km for concurrent piling (volume 3, appendix 10.1).

180. Initial outputs of post construction monitoring at the Beatrice Offshore Wind Farm (BOWL, 2021a) concluded that for sandeel there was no evidence of adverse effects on sandeel populations between pre and post construction levels over a six year period (as described in paragraph 80). Cod spawning was also monitored at the same wind farm site (BOWL, 2021b) and similarly, it was concluded that there was no change in the presence of cod spawning between pre and post construction (although spawning intensity was found to be low across both surveys). From these studies, it can be inferred that noise impacts

associated with installation of an offshore wind development are temporary and that fish communities (specifically cod and sandeel in this case) show a high degree of recoverability following construction.

181. As set out in previous sections, information on the impact of underwater noise on marine invertebrates is scarce, and no attempt has been made to set exposure criteria (Hawkins *et al*., 2014b). Studies on marine invertebrates have shown their sensitivity to substrate borne vibration (Roberts *et al*., 2016). Aquatic decapod crustaceans are equipped with a number of receptor types potentially capable of responding to the particle motion component of underwater noise (e.g. the vibration of the water molecules which results in the pressure wave) and ground borne vibration (Popper *et al*., 2001). It is generally their hairs which provide the sensitivity, although these animals also have other sensor systems which could be capable of detecting vibration. It has also been reported that sound wave signature of piling noise can travel considerable distances through sediments (Hawkins and Popper, 2016), with implications for demersal and sediment dwelling fish (e.g. sandeel) and shellfish (e.g. *Nephrops*) in close proximity to piling operations. Sandeel may be particularly affected by vibration through the seabed during winter hibernation when they remain buried in sandy sediments.

182. *Nephrops* have been found to bury less deeply, flush their burrows less regularly and are considerably less active when exposed to impulsive anthropogenic noise (Solan *et al*., 2016). *Nephrops* also showed reduced movement and burrowing behaviour in response to simulative shipping and construction noise, however, simulated shipping noise had no effect on the physiology of *Nephrops* (Solan *et al*., 2016). Another study on brown shrimp *Crangon crangon* revealed elevated SPL are implicated in increased incidences of cannibalism and significantly delayed growth (Lagardère and Spérandio, 1981). Simulated shipping noise has been demonstrated to cause some individuals of common shore crab to cease feeding (Wale *et al*., 2013). The mud crab *Scylla paramamosain* and European spiny lobsters *Palinurus elephas* have been reported to have aspects of life history disrupted by anthropogenic noise (e.g. movement and anti-predation behaviour). In contrast to *Nephrops*, increased movement has been seen in these species in response to simulated shipping noise and offshore activities (Filiciotto *et al*., 2016; Zhou *et al*., 2016). Such findings have implications with regard to species fitness, stress and compensatory foraging requirements, along with increased exposure to predators.

183. However as set out above, monitoring of European lobster catch rates at the Westermost Rough Offshore Wind Farm indicated that population level effects on shellfish species did not occur (Roach *et al*., 2018). While there may be some residual uncertainty with regard to behavioural effects while piling operations are ongoing, the evidence suggests that long term effects will not occur, and any effects will be reversible.

184. Scott *et al*. (2020) provides the most recent review of the existing published literature on the influence of anthropogenic noise and vibration and on crustaceans. The review concluded that some literature sources identified behavioural and physiology effects on crustaceans from anthropogenic noise, however, there were several that showed no effect. The paper notes that to date no effect or influence of noise or vibrations has been reported on mortality rates or fisheries catch rates or yields. In addition, no studies have indicated a direct effect of anthropogenic noise on mortality, immediate or delayed (Scott *et al*., 2020).

Summary – Marine Species

185. Injury and/or mortality for all fish species is to be expected for individuals within very close proximity to piling operations, shellfish species injury is expected to be similar however there is some evidence injury may occur at smaller ranges as they may be less sensitive to noise impacts. However, this is unlikely to result in significant mortality due to soft start procedures allowing individuals in close proximity to flee the area prior to maximum hammer energy levels which may cause injury to greater ranges.

186. In contrast, behavioural effects are expected over much larger ranges, as discussed above. To illustrate this, Figure 9.6 to Figure 9.9 show the modelled underwater noise levels for SPL_{pk} based on the results from volume 3 appendix 10.1, relative to key fish spawning habitats in the vicinity of the Proposed Development fish and shellfish ecology study area. Figure 9.6 and Figure 9.7 show noise contours for two hammer energies (i.e. the maximum 4,000 kJ hammer energy and the average maximum hammer energy of 3,000 kJ, respectively) at the south-west location and Figure 9.8 and Figure 9.9 show the same for the northern piling location. The north and south-west piling locations were chosen as locations which were closest to the most sensitive habitats/areas: the northern location due to its proximity to herring spawning grounds to the north; the south-west as it is closest to the coastline and most likely to cause barrier effects to diadromous species at that location.

187. Noting that there are no published or agreed thresholds for behavioural effects on fish from piling operations, these figures suggest that behavioural responses will extend over ranges of 10 km to 20 km; for example, assuming avoidance occurs at levels in excess of 160 dB re 1 µPa SPL_{pk}, which is a lower threshold than the levels at which behavioural effects in fish were detected (including McCauley *et al*., 2000). These results broadly align with qualitative thresholds for behavioural effects on fish as set out in Table 9.26, with moderate risk of behavioural effects in the range of hundreds of metres to thousands of metres from the piling activity, depending on the species. This is also in line with criterion used in site specific modelling, which predicted behavioural effects to approximately 17 km to 23 km, based on a threshold of 150 dB re 1 µPa (RMS) (see paragraph 179).

188. With respect to marine species, the key habitats for these species are spawning and nursery habitats, as set out volume 3, appendix 9.1. Although spawning and nursery habitats are present within the Proposed Development fish and shellfish ecology study area (see Table 9.11) and the ZoI of underwater noise from piling, these habitats extend over a very wide area across the Proposed Development northern North Sea fish and shellfish ecology study area. The relative proportion of these habitats affected by piling operations at any one time will therefore be small in the context of the wider habitat available. Further, as outlined above, piling operations will be temporary and intermittent throughout the construction phase of the Proposed Development.

189. Herring are known to be particularly sensitive to underwater noise and have specific habitat requirements for spawning (see section 9.7 and volume 3, appendix 9.1) which makes them particularly vulnerable to impacts associated with construction related underwater noise. The core herring spawning grounds in the ZoI of the Proposed Development sit to the north of the Proposed Development fish and shellfish ecology study area (see volume 3, appendix 9.1). At maximum hammer energy (4,000 kJ) for the north piling location (closest to mapped herring core spawning grounds), there is minimal overlap of the noise contours into the spawning area (see Figure 9.8). Where there is overlap with mapped noise contours, these are at the lower range of noise level (e.g. 130-140 dB re 1 µPa SPL_{pk}) which is considerably lower than levels expected to cause any behavioural effects, as previously discussed.

190. Other species with spawning grounds in the vicinity of the Proposed Development fish and shellfish ecology study area (e.g. sandeel, cod and sprat) have a greater level of overlap with higher noise levels exist within the spawning areas. However, the area of overlap is small in comparison to the extensive nature of the spawning habitats around the Scottish and UK coast. Further, as discussed in paragraph 80, initial outputs of monitoring from the Beatrice Offshore Wind Farm indicate that following cessation of construction operations (including piling) that both cod and sandeel have recovered into any areas potentially affected by construction related underwater noise.

191. Most marine fish IEFs species in the Proposed Development fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and local to national importance. The sensitivity of the receptor is therefore, considered to be low.

192. Herring, sprat, cod and sandeel are deemed to be of medium vulnerability, high recoverability and regional to national importance. The sensitivity of the receptor is therefore, considered to be medium.

193. European lobster, *Nephrops* and edible crab are deemed to be of low vulnerability, high recoverability and regional importance. The sensitivity of the receptor is therefore, considered to be low.

Summary – Diadromous Species

194. As with marine species, diadromous fish species within close proximity to piling operations may experience injury or mortality. However, the nature of diadromous fish species being highly mobile and tending to only utilise the environment within the Proposed Development fish and shellfish ecology study area to pass through during migration, it is unlikely to result in significant mortality of diadromous species. The use of soft start piling procedures (see Table 9.20), allowing individuals in close proximity to piling to flee the ensonified area, further reduces the likelihood of injury and mortality on diadromous species.

195. Diadromous fish species may experience behavioural effects in response to piling noise, including a startle response, disruption of feeding, or avoidance of an area. As discussed in preceding sections, these would be expected to occur at ranges of 10 km to 20 km, depending on the species and their relative sensitivities to underwater noise (i.e. in order of lowest to highest sensitivities: lamprey species, Atlantic salmon and sea trout, European eel and shad species). Research from Harding *et al.* (2016) failed to produce physiological or behavioural responses in Atlantic salmon when subjected to noise similar to piling. However, the noise levels tested were estimated at <160 dB re 1 µPa RMS, below the level at which injury or behavioural disturbance would be expected for Atlantic salmon. Due to the distance between the Proposed Development array area and the coast, these behavioural impacts are unlikely to cause barrier effects between the Proposed Development fish and shellfish ecology study area and the migration routes of diadromous species along the east coast of Scotland, due to the relatively small area around piling events where noise levels are high enough to cause behavioural responses (as demonstrated in Figure 9.6 to Figure 9.9). This is the case for both downstream migration of smolts and upstream migration of adults. The low risk of effects on migration of diadromous fish species extends to the freshwater pearl mussel, which is included in the diadromous species section, as part of its life stage is reliant on diadromous fish species including Atlantic salmon and sea trout.

196. Diadromous fish species IEFs in the Proposed Development fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is therefore, considered to be low.

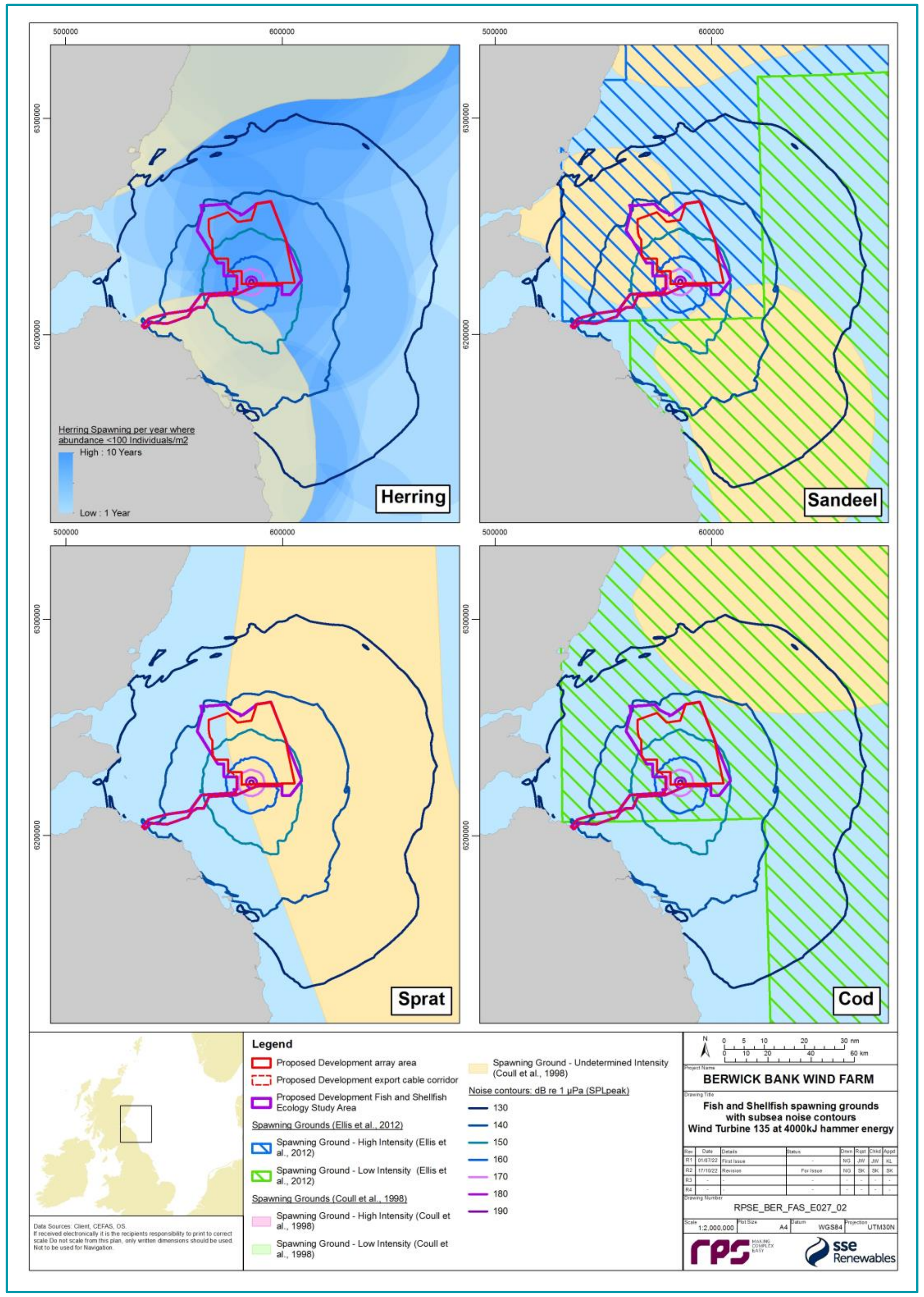

Figure 9.6: **Spawning Habitats for Herring, Sandeel, Sprat and Plaice with Underwater Noise Contours (Unweighted SPL_{pk}) Associated with the Southwest Piling Location at 4,000 kJ Hammer Energy**

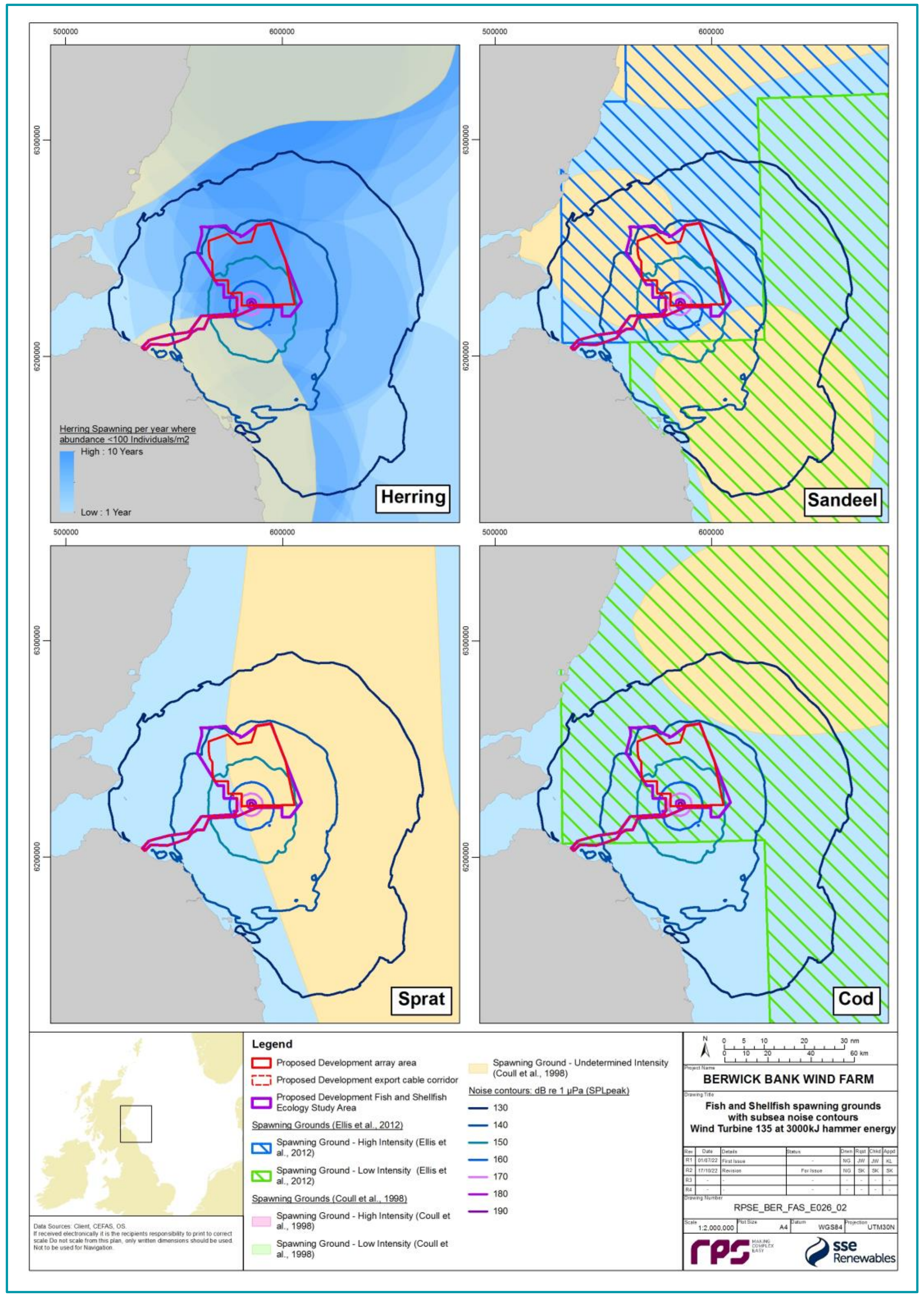

Figure 9.7: Spawning Habitats for Herring, Sandeel, Sprat and Plaice with Underwater Noise Contours (Unweighted SPL_{pk}) Associated with the Southwest Piling Location at 3,000 kJ Hammer Energy

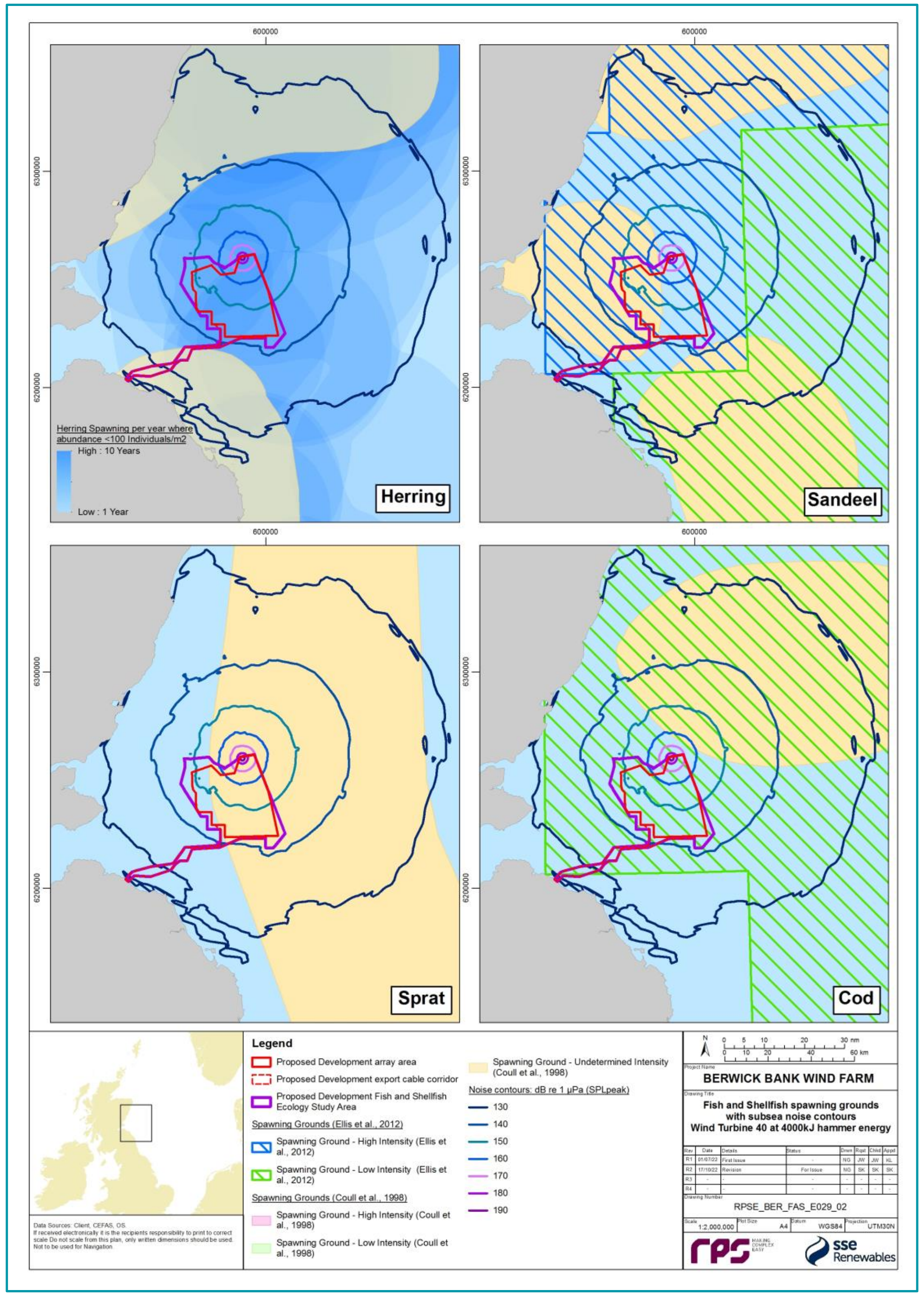

Figure 9.8: Spawning Habitats for Herring, Sandeel, Sprat and Plaice with Underwater Noise Contours (Unweighted SPL_{pk}) Associated with the Northern Piling Location at 4,000 kJ Hammer Energy

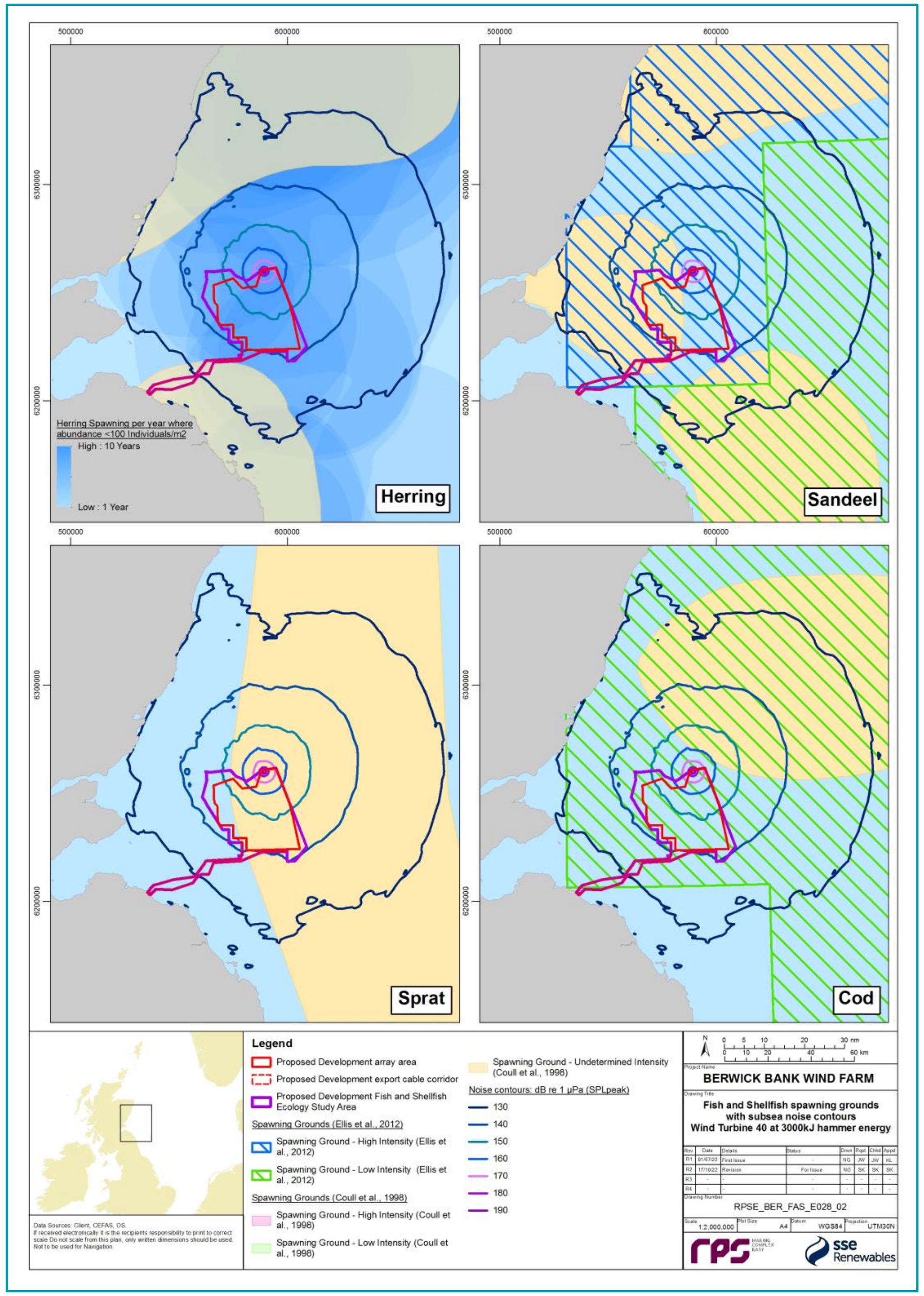

Figure 9.9: Spawning Habitats for Herring, Sandeel, Sprat and Plaice with Underwater Noise Contours (Unweighted SPL_{pk}) Associated with the Northern Piling Location at 3,000 kJ Hammer Energy

<u>Significance of the Effect</u>

Marine Species

197. For most fish and shellfish IEF species, 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.

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

199. For European lobster, *Nephrops* and edible crab 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 Species

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

201. Similarly, for freshwater pearl mussel, as migration of Atlantic salmon and sea trout will not be significantly affected, effects on freshwater pearl mussel will be of **negligible** adverse significance, which is not significant in EIA terms.

<u>Secondary Mitigation and Residual Effect</u>

202. No additional fish and shellfish ecology mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond the designed in measures outlined in section 9.10) is not significant in EIA terms.

LONG-TERM SUBTIDAL HABITAT LOSS

203. Long-term subtidal habitat loss within the Proposed Development fish and shellfish ecology study area will occur during construction (i.e. through placement of infrastructure) although effects will extend throughout the operation and maintenance phase (Table 9.15). Long-term habitat loss will occur directly under all wind turbine and OSP/Offshore convertor substation platform foundation structures (suction caisson and piled jacket foundations respectively), associated scour protection and cable protection (including at cable crossings) where this is required. The magnitude has been considered for both construction and operation and maintenance phases combined as the structures will be placed during construction and will be in place during the operation and maintenance phase. This impact also considers the habitat loss occurring during the decommissioning phase based on the maximum design scenario that scour and cable protection may be left *in situ* following decommissioning.

Construction and Operation and Maintenance Phase

<u>Magnitude of Impact</u>

204. The presence of infrastructure within the Proposed Development fish and shellfish ecology study area will result in long term habitat loss. The maximum design scenario is for up to 7,798,856 m^2 of long term habitat loss due to the installation of foundations and associated scour protection and cable protection associated with array, OSP/Offshore convertor substation platform interconnector, and offshore export cables. Cable

protection will also be required for up to 78 cable crossings for the inter-array and OSP/Offshore convertor substation platform interconnector cables and 16 crossings for the offshore export cable. This equates to a small proportion (0.7%) of the Proposed Development fish and shellfish ecology study area.

205. The long term loss of subtidal habitat involves a change of sediment composition in affected areas (e.g. surrounding foundations and along sections of the Proposed Development array and offshore export cables) from soft sediment habitats (sands, gravels and muds) to hard substrates (foundations, cable protection and scour protection). These areas of habitat loss will be discrete, either in the immediate vicinity of foundations (i.e. foundations and scour protection), or for cable protection these will be relatively small isolated stretches of cable within large areas of sediment which characterise the baseline environment (i.e. soft sediments). This translates into the loss of one type of habitat and the increase of a new habitat. The implications of this are discussed in the sensitivity section (paragraph 207 *et seq.*) and the potential colonisation of these new substrates is presented and discussed in later assessments of effects (paragraph 259 *et seq.*). Long-term subtidal habitat loss impacts will occur during the construction phase and will be continuous throughout the 35-year operation and maintenance phase.

206. The impact is predicted to be of local spatial extent (i.e. affecting only a very small proportion of the Proposed Development particularly in the context of the habitats in the wider area), long term duration, continuous and not reversible during the operation and maintenance phase. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

<u>Sensitivity of the Receptor</u>

Marine Species

207. Fish and shellfish species that are reliant upon the presence of suitable sediment/habitat for their survival are considered to be more vulnerable to change depending on the availability of habitat within the wider geographical region. The seabed habitats removed by the installation of infrastructure will reduce the amount of suitable habitat and available food resource for fish and shellfish species and communities associated with the baseline substrates/sediments however this area represents a low percentage compared with the area of habitats located within the Proposed Development northern North Sea fish and shellfish ecology study area.

208. As confirmed by site specific surveys, the Proposed Development fish and shellfish ecology study area coincides with fish spawning and nursery habitats including plaice, lemon sole, herring, sprat, whiting, cod, haddock, sandeel, mackerel, sprat, *Nephrops* and elasmobranchs (Coull *et al*., 1998; Ellis *et al*., 2012; Aires *et al*., 2014; see Table 9.11 and volume 3, appendix 9.1). The fish species most vulnerable to habitat loss include sandeel which are demersal spawning species (i.e. eggs are laid on the seabed), as these have specific habitat requirements for spawning (i.e. sandy sediments). This is as identified by the FeAST tool as the pressure 'Physical change (to another seabed type)' which has identified that sandeel have high sensitivity to this impact (Wright *et al*., 2000). As well as laying demersal eggs, sandeel also have specific habitat requirements throughout their juvenile and adult life history and loss of this specific type of habitat could represent an impact on this species. However, monitoring at Horns Rev I, located off the Danish coast, has indicated that the presence of operation wind farm structures has not led to significant adverse effects on sandeel populations in the long term (van Deurs *et al*., 2012; Stenberg *et al*., 2011). Initial results of a pre to post construction monitoring study have reported that in some areas of the Beatrice Offshore Wind Farm there was an increase in sandeel abundance (BOWL, 2021a). The findings of a single monitoring study are not able to categorically confirm the conclusion that offshore wind developments are beneficial to sandeel populations; however, it does provide additional evidence that there is no adverse effect on sandeel populations.

209. The Proposed Development fish and shellfish ecology study area also coincides with high intensity sandeel spawning habitat as confirmed by site-specific surveys (see volume 3, appendix 9.1). The presence of infrastructure will result in direct impacts on this habitat, though as detailed above the proportion of habitat affected within the Proposed Development fish and shellfish ecology study area is small and this area is smaller still in the context of the known sandeel habitats (including spawning and nursery habitats) and the potential sandeel habitats in the Proposed Development northern North Sea fish and shellfish ecology study area (volume 3, appendix 9.1).

210. Monitoring at Belgian offshore wind farms has reported that fish assemblages undergo no drastic changes due to the presence of offshore wind farms (Degraer *et al*., 2020). They reported slight, but significant increases in the density of some common soft sediment-associated fish species (common dragonet *Callionymus lyra*, solenette *Buglossidium luteum*, lesser weever *Echiichthys vipera* and plaice) within the offshore wind farm (Degraer *et al*., 2020). There was also some evidence of increases in numbers of species associated with hard substrates, including crustaceans (including edible crab), sea bass and common squid (potentially an indication that foundations were being used for egg deposition; Degraer *et al*., 2020). The author noted that these effects were site specific and therefore may not necessarily be extrapolated to other offshore wind farms, although this does indicate the presence of offshore wind farm infrastructure does not lead to adverse, population wide effects.

211. The Proposed Development fish and shellfish ecology study area is located in the vicinity of known *Nephrops* spawning habitat, although site specific surveys (including sediment sampling, trawls and seabed imagery) showed that *Nephrops* habitat was only present along the Proposed Development export cable corridor. Long term habitat loss is predicted to affect a small proportion of this habitat, which will be limited to along the Proposed Development export cable corridor (i.e. array infrastructure is unlikely to affect *Nephrops* spawning habitat). Lobster spawning and nursery habitats have the potential to occur within the Proposed Development fish and shellfish ecology study area. The proportion of lobster spawning and overwintering habitats affected is, however, likely to be small in the context of the available habitats in this part of the Proposed Development fish and shellfish ecology study area and the wider Proposed Development northern North Sea fish and shellfish ecology study area.

212. Most fish and shellfish ecology IEFs in the Proposed Development fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and local to national importance. The sensitivity of the receptor is therefore, considered to be low.

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

214. Sandeel are deemed to be of high vulnerability, high recoverability and of national importance. The sensitivity of these fish and shellfish receptor is therefore considered to be medium.

215. Herring are deemed to be of high vulnerability, medium recoverability and of regional importance. However, the sensitivity of herring to this impact is considered to be low, due to the limited suitable spawning sediments overlapping with the Proposed Development fish and shellfish ecology study area and the core herring spawning ground being located well outside the Proposed Development fish and shellfish ecology study area.

Diadromous Species

216. Diadromous fish species are highly mobile and therefore are generally able to avoid areas subject to long term subtidal habitat loss. Diadromous species that are likely to interact with the Proposed Development fish and shellfish ecology study area are only likely to do so by passing through the area during migrations to and from rivers located on the east coast of Scotland (e.g. those designated sites with diadromous fish species listed as qualifying features; see Table 9.12 and volume 3, appendix 9.1). The habitats within the Proposed Development fish and shellfish ecology study area are not expected to be particularly important for diadromous fish species and therefore habitat loss during the construction and operation and

maintenance phase of the Proposed Development is unlikely to cause any direct impact to diadromous fish species and would not affect migration to and from rivers.

217. Indirect impacts on diadromous fish species may occur due to impacts on prey species, for example larger fish species for sea lamprey and sandeel for sea trout. As outlined previously for marine species, the majority of large fish species would be able to avoid habitat loss effects due to their greater mobility but would recover into the areas affected following cessation of construction. Sandeel (and other less mobile prey species) would be affected by long term subtidal habitat loss, although recovery of this species is expected to occur quickly as the sediments recover following installation of infrastructure and adults recolonise and also via larval recolonisation of the sandy sediments which dominate the Proposed Development fish and shellfish ecology study area. These sediments are known to recover quickly following cable installation (RPS, 2019). Impacts on diadromous species associated with the creation of new hard substrates are presented and discussed in later assessments of effects (see paragraph 259 *et seq.*).

218. With reference to the criteria in Table 9.13 and as set out in Table 9.14, diadromous fish species are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is therefore, considered to be low.

Significance of the Effect

Marine Species

219. For most fish and shellfish IEF species, 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.

220. For European lobster and *Nephrops,* 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.

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

Diadromous Species

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

Secondary Mitigation and Residual Effect

223. No additional fish and shellfish ecology mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond the designed in measures outlined in section 9.10) is not significant in EIA terms.

Decommissioning Phase

Magnitude of Impact

224. The presence of the infrastructure within the Proposed Development fish and shellfish ecology study area will result in long-term habitat loss. The maximum design scenario is for up to 7,562,609 m^2 of permanent habitat loss due to the scour protection associated with wind turbine and OSP/Offshore convertor substation platform foundations and cable protection associated with array, OSP/Offshore convertor substation platform interconnector and offshore export cables being left *in situ* after decommissioning. This equates to a small proportion (0.6%) of the Proposed Development fish and shellfish ecology study area.

225. The impact is predicted to be of local spatial extent, long term duration, continuous and not reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Sensitivity of the Receptor

226. The sensitivity of the fish and shellfish IEFs, for both marine and diadromous species, can be found in the construction and operation and maintenance phase assessment above (paragraph 207 *et seq.*).

Significance of the effect

Marine Species

227. For most fish and shellfish IEF species, 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.

228. For European lobster and *Nephrops,* 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.

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

Diadromous Species

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

Secondary Mitigation and Residual Effect

231. No additional fish and shellfish ecology mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond the designed in measures outlined in section 9.10) is not significant in EIA terms.

ELECTROMAGNETIC FIELDS FROM SUBSEA ELECTRICAL CABLING

232. The installation of inter-array, interconnector and offshore export cables will result in either High Voltage Alternating Current (HVAC) or High Voltage Direct Current (HVDC) under the maximum design scenario (see Table 9.15). The conduction of electricity through subsea power cables will result in emission of localised EMFs which could potentially affect the sensory mechanisms of some species of fish and shellfish, particularly electrosensitive species (including elasmobranchs) and diadromous fish species (Centre for Marine and Coastal Studies (CMACS), 2003).

Operation and Maintenance Phase

Magnitude of Impact

233. The presence and operation of inter-array, interconnector and offshore export cables within the Proposed Development fish and shellfish ecology study area will result in emission of localised EMFs affecting fish and shellfish IEFs. EMF comprise both the electrical (E) fields, measured in volts per metre (V/m), and the magnetic (B) fields, measured in microtesla (μT) or milligauss (mG). Background measurements of the magnetic field are approximately 50 μT in the North Sea, and the naturally occurring electric field in the North Sea is approximately 25 μV/m (Tasker *et al*., 2010).

234. It is common practice to block the direct electrical field (E) using conductive sheathing, meaning that the EMFs that are emitted into the marine environment are the magnetic field (B) and the resultant induced electrical field (iE). It is generally considered impractical to assume that cables can be buried at depths that will reduce the magnitude of the B field, and hence the sediment-sea water interface iE field, to below that at which these fields could be detected by certain marine organisms on or close to the seabed (Gill *et al*., 2005; Gill *et al*., 2009). By burying a cable, the magnetic field at the seabed is reduced due to the distance between the cable and the seabed surface as a result of field decay with distance from the cable (CSA, 2019).

235. A variety of design and installation factors affect EMF levels in the vicinity of the cables. These include current flow, distance between cables, cable orientation relative to the earth's magnetic field (DC only), cable insulation, number of conductors, configuration of cable and burial depth. Clear differences between AC and DC systems are apparent: the flow of electricity associated with an AC cable changes direction (as per the frequency of the AC transmission) and creates a constantly varying electric field in the surrounding marine environment (Huang, 2005). Conversely, DC cables transmit energy in one direction creating a static electric and magnetic field. Average magnetic fields of DC cables are also higher than those of equivalent AC cables (Table 9.27).

236. The strength of the magnetic field (and consequently, induced electrical fields) decreases rapidly horizontally and vertically with distance from source. A recent study conducted by CSA (2019) found that inter-array and offshore export cables buried between depths of 1 m to 2 m reduces the magnetic field at the seabed surface four-fold. For cables that are unburied and instead protected by thick concrete mattresses or rock berms, the field levels were found to be similar to buried cables.

237. CSA (2019) found magnetic field levels directly over live AC undersea power cables associated with offshore wind energy projects range between 65 mG (at seafloor) and 5 mG (1 m above sea floor) for array cables. and 165 mG (at seafloor) and 10 mG (1 m above seafloor) for offshore export cables. At lateral distances from the cable, magnetic fields greatly reduced at the sea floor to between 10 mG and <0.1 mG (from 3 to 7.5 m respectively) for array cables, and at 1 m above the sea floor, magnetic fields reduced to between 15 mG and <0.1 mG (from 3 to 7.5 m respectively) for offshore export cables.

238. The induced electric fields directly over live AC undersea power cables ranged between 1.7 mV/m (at seafloor) and 0.1 mV/m (1 m above seafloor) for array cables and 3.7 mV/m (at seafloor) and 0.2 mV/m (1 m above seafloor) for offshore export cables (CSA, 2019). At lateral distances electric fields at the sea floor reduced to between 0.01 mV/m and 1.1 mV/m (from 3 to 7.5 m respectively) for array cables and 1 m above the sea floor, the magnetic fields reduced to between 0.02 mV/m and 1.3 mV/m (from 3 to 7.5 m respectively) for offshore export cables. This pattern of reduction in the level of magnetic fields with increasing lateral and vertical distance from offshore export cables as described above is visually displayed in Figure 9.10. Higher colour density of rings demonstrate where magnetic field is strongest, with weaker colour density demonstrating weak magnetic fields (CSA, 2019), with increasing distance from the cable (Figure 9.10).

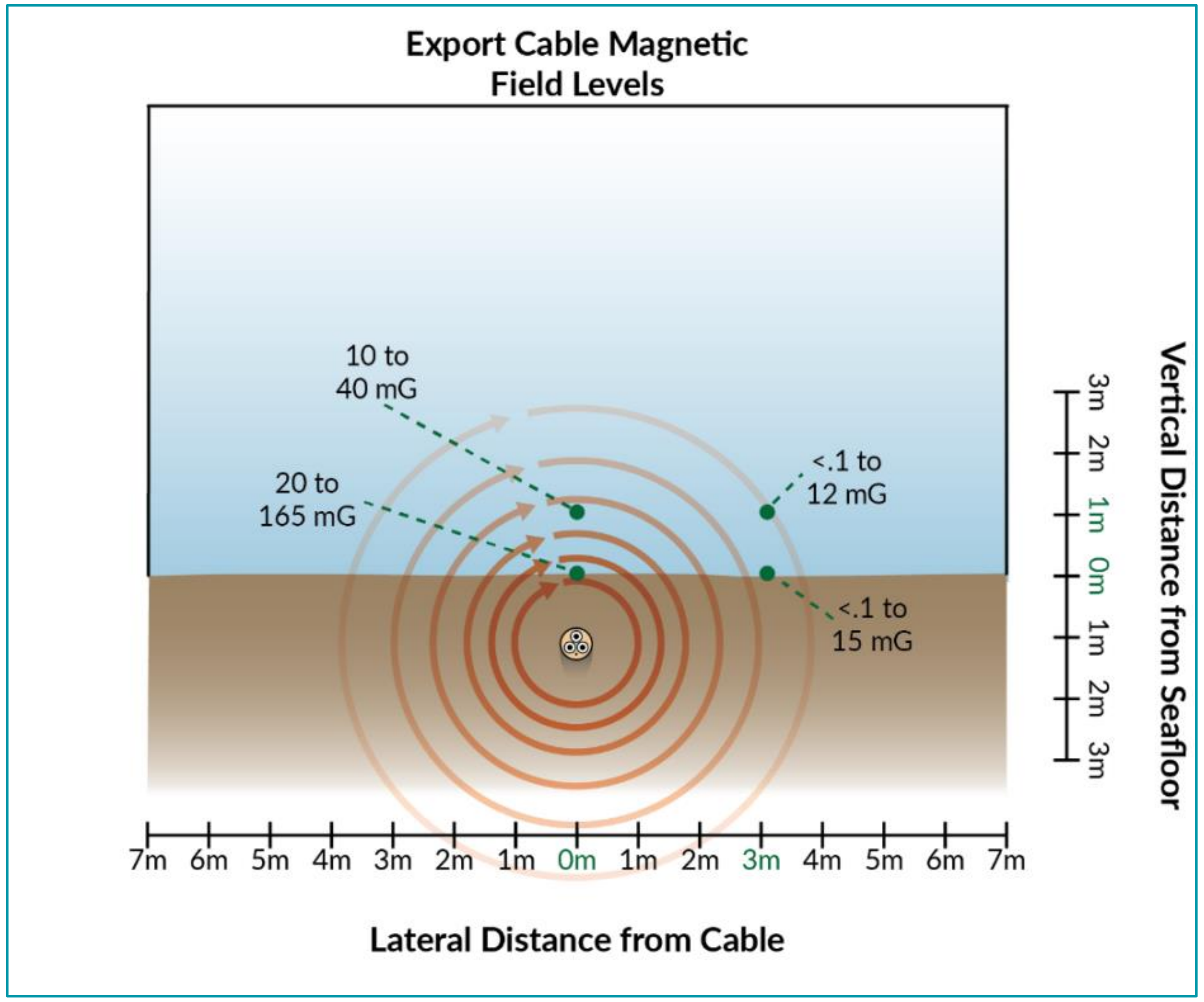

Figure 9.10: Illustration of Magnetic Field Reduction with Distance, both Laterally and Vertically, from Undersea Inter-array Power Cable (reproduced from CSA, 2019)

239. Normandeau *et al*. (2011) provided additional data (Table 9.27) demonstrating the rapid drop off of magnetic fields with increasing vertical and horizontal distance from both AC and DC cables. This supports the findings from the CSA (2019) study, with AC cables ranging from 7.85 μT on the seafloor with no horizontal distance to 0.08 μT at 10 m above the seafloor and 10 m horizontal distance. DC cables showed a similar decrease albeit starting from a higher level with cables ranging from 78.27 μT on the seafloor with no horizontal distance to 0.46 μT at 10 m above the seafloor and 10 m horizontal distance.

Table 9.27: Average Magnetic Fields (μT) Generated for AC and DC Offshore Export Cables at Horizontal Distances from the Cable (Assuming Cable Burial to a Depth of 1 m; Source: Modified from Normandeau *et al*., 2011)

Distance above seabed (m)	Magnetic field (μT) measured at horizontal distance from cable					
	0 m AC	0 m DC	4 m AC	4 m DC	10 m AC	10 m DC
0	7.85	78.27	1.47	5.97	0.22	1.02
5	0.35	2.73	0.29	1.92	0.14	0.75
10	0.13	0.83	0.12	0.74	0.08	0.46

240. The impact is predicted to be of local spatial extent (i.e. within a few metres of buried cables), long term duration, continuous and not reversible during the operation and maintenance phase (impact is reversible upon decommissioning). It is predicted that the impact will affect fish and shellfish IEFs directly. The magnitude is therefore considered to be low.

Sensitivity of the Receptor

Marine Species

241. Fish and shellfish species (particularly elasmobranchs) are able to detect applied or modified magnetic fields. Species for which there is evidence of a response to E and/or B fields include elasmobranchs (sharks, skates and rays), and plaice (Gill *et al*., 2005; CSA, 2019). It can be inferred that the life functions supported by an electric sense may include detection of prey, predators or conspecifics to assist with feeding, predator avoidance, and social or reproductive behaviours. Life functions supported by a magnetic sense may include orientation, homing, and navigation to assist with long or short-range migrations or movements (Gill *et al*., 2005; Normandeau *et al*., 2011).

242. Studies examining the effects of EMF from AC undersea power cables on fish behaviours have been conducted to determine the thresholds for detection and response to EMF. Table 9.28 provides a summary of the scientific studies conducted to assess sensitivity of EMF on varying fish species.

Table 9.28: Relationship between Geomagnetic Field Detection Electrosensitivity, and the Ability to Detect 50/60-Hz AC Fields in Common Marine Fish and Shellfish Species (Adapted from CSA, 2019)

Species Group	Detect Geomagnetic Field	Detect Electric Field	Evidence from Laboratory Studies of 50/60-Hz EMF from AC Power Cables	Evidence from Field Studies of AC Power Cables
Skates	Yes, multiple species (Normandeau *et al.*, 2011)	Yes, multiple species (Normandeau *et al.*, 2011)	No responses expected at 60 Hz (Kempster *et al*., 2013)	No attraction at California AC cable sites operating at up to 914 mG (Love *et al.*, 2016).
Flounders	Potentially, due to observed orientation behaviours (Metcalf *et al.*, 1993)	Not tested	Not tested	No population-level effects, but some evidence of delayed cable crossing. It is unclear whether effect was due to cable EMF or prior sediment disturbance (Vattenfall, 2006).
Tunas and mackerels	Yes, for some species (Walker, 1984)	Not tested (Normandeau *et al.*, 2011)	Not tested	Some evidence of attraction of mackerel to monopile structure, but no effect from cables (Bouma, 2008).
Lobsters and crabs	Yes, for some lobster species (Lohmann *et al.*, 1995; Hutchison *et al.*, 2018)	Not tested (Normandeau *et al.* 2011)	No effect at 800,000 µT (Ueno *et al.*, 1986)	Distribution unaffected by 60-Hz AC cable operating up to 800 mG (Love *et al.*, 2017).

243. A number of field studies have observed behaviours of fish and other species around AC submarine cables in the U.S.A. (see citations in Table 9.28). Observations at three energized 35-kV AC undersea power cable sites off the coast of California that run from three offshore platforms to shore, which are unburied along much of the route, did not show that fish were repelled by or attracted to the cables (Love *et al*., 2016) (it should be noted that these cables are significantly lower voltage than the maximum design scenario for the Proposed Development). A study investigating the effect of EMF on lesser sandeel larvae spatial distribution found that there was no effect on the larvae (Cresci *et al*., 2022), and a further study concluded the same for herring (Cresci *et al*.,2020).

244. Elasmobranchs (i.e. sharks, skates and rays) are known to be the most electro-receptive of all fish. These species possess specialised electro-receptors which enable them to detect very weak voltage gradients (down to 0.5 µV/m) in the environment naturally emitted from their prey (Gill *et al*., 2005). Both attraction and repulsion reactions to E-fields have been observed in elasmobranch species. Spurdog, an elasmobranch species known to occur within the Proposed Development fish and shellfish ecology study area, avoided electrical fields at 10 µV/cm (Gill and Taylor, 2001), although it should be noted that this level (i.e. 10 µV/cm is equivalent to 1,000 µV/m) is considerably higher than levels associated with offshore electrical cables (see paragraph 238). A COWRIE-sponsored mesocosm study demonstrated that the lesser spotted dogfish and thornback ray were able to respond to EMF of the type and intensity associated with subsea cables; the responses of some ray individuals suggested a greater searching effort when the cables were switched on (Gill *et al*., 2009). However, the responses were not predictable and did not always occur (Gill *et al*., 2009). In another study, EMF from 50/60-Hz AC sources appears undetectable in elasmobranchs. Kempster *et al. (*2013) reported that small sharks could not detect EMF produced at 20 Hz and above, and a magnetic field of 14,300 mG produced by a 50 Hz source had no effect on bamboo shark (*Scyliorhinidae*, a group that includes catsharks and dogfish) behaviour.

245. Crustacea, including lobster and crab, have been shown to demonstrate a response to B fields, with the Caribbean spiny lobster *Panulirus argus* shown to use a magnetic map for navigation (CSA, 2019). EMF exposure has been shown to result in varying egg volumes for edible crabs compared to controls. Exposed larvae were significantly smaller, but there were no statistically significant differences in hatched larval numbers, deformities, mortalities, or fitness (Scott, 2019). Exposure to EMF has also been shown to affect a variety of physiological processes within crustaceans. For example, Lee and Weis demonstrated that EMF exposure affected moulting in fiddler crabs (*Uca pugilator* and *Uca pugnax*) (Lee and Weis, 1980). Several studies have also suggested that EMFs affect serotonin regulation which may affect the internal physiology of crustaceans potentially leading to behavioural changes, although such changes have not

been reported (Atema and Cobb, 1980; Scrivener, 1971). Crab movement and location inside large cages has been reported to be unaffected by proximity to energized AC undersea power cables off southern California and in Puget Sound, indicating crabs also were not attracted to or repelled by energized AC undersea power cables that were either buried or unburied (Love *et al*., 2016). However, studies on the Dungeness crab and edible crab have reported behavioural changes during exposure to increased EMF and both species showed increased activity when compared to crabs that were not exposed (Scott *et al*., 2018; Woodruff *et al*., 2012). Crabs may also spend less time buried, a natural predator avoidance behaviour (Rosaria and Martin, 2010).

246. It is uncertain if other crustaceans including commercially important European lobster and *Nephrops* are able to respond to magnetic fields in this way. Limited research undertaken with the European lobster found no neurological response to magnetic field strengths considerably higher than those expected directly over an average buried power cable (Normandeau *et al*., 2011; Ueno *et al*., 1986). A field study by Hutchison *et al*. (2018) observed the behaviour of American lobster (a magneto-sensitive species) to DC and AC fields from a buried cable and found that it did not cause a barrier to movement or migration, as both species were able to freely cross the offshore cable route. However, lobsters were observed to make more turns when near the energised cable. Adult lobsters have been shown to spend a higher percentage of time within shelter when exposed to EMF. European lobsters exposed to EMF have also been found to have a significant decrease in egg volume at later stages of egg development and more larval deformities (Scott, 2020).

247. Scott *et al*. (2020) presents a review of the existing papers on the impact of EMF on crustacean species. Of the papers reviewed by Scott *et al*. (2020), three studied EMF effects on fauna in the field, the rest were laboratory experiments which directly exposed the target fauna to EMF (Scott *et al*., 2020). These laboratory experiments, while giving us an indication of crustacean behaviour to EMF, may be less applicable in the context of subsea cables in the marine environment. Of the field experiments, one demonstrated that lobsters have a magnetic compass by tethering lobsters inside a magnetic coil (Lohmann *et al*., 1995), one focused on freshwater crayfish and put magnets within the crayfish hideouts (Tański *et al*., 2005), and the last one looked at shore crabs at an offshore wind farm and found no adverse impact on the population. The two former papers are not applicable to offshore wind farm subsea cables and the latter found no adverse impact on the population of shore crabs from the offshore wind farm (Langhamer *et al*., 2016).

248. Further research by Scott *et al.* (2021) found that physiological and behavioural impacts on edible crab occurred at 500 μT and 1000 μT, causing disruption to the L-Lactate and D-Glucose circadian rhythm and altering Total Haemocyte Count, and also causing attraction to EMF exposed areas and reduced roaming time. However, these physiological and behavioural effects did not occur at 250 μT. Seeing as even in the event of an unburied cable the maximum magnetic field reported was 78.27 μT (Normandeau *et al.*, 2011), it can be assumed that the magnetic fields generated by the offshore export cables will be lower than 250 μT, and therefore will not present any adverse effects on edible crab. Harsanyi *et al*. (2022) noted that chronic exposure to EMF effects could lead to physiological deformities and reduced swimming test rates in lobster and edible crab larvae. However, these deformities were in response to EMF levels of 2,800 μT and therefore are higher than EMF effects expected for buried and unburied cables. The report recommends burying of cables in order to reduce any potential impacts associated with high levels of EMF.

249. In summary, the range over which these species can detect electric fields is limited to centimetres, rather than metres, around these species (CSA, 2019). Pelagic species generally swim well above the seafloor and can be expected to rarely be exposed to the EMF at the lowest levels from AC undersea power cables buried in the seafloor, resulting in impacts that would therefore be localised and transient. Demersal species (e.g. skates) that dwell on the bottom, will be closer to the undersea power cables and thus encounter higher EMF levels when near the cable. Demersal species and shellfish are also likely to be exposed for longer periods of time and may be largely constrained in terms of location. However, the rapid decay of the EMF with horizontal distance (i.e. within metres) minimises the extent of potential impacts. Finally, fish that can detect the Earth's magnetic field are unlikely to be able to detect magnetic fields produced by 50/60-Hz AC power cables and therefore these species are unlikely to be affected in the field (CSA, 2019).

250. Marine fish and shellfish ecology IEFs in the Proposed Development fish and shellfish ecology study area are deemed to be of low to medium vulnerability, high recoverability and local to national importance. The sensitivity of the receptor is therefore, considered to be low (most fish and shellfish IEFs) to medium (decapod crustaceans and elasmobranchs).

Diadromous Species

251. EMF may also interfere with the navigation of sensitive diadromous species. Species for which there is evidence of a response to E and/or B fields include river lamprey, sea lamprey, European eel, and Atlantic salmon (Gill *et al*., 2005; CSA, 2019). Lampreys possess specialised ampullary electroreceptors that are sensitive to weak, low frequency electric fields (Bodznick and Northcutt, 1981; Bodznick and Preston, 1983), but information regarding what use they make of the electric sense is limited. Chung-Davidson *et al*. (2008) found that weak electric fields may play a role in the reproduction of sea lamprey and it was suggested that electrical stimuli mediate different behaviours in feeding-stage and spawning-stage individuals. This study (Chung-Davidson *et al*., 2008) showed that migration behaviour of sea lamprey was affected (i.e. adults did not move) when stimulated with electrical fields of intensities of between 2.5 and 100 mV/m, with normal behaviour observed at electrical field intensities higher and lower than this range. It should be noted, however, that these levels are considerably higher than modelled induced electrical fields expected from AC subsea cables (see Table 9.27).

252. Atlantic salmon and European eel have both been found to possess magnetic material of a size suitable for magnetoreception, and these species can use the earth's magnetic field for orientation and direction finding during migration (Gill and Bartlett, 2010; CSA, 2019). Mark and recapture experiments undertaken at the Nysted operation offshore wind farm showed that eel did cross the offshore export cable (Hvidt *et al*., 2003) but studies on European eel in the Baltic Sea have highlighted some limited effects of subsea cables (Westerberg and Lagenfelt, 2008). The swimming speed during migration was shown to change in the short term (tens of minutes) with exposure to AC electric subsea cables, even though the overall direction remained unaffected (Westerberg and Langenfelt, 2008). The authors concluded that any delaying effect (i.e. on average 40 minutes) would not be likely to influence fitness in a 7,000 km migration. Research in Sweden on the effects of a HVDC cable on the migration patterns of a range of fish species, including salmonids, failed to find any effect (Westerberg *et al*., 2007; Wilhelmsson *et al*., 2010). Research conducted at the Trans Bay cable, a DC undersea cable near San Francisco, California, found that migration success and survival of chinook salmon (*Oncorhynchus tshawytscha*) was not impacted by the cable. However, as with the Hutchison *et al*. (2018) study on lobster (paragraph 246), behavioural changes were noted when these fish were near the cable (Kavet *et al*., 2016) with salmon appearing to remain around the cable for longer periods. These studies demonstrate that while DC undersea power cables can result in altered patterns of fish behaviour, these changes are temporary and do not interfere with migration success or population health.

253. Table 9.29 provides a summary of the scientific studies conducted to assess sensitivity of EMF on varying fish species.

Table 9.29: Relationship between Geomagnetic Field Detection Electrosensitivity, and the Ability to Detect 50/60-Hz AC Fields in Diadromous Fish Species (Adapted from CSA, 2019)

Species Group	Detect Geomagnetic Field	Detect Electric Field	Evidence from Laboratory Studies of 50/60-Hz EMF from AC Power Cables	Evidence from Field Studies of AC Power Cables
American/European Eels	Yes, for multiple species (Normandeau *et al.*, 2011)	Mixed evidence (Normandeau *et al.*, 2011)	No effect of 950 mG magnetic field at 50 Hz on swim behaviour or orientation (Orpwood *et al.,* 2015)	Unburied AC cable did not prevent migration of eels (Westerberg *et al.,* 2007).
Salmon	Yes, for multiple species (Yano *et al.*, 1997, Putman *et al.*, 2014)	Not tested (Normandeau *et al.,* 2011)	No effect of 950 mG magnetic field at 50 Hz on swim behaviour (Armstrong *et al.*, 2015)	Not surveyed.

254. Diadromous fish IEFs in the Proposed Development fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is therefore, considered to be low.

<u>Significance of the Effect</u>

Marine Species

255. For most fish and shellfish IEF species, 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.

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

Diadromous Species

257. 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.

<u>Secondary Mitigation and Residual Effect</u>

258. No additional fish and shellfish ecology mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond the designed in measures outlined in section 9.10) is not significant in EIA terms.

COLONISATION OF FOUNDATIONS, SCOUR PROTECTION AND CABLE PROTECTION

259. Foundation, cable protection and scour protection components of offshore wind farms can be viewed as artificial reefs, as these add hard substrate to areas typically characterised by soft, sedimentary environments. Man-made structures placed on the seabed attract many marine organisms including benthic species normally associated with hard substrates and therefore, may have indirect effects on fish and shellfish populations through their potential to act as artificial reefs and to bring about changes to food resources (Inger *et al*., 2009). Additionally, man-made structures may also have direct effects on fish through their potential to act as fish aggregation devices (Petersen and Malm, 2006).

Operation and Maintenance Phase

<u>Magnitude of Impact</u>

260. The presence of infrastructure within the Proposed Development fish and shellfish ecology study area may result in the colonisation of foundations, scour protection and cable protection. The maximum design scenario is for up to 10,198,971 m^2 of habitat created due to the installation of jacket foundations, associated scour protection and cable protection associated with inter-array cables, OSP/Offshore convertor substation platform interconnector cables and offshore export cables (Table 9.15). This value however is likely an over estimation of habitat creation as it is based on solid panels being used for the 317 jacket foundations. The four sides of these jackets will be made of a lattice structure; however the precise dimensions of these lattices are unknown at the time of writing, therefore a solid structure has been assumed from the values available, noting that this will result in an overestimate of the habitat created. It is expected that the foundations and scour and cable protection will be colonised by species already occurring in the benthic subtidal and intertidal ecology study area (e.g. tunicates, bryozoa sp., mussels and barnacles which are typical of temperate seas; see volume 2, chapter 8). The increased availability of prey species may lead to increased numbers of fish and shellfish species utilising the additional prey resource and hard substrate habitats. In addition, this may lead to further effects to higher trophic levels, including marine mammals and birds, the implications of which are further discussed in volume 2, chapter 10 and volume 2, chapter 11.

261. These effects are only considered in the operation and maintenance phase as it takes time for organisms to colonisation a structure post-installation.

262. The impact is predicted to be of local spatial extent, long term duration (35-year operation phase), continuous and medium reversibility. It is predicted that the impact will affect the receptor both directly and indirectly. The magnitude is therefore considered to be low.

<u>Sensitivity of the Receptor</u>

Marine Species

263. Hard substrate habitat created by the introduction of wind turbine foundations and scour/cable protection are likely to be primarily colonised within hours or days after construction by demersal and semi-pelagic fish species (Andersson, 2011). Continued colonisation has been seen for a number of years after the initial construction, until a stratified recolonised population is formed (Krone *et al*., 2013). Feeding opportunities or the prospect of encountering other individuals may attract fish aggregate from the surrounding areas, which may increase the carrying capacity of the area (Andersson and Öhman, 2010; Bohnsack, 1989).

264. The dominant natural substrate character of the Proposed Development fish and shellfish ecology study area (e.g. soft sediment or hard rocky seabed) will determine the number of new species found on the

introduced vertical hard surface and associated scour protection. When placed on an area of seabed which is already characterised by rocky substrates, few species will be added to the area, but the increase in total hard substrate could sustain higher abundance (Andersson and Öhman, 2010). Conversely, when placed on a soft seabed, most of the colonising fish will be normally associated with rocky (or other hard bottom) habitats, thus the overall diversity of the area may increase (Andersson *et al*., 2009). A new baseline species assemblage will be formed via recolonisation and the original soft-bottom population will be displaced (Desprez, 2000). This was observed in studies by Leonhard *et al*. (Danish Energy Agency, 2012) at the Horns Rev offshore wind farm, and Bergström *et al*. (2013) at the Lillgrund offshore wind farm. An increase in fish species associated with reefs such as goldsinny wrasse *Ctenolabrus rupestris*, lumpsucker *Cycloplerus lumpus* and eelpout *Zoarces viviparous*, and a decrease in the original sandy-bottom fish population were reported (Danish Energy Agency, 2012; Bergström *et al*., 2013). A decrease in soft sediment species is contradictory to findings of Degraer *et al*. (2020) where an increase in density of soft sediment species was seen, although this increase may be related to reduced fishing pressure within the array. However it is noted by Degraer *et al*. (2020) that these effects were site specific and therefore may not necessarily be extrapolated to other offshore wind farms (see paragraph 210 for further information on increases of crustacean species associated with installation of an offshore wind development).

265. The longest monitoring programme conducted to date at the Lillgrund offshore wind farm in the Öresund Strait in southern Sweden, showed no overall increase in fish numbers, although redistribution towards the foundations within the offshore wind farm area was noticed for some species (i.e. cod, eel and eelpout; Andersson, 2011). More species were recorded after construction than before, which is consistent with the hypothesis that localised increases in biodiversity may occur following the introduction of hard substrates in a soft sediment environment. Overall, results from earlier studies reported in the scientific literature did not provide robust data (e.g. some were visual observations with no quantitative data) that could be generalised to the effects of artificial structures on fish abundance in offshore wind farm areas (Wilhelmsson *et al*., 2010). More recent papers are, however, beginning to assess population changes and observations of recolonisation in a more quantitative manner (Krone *et al*., 2013).

266. There is uncertainty as to whether artificial reefs facilitate recruitment in the local population, or whether the effects are simply a result of concentrating biomass from surrounding areas (Inger *et al*., 2009). Linley *et al*. (2007) concluded that finfish species were likely to have a neutral to beneficial likelihood of benefitting, which is supported by evidence demonstrating that abundance of fish can be greater within the vicinity of wind turbine foundations than in the surrounding areas, although species richness and diversity show little difference (Wilhelmsson *et al*., 2006a; Inger *et al*., 2009). A number of studies on the effects of vertical structures and offshore wind farm structures on fish and benthic assemblages have been undertaken in the Baltic Sea (Wilhelmsson *et al*., 2006a; 2006b). These studies have shown evidence of increased abundances of small demersal fish species (including gobies *Gobidae*, and goldsinny wrasse) in the vicinity of structures, most likely due to the increase in abundance of epifaunal communities which increase the structural complexity of the habitat (e.g. mussels and barnacles *Cirripedia spp*.). It was speculated that in true marine environments (e.g. the North Sea), offshore wind farms may enhance local species richness and diversity, with small demersal species such as gobies providing prey items for larger, commercially important species including cod (which have been recorded aggregating around vertical steel constructions in the North Sea; Wilhelmsson *et al*., 2006a). Monitoring of fish populations in the vicinity of an offshore wind farm off the coast of the Netherlands indicated that the offshore wind farm acted as a refuge for at least part of the cod population (Lindeboom *et al*., 2011; Winter *et al*., 2010).

267. In contrast, post construction fisheries surveys conducted in line with the Food and Environmental Protection Act (FEPA) licence requirements for the Barrow and North Hoyle offshore wind farms, found no evidence of fish abundance across these sites being affected, either beneficially or adversely, by the presence of the offshore wind farms (Cefas, 2009; BOWind, 2008) therefore suggesting that any effects, if seen, are likely to be highly localised and while of uncertain duration, the evidence suggests effects are not adverse.

268. It is likely that the greatest potential for beneficial effects exist for crustacean species, such as crab and lobster, due to expansion of their natural habitats (Linley *et al*., 2007) and the creation of additional refuge areas. Where foundations and scour protection are placed within areas of sandy and coarse sediments, this will represent novel habitat and new potential sources of food in these areas and could potentially extend the habitat range of some shellfish species. Post-construction monitoring surveys at the Horns Rev offshore wind farm noted that the hard substrates were used as a hatchery or nursery grounds for several species, and was particularly successful for brown crab (BioConsult, 2006). They concluded that larvae and juveniles rapidly invade the hard substrates from the breeding areas (BioConsult, 2006). As both crab and lobster are commercially exploited in the vicinity of the Proposed Development fish and shellfish ecology study area, there is potential for benefits to the fisheries, depending on the materials used in construction of the offshore wind farm.

269. Other shellfish species, such as the blue mussel *Mytilus edulis*, have the potential for great expansion of their normal habitat due to increased hard substrate in areas of sandy habitat. Krone *et al. (*2013) coined the term 'Mytilusation' to describe this mass biofouling process recorded at a platform in the German Bight, North Sea. It was found that over a three-year period, almost the entire vertical surface of area of the platform piles had been colonised by three key species blue mussel, the amphipod *Jassa spp*. and anthozoans (mainly *Metridium senile*). These three species were observed to occur in depth-dependant bands, attracting pelagic fish species such as horse mackerel *Trachurus trachurus* and demersal pouting *Trisopterus luscus* in great numbers. Layers of shell detritus were visible at the base of the foundations due to the mussel populations above and both velvet swimming crab and brown crabs were recorded here. These species were not typical of baseline species assemblage, providing further evidence of localised changes in fish and shellfish assemblages in the vicinity of foundation structures.

270. The colonisation of new habitats may potentially lead to the introduction of invasive and non-native species species (see volume 2, chapter 8 for detailed discussion). With respect to fish and shellfish populations, this may have indirect adverse effects on shellfish populations as a result of competition. However, no invasive and non-native species species were identified as present in the area during surveys across the Proposed Development fish and shellfish ecology study area. There is little evidence of adverse effects on fish and shellfish IEFs resulting from colonisation of other offshore wind farms by invasive and non-native species species. The post construction monitoring report for the Barrow offshore wind farm demonstrated no evidence of invasive and non-native species species on or around the monopiles (EMU, 2008a), and a similar study of the Kentish Flats monopiles only identified slipper limpet *Crepidula fornicata* (EMU, 2008b). Potential adverse effects of the introduction of invasive and non-native species species are discussed in detail in volume 2, chapter 8.

271. Marine fish and shellfish ecology IEFs in the Proposed Development fish and shellfish ecology study area are deemed to be of low vulnerability, and local to national importance (recoverability is not relevant to this impact during the operation maintenance phase). The sensitivity of the receptor is therefore, considered to be low.

Diadromous Species

272. Diadromous species that are likely to interact with the Proposed Development fish and shellfish ecology study area are only likely to do so by passing through the area during migrations to and from rivers located on the east coast of Scotland, such as to rivers with designated sites, with diadromous fish species listed as qualifying features, as presented in volume 3, appendix 9.1. In most cases, it is expected that diadromous fish are unlikely to utilise the increase in hard substrate within the Proposed Development fish and shellfish ecology study area for feeding or shelter opportunities as they are only likely to be in the vicinity when passing through during migration.

273. However, there is potential for impacts upon diadromous fish species resulting from increased predation by marine mammal species within offshore wind farms. Tagging of harbour seal *Phoca vitulina* and grey seal *Halichoerus grypus* around Dutch and UK wind farms provided significant evidence that the seal species were utilising wind farm sites as foraging habitats (Russel *et al*., 2014), specifically targeting introduced structures such as wind turbine foundations. However, a further study using similar methods concluded that there was no change in behaviour within the wind farm (McConnell *et al*., 2012), so it is not certain exactly to what extent seals utilise offshore wind developments and therefore effects may be site specific. Assuming that seals do utilise offshore wind developments as foraging areas, diadromous fish species may be impacted by the increased predation in an area where predation was lower prior to development. It is, however, unlikely that this would result in significant predation on diadromous species. Research has shown that Atlantic salmon smolts spend little time in the coastal waters, and instead are very active swimmers in coastal waters, making their way to feeding grounds in the north quickly (Gardiner *et al*., 2018a; Gardiner *et al*., 2018a; Newton *et al*., 2017; Newton *et al*., 2019; Newton *et al*., 2021) (see volume 3, appendix 9.1 for further detail on Atlantic salmon migration). Due to the evidence that Atlantic salmon tend not to forage in the coastal waters of Scotland, it is unlikely that they will spend time foraging around wind turbine foundations and therefore are at low risk of impact from increased predation from seals and other predators.

274. Sea trout may be at higher risk of increased predation from seals than Atlantic salmon due to their higher usage of coastal environments. Sea trout are generalist, opportunistic feeders with their diet comprising mainly of fish, crustaceans, polychaetes and surface insects with proportion of each of these prey categories varying dependent on season (Rikardsen *et al*., 2006; Knutsen *et al*., 2001). Due to the potential for increase in juvenile crustacean species and other shellfish species (see paragraphs 268 and 269) which are potential prey items from sea trout, it is possible that foraging sea trout may be attracted to the hard substrates introduced by installation of the Proposed Development. This attraction could in turn lead to increased predation of seal species upon sea trout species. However, there is little evidence at present documenting an increased abundance of sea trout around wind turbine foundations (increases in fish abundance tend to be hard bottom dwelling fish species), therefore the above effect of increased prey items attracting sea trout is yet to be recorded. Further, the Proposed Development fish and shellfish ecology study area is situated in an area of high sandeel abundance, and it is likely that sandeel will make up a considerable proportion of sea trout diet when in the marine environment (Svenning *et* al., 2005; Thorstad *et al., 2016)*. Sandeel species are unlikely to be associated with wind turbine structures due to habitat preferences (discussed in volume 3, appendix 9.1) and therefore sea trout may be less likely to be attracted to increased prey availability colonised on hard substrates, when there is an abundance of prey species which is not associated with the installation of hard substrate.

275. The low risk of effects on diadromous fish species extends to the freshwater pearl mussel, which is included in the diadromous species section, as part of its life stage is reliant on diadromous fish species including Atlantic salmon and sea trout.

276. Sea lamprey are parasitic in their marine phase, feeding off larger fish and marine mammals (Hume, 2017). As such it is not expected that they will be particularly attracted to structures associated with offshore wind developments. However, this is not certain, as there is limited information available on the utilisation of the marine environment by sea lamprey.

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

278. Atlantic salmon and sea lamprey are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is therefore, considered to be low.

279. Sea trout are deemed to be of medium vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is therefore, considered to be low.

<u>Significance of the Effect</u>

Marine Species

280. Overall for IEF species, 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. This is likely to be a conservative prediction as there is some evidence (although with uncertainties) that some fish and shellfish populations are likely to benefit from introduction of hard substrates.

Diadromous Species

281. 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.

<u>Secondary Mitigation and Residual Effect</u>

282. No additional fish and shellfish ecology mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond the designed in measures outlined in section 9.10) is not significant in EIA terms.

Decommissioning Phase

<u>Magnitude of Impact</u>

283. During the decommissioning phase, some infrastructure is assumed to be left *in situ* within the Proposed Development fish and shellfish ecology study area with the impact of colonisation of infrastructure continuing in perpetuity following decommissioning. The maximum design scenario assumes that up to 7,493,186 m^2 of scour and cable protection will remain post decommissioning with all foundation structures removed during decommissioning (see Table 9.15). This equates to a small proportion (0.6%) of the Proposed Development fish and shellfish ecology study area.

284. The impact is predicted to be of local spatial extent, permanent duration, continuous and not reversible. It is predicted that the impact will affect fish and shellfish receptors directly. The magnitude is therefore considered to be low.

<u>Sensitivity of the Receptor</u>

285. The sensitivity of all fish and shellfish IEFs, for both marine and diadromous species, can be found in the construction and operation and maintenance phase assessment above (paragraph 271 *et seq.*) and are concluded to be low.

Significance of the effect

Marine Species

286. Overall for IEF species, 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 Species

287. 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.

Secondary Mitigation and Residual Effect

288. No additional fish and shellfish ecology mitigation is considered necessary because the likely effect in the absence of further mitigation (beyond the designed in measures outlined in section 9.10) is not significant in EIA terms.

9.11.1. PROPOSED MONITORING

289. This section outlines the proposed monitoring proposed for fish and shellfish ecology. Proposed monitoring measures are outlined in Table 9.30.

Table 9.30: Monitoring Commitments for Fish and Shellfish Ecology

Potential Environmental Effect	Monitoring Commitment	Means of Implementation
N/A	Commitment to engaging in discussions with Marine Scotland and the SNCBs post consent to identify opportunities for contributing to proportionate and appropriate strategic monitoring of diadromous fish species. This may include research priorities identified by ScotMER steering group.	Monitoring commitments will be recorded in the Enhancement, Mitigation and Monitoring Commitments (see volume 3, appendix 6.3). Detailed monitoring commitments will be agreed post consent and included in the Project Environmental Monitoring Programme (PEMP).

9.12. CUMULATIVE EFFECTS ASSESSMENT

9.12.1. METHODOLOGY

290. The CEA assesses the impact associated with the Proposed Development together with other relevant plans, projects and activities. Cumulative effects are therefore the combined effect of the Proposed Development in combination with the effects from a number of different projects, on the same receptor or resource. Please see volume 1, chapter 6 for detail on CEA methodology.

291. The projects and plans selected as relevant to the CEA presented within this chapter are based upon the results of a screening exercise (see volume 3, appendix 6.4 of the Offshore EIA Report). Volume 3, appendix 6.4 further provides information regarding how information pertaining to other plans and projects is gained and applied to the assessment. Each project or plan has been considered on a case by case basis for screening in or out of this chapter's assessment based upon data confidence, effect-receptor pathways and the spatial/temporal scales involved.

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

- tier 1 assessment – Proposed Development (Berwick Bank Wind Farm offshore) with Berwick Bank Wind Farm onshore;
- tier 2 assessment – All plans/projects assessed under Tier 1, plus projects which became operational since baseline characterisation, those under construction, those with consent and submitted but not yet determined;
- tier 3 assessment – All plans/projects assessed under Tier 2, plus those projects with a Scoping Report; and
- tier 4 assessment – All plans/projects assessed under Tier 3, which are reasonably foreseeable, plus those projects likely to come forward where an Agreement for Lease (AfL) has been granted.

293. The specific projects scoped into the CEA for fish and shellfish ecology, are outlined in Table 9.31.

294. Due to the uncertainty regarding assessment of projects in the far future including when projects may be decommissioned and what activities this might involve it has been assumed that the magnitude of impact from decommissioning is likely to be similar or substantially less than those experienced for the construction phase. As a result, no cumulative assessments of decommissioning phases have been undertaken.

295. As described in volume 1, chapter 3, the Applicant is developing an additional export cable grid connection to Blyth, Northumberland (the Cambois connection). Necessary consents (including marine licences) will be applied for separately. The CEA for the Cambois connection is based on information presented in the Cambois connection Scoping Report (SSER, 2022e), submitted in October 2022. The Cambois connection has been scoped into the CEA for fish and shellfish ecology on the basis that Cambois connection will overlap spatially and temporally with the Proposed Development and the project will engage in activities such as cable burial and installation of cable protection which will impact fish and shellfish IEFs.

296. The range of potential cumulative impacts that are identified and included in Table 9.32, is a subset of those considered for the Proposed Development alone assessment. This is because some of the likely significant effects identified and assessed for the Proposed Development alone, are localised and temporary in nature. It is considered therefore, that these potential impacts have limited or no potential to interact with similar changes associated with other plans or projects. These have therefore been scoped out of the cumulative effects assessment.

297. Similarly, some of the potential impacts considered within the Proposed Development alone assessment are specific to a particular phase of development (e.g. construction, operation and maintenance or decommissioning). Where the potential for cumulative effects with other plans or projects only have potential to occur where there is spatial or temporal overlap with the Proposed Development during certain phases of development, impacts associated with a certain phase may be omitted from further consideration

where no plans or projects have been identified that have the potential for cumulative effects during this period.

298. For the purposes of the fish and shellfish ecology assessment of effects, cumulative effects have been assessed within a representative 25 km buffer of the Proposed Development fish and shellfish ecology study area which encompasses the areas within two tidal excursions (Figure 9.11). This buffer, which is based on two tidal excursions from the Proposed Development fish and shellfish ecology study area, is considered appropriate as the majority of impacts considered in section 9.11 will be localised in extent and this encompasses all projects in the Forth and Tay region. This approach aligns with that taken for Benthic Subtidal and Intertidal Ecology (volume 2, chapter 8) and Physical Processes (volume 2, chapter 7). The only exception to this is underwater noise during the construction phase, where a larger buffer of 100 km has been used to account for the larger ZoI of this impact (i.e. behavioural effects to ranges of tens of km from the Proposed Development fish and shellfish ecology study area).

299. All impacts that have been identified as having potential cumulative effects have been assessed at the appropriate phases of development in the following sections. Cumulative impacts of increased SSC and associated deposition for the operation and maintenance phase (for both the Proposed Development and cumulative projects) have been excluded from the cumulative assessment. This is due to operation and maintenance activities being of much lower magnitude than construction impacts, being limited to reburial/repair of cables, rather than installation of hundreds of km of cable. Further, there is a relatively low likelihood of cumulative projects operation and maintenance activities occurring at the same time however, there is minimal spatial overlap between projects and due to the relative local scale of SSC impacts it is unlikely that in the event of concurrent maintenance activities, SSC plumes would interact causing a cumulative effect.

Table 9.31: List of Other Developments Considered Within the CEA for Fish and Shellfish Ecology

Development	Status [i.e. Application, Consented, Under Construction, Operation]	Distance from Proposed Development Array Area (km)	Distance from Offshore Export Cable Routes (km)	Description of Development	Dates of Construction (If Applicable)	Dates of Operation (If Applicable)	Overlap with the Proposed Development [e.g. Project Construction Phase Overlaps with Proposed Development Construction Phase]
Tier 1							
Offshore Wind Projects and Associated Cables							
No Tier 1 projects identified within the fish and shellfish ecology CEA study area.							
Tier 2							
Offshore Wind Projects and Associated Cables							
Inch Cape Offshore Wind Farm – 15680	Consented	19	39	Up to 1,000 MW (up to 72 wind turbines)	2023-2025	2025 onwards	Project construction and operation phase overlaps with Proposed Development construction and operation and maintenance phases
Neart Na Gaoithe Offshore Wind – 66600019	Under construction	16	15	Up to 450 MW (up to 75 wind turbines)	2020-2023	2023 onwards	Project operation phase overlaps with Proposed Development construction and operation and maintenance phases
Seagreen 1	Under construction	5	35	Up to 1*14* wind turbines with no capacity limit	2020-2023	2023 onwards	Project construction and operation phase overlaps with Proposed Development construction and operation and maintenance phases
Seagreen 1A Project	Consented	5	36	Up to 36 wind turbines with no capacity limit	2023-2025	Q*3* 2025 onwards	Project construction and operation phase overlaps with Proposed Development construction and operation and maintenance phases
Seagreen 1A Export Cable Corridor	Consented	0.4	16	A 100 km offshore export cable from Seagreen 1A to the landfall at Cockenzie	2023 –2024	2024 onwards	Project operation phase overlaps with Proposed Development construction and operation and maintenance phases
Oil and Gas Activities							
No oil and gas projects identified within the fish and shellfish ecology CEA study area.							
Aggregate Extraction							
No aggregate extraction projects identified within the fish and shellfish ecology CEA study area.							
Disposal Sites							
Eyemouth – FO0080	Operation	35	17	Dredged material disposal site	N/A	Ongoing	Project operation phase overlaps with Proposed Development construction and operation and maintenance phases
Coastal Protection							
No coastal protection projects identified within the fish and shellfish ecology CEA study area.							
Subsea Cables (Telecommunications and Interlinks)							
Eastern link 1	Planning application submitted	23	*2*	Scotland England Green Link 1 - interconnector between Torness in Scotland and County Durham in England	2024 - 2027	2027 onwards	Project construction and operation phase overlaps with Proposed Development construction and operation and maintenance phases

Development	Status [i.e. Application, Consented, Under Construction, Operation]	Distance from Proposed Development Array Area (km)	Distance from Offshore Export Cable Routes (km)	Description of Development	Dates of Construction (If Applicable)	Dates of Operation (If Applicable)	Overlap with the Proposed Development [e.g. Project Construction Phase Overlaps with Proposed Development Construction Phase]
Eastern link 2	Planning application submitted	11	21	Scotland England Green Link 2 - interconnector between Peterhead in Scotland and North Yorkshire in England	2025 - 2029	2029 onwards	Project construction and operation phase overlaps with Proposed Development construction and operation and maintenance phases
Infrastructure							
No Infrastructure projects identified within the fish and shellfish ecology CEA study area							
Ministry of Defence sites							
No MoD sites identified within the fish and shellfish ecology CEA study area							
Tier 3							
Subsea Cables (Telecommunications and Interlinks)							
Cambois connection	Pre-Application	0	0	Export cable to facilitate additional grid connection	Q1 2028 – Q4 2031 (24 month construction activity within overall construction period outlined)	Q4 2031	The construction and operation and maintenance phases of the Cambois connection overlap with the construction and operation and maintenance phases of the Proposed Development.
Tier 4							
ScotWind	Lease offer	Unknown	Unknown	17 offshore wind projects with combined capacity of 24.8 GW	Unknown	Unknown	Screened out. There is currently insufficient data to make a fair and robust assessment of any overlap and therefore cumulative effects associated with the ScotWind proposals have been screened out.

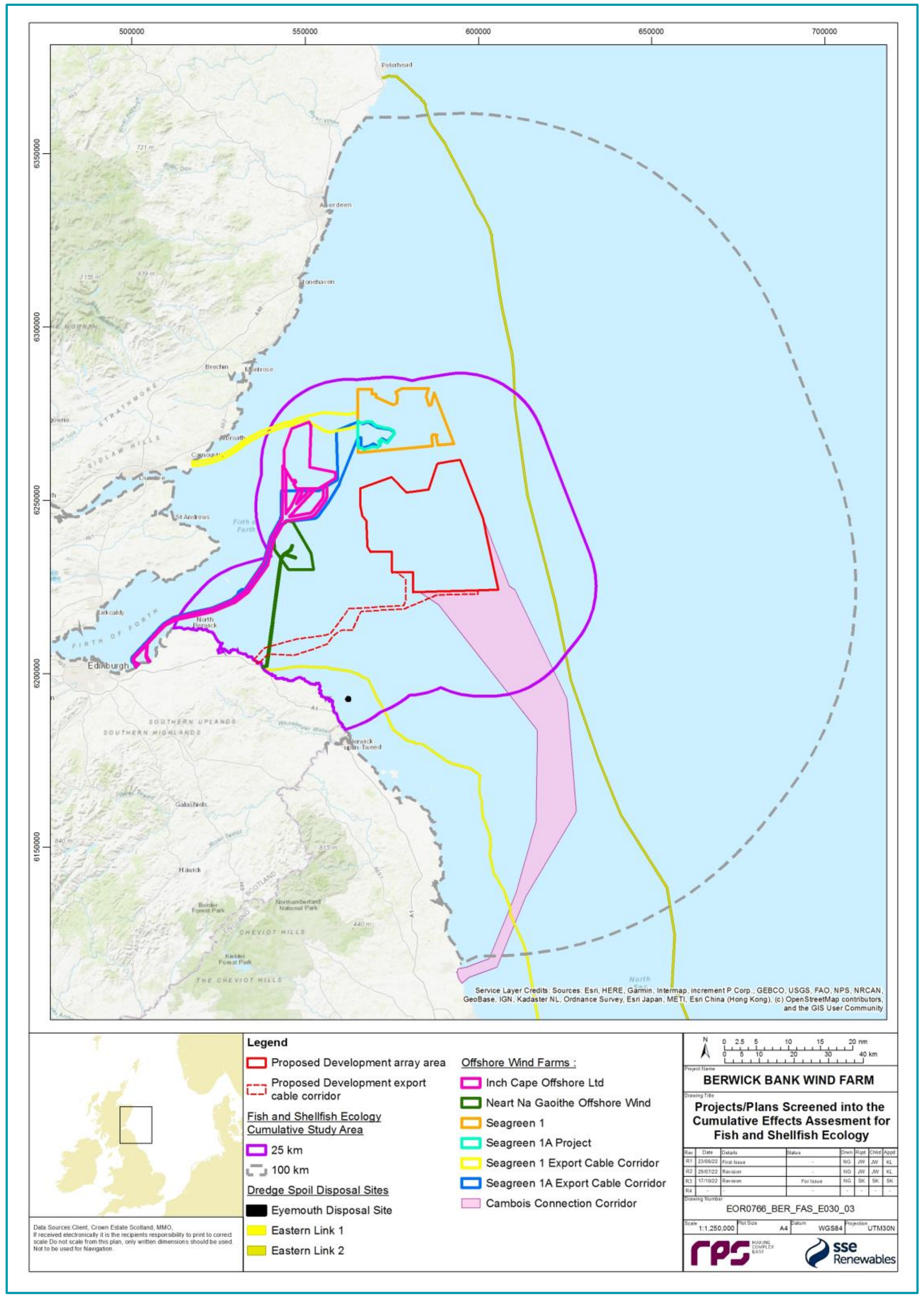

Figure 9.11: Other Projects/Plans Screened into the Cumulative Effects Assessment for Fish and Shellfish Ecology

9.12.2. MAXIMUM DESIGN SCENARIO

300. The maximum design scenarios identified in Table 9.32 have been selected as those having the potential to result in the greatest effect on an identified IEF or receptor group. The cumulative effects presented and assessed in this section have been selected from the details provided in volume 1, chapter 3 of the Offshore EIA Report as well as the information available on other projects and plans (see volume 3, appendix 6.4), to inform a 'maximum design scenario'. Effects of greater adverse significance are not predicted to arise should any other development scenario, based on details within the PDE (e.g. different wind turbine layout), to that assessed here, be taken forward in the final design scheme.

Table 9.32: Maximum Design Scenario Considered for Each Impact as Part of the Assessment of Likely Significant Cumulative Effects on Fish and Shellfish Ecology

Potential Cumulative Effect	Phase[5] C	O	D	Tier	Maximum Design Scenario
Temporary Subtidal Habitat loss/disturbance	✓	✓	✓	2	**Construction Phase** Maximum design scenario as described for construction phase in Table 9.15 assessed cumulatively with the following marine projects within a representative 25 km buffer of the Proposed Development fish and shellfish ecology study area boundary: • construction and operation and maintenance of the Inch Cape Offshore Wind Farm; • operation and maintenance of the Neart na Gaoithe Offshore Wind Farm; • operation and maintenance of the Seagreen 1; • construction and operation and maintenance of the Seagreen 1A Project; • construction and operation and maintenance of Eastern Link 1; • construction and operation and maintenance of Eastern Link 2; and • operation of the Eyemouth disposal site. **Operation and Maintenance Phase** Maximum design scenario as described for operation and maintenance phase in Table 9.15 assessed cumulatively with the operation and maintenance of the following marine projects within a representative 25 km buffer of the Proposed Development fish and shellfish ecology study area boundary: • operation and maintenance, and decommissioning of the Inch Cape Offshore Wind Farm; • operation and maintenance, and decommissioning of the Neart na Gaoithe Offshore Wind Farm; • operation and maintenance, and decommissioning of the Seagreen 1; • operation and maintenance and decommissioning of the Seagreen 1A Project; • operation and maintenance of the Seagreen 1A Export Cable Corridor; • operation and maintenance of Eastern Link 1; • operation and maintenance of Eastern Link 2; and • operation of the Eyemouth disposal site. **Decommissioning Phase** There are currently no known projects which will result in a cumulative effect during this phase of the Proposed Development.
Temporary subtidal habitat loss/disturbance	✓	✓	✓	3	**Construction Phase** Maximum design scenario as described for construction phase assessed cumulatively with the full development of the following marine projects within a 25 km buffer (i.e. 2 tidal excursions) of the Proposed Development fish and shellfish ecology study area boundary: • tier 2 projects; and • construction and operation and maintenance of Cambois connection. **Operation and Maintenance Phase** Maximum design scenario as described for operation and maintenance phase assessed cumulatively with the full development of the following marine projects within a 25 km buffer (i.e. 2 tidal excursions) of the Proposed Development fish and shellfish ecology study area boundary:

[5] C = Construction, O = Operation and maintenance, D = Decommissioning

Potential Cumulative Effect	Phase[5] C	O	D	Tier	Maximum Design Scenario
					• tier 2 projects; and • operation and maintenance of Cambois connection. **Decommissioning Phase** There are currently no known projects which will result in a cumulative effect during this phase of the Proposed Development.
Increased SSC and associated sediment deposition	✓	×	✓	2	**Construction Phase** Maximum design scenario as described for construction phase in Table 9.15 assessed cumulatively with the following offshore wind farms and disposal sites within a 25 km buffer (i.e. 2 tidal excursions) of the Proposed Development fish and shellfish ecology study area boundary: • construction of Inch Cape Offshore Wind Farm; • construction of the Seagreen 1A Project; • construction of Eastern Link 1; • construction of Eastern Link 2; and • use of Eyemouth disposal site. **Decommissioning Phase** There are currently no known projects which will result in a cumulative effect during this phase of the Proposed Development.
Increased SSC and associated sediment deposition	✓	×	✓	3	**Construction Phase** Maximum design scenario as described for construction phase assessed cumulatively with the full development of the following marine projects within a 25 km buffer (i.e. 2 tidal excursions) of the Proposed Development fish and shellfish ecology study area boundary: • tier 2 projects; and • construction and operation and maintenance of Cambois connection. **Decommissioning Phase** There are currently no known projects which will result in a cumulative effect during this phase of the Proposed Development.
Injury and/or disturbance to fish and shellfish from underwater noise and vibration	✓	×	×	2	**Construction Phase** Maximum design scenario as described for construction phase in Table 9.15 assessed cumulatively with the following marine projects within a representative 100 km buffer of the Proposed Development boundary: • construction of Inch Cape Offshore Wind Farm; and • construction of the Seagreen 1A Project.

Potential Cumulative Effect	Phase[5] C	O	D	Tier	Maximum Design Scenario
Long-term subtidal habitat loss	✓	✓	✓	2	**Construction and Operation and Maintenance Phases** Maximum design scenario as described for construction, and operation and maintenance phases in Table 9.15 assessed cumulatively with the full development of the following marine projects within a representative 25 km buffer of the Proposed Development boundary: • construction, operation and maintenance and decommissioning of Inch Cape Offshore Wind Farm; • operation and maintenance and decommissioning of Neart Na Gaoithe Offshore Wind Farm; • operation and maintenance and decommissioning of Seagreen 1; • construction, operation and maintenance and decommissioning of Seagreen 1A Project • construction and operation and maintenance of Eastern Link 1; • construction and operation and maintenance of Eastern Link 2; • operation and maintenance and decommissioning of Seagreen 1A Export Cable Corridor; and • use of Eyemouth disposal site. **Decommissioning Phase** There are currently no known projects which will result in a cumulative effect during this phase of the Proposed Development.
Long-term subtidal habitat loss	✓	✓	✓	3	**Construction Phase and Operation and Maintenance Phases** Maximum design scenario as described for construction phase assessed cumulatively with the full development of the following marine projects within a 25 km buffer (i.e. 2 tidal excursions) of the Proposed Development boundary: • tier 2 projects; and • construction and operation and maintenance of Cambois connection. **Decommissioning Phase** There are currently no known projects which will result in a cumulative effect during this phase of the Proposed Development.
EMFs from subsea electrical cabling	×	✓	×	2	**Operation and Maintenance Phase** Maximum design scenario as described for operation and maintenance phase in Table 9.15 assessed cumulatively with the full development of the following marine projects within a representative 25 km buffer of the Proposed Development fish and shellfish ecology study area boundary: • operation and maintenance of Inch Cape Offshore Wind Farm; • operation and maintenance of Neart Na Gaoithe Offshore Wind Farm; • operation and maintenance of Seagreen 1; • operation and maintenance of Seagreen 1A Project; • operation and maintenance of Seagreen 1A Export Cable Corridor; • operation and maintenance of Eastern Link 1; and • operation and maintenance of Eastern Link 2.

Potential Cumulative Effect	Phase[5] C	O	D	Tier	Maximum Design Scenario
EMFs from subsea electrical cabling	×	✓	×	3	**Operation and Maintenance Phase** Maximum design scenario as described for operation and maintenance phase assessed cumulatively with the full development of the following marine projects within a 25 km buffer (i.e. 2 tidal excursions) of the Proposed Development boundary: • tier 2 projects; and • operation and maintenance of Cambois connection.
Colonisation of foundations, scour protection and cable protection	×	✓	×	2	**Operation and Maintenance Phase** Maximum design scenario as described for operation and maintenance phase in Table 9.15 assessed cumulatively with the full development of the following marine projects within a representative 25 km buffer of the Proposed Development fish and shellfish ecology study area boundary: • operation and maintenance of Inch Cape Offshore Wind Farm; • operation and maintenance of Neart Na Gaoithe Offshore Wind Farm; • operation and maintenance of Seagreen 1; • operation and maintenance of Seagreen 1A Project; • operation and maintenance of Seagreen 1A Export Cable Corridor; • operation and maintenance of Eastern Link 1; and • operation and maintenance of Eastern Link 2. **Decommissioning Phase** There are currently no known projects which will result in a cumulative effect during this phase of the Proposed Development.
Colonisation of foundations, scour protection and cable protection	×	✓	×	3	**Operation and Maintenance Phase** Maximum design scenario as described for operation and maintenance phase assessed cumulatively with the full development of the following marine projects within a 25 km buffer (i.e. 2 tidal excursions) of the Proposed Development fish and shellfish ecology study area boundary: • tier 2 projects; and • operation and maintenance of Cambois connection. **Decommissioning Phase** There are currently no known projects which will result in a cumulative effect during this phase of the Proposed Development.

9.12.3. CUMULATIVE EFFECTS ASSESSMENT

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

CUMULATIVE TEMPORARY SUBTIDAL HABITAT LOSS/DISTURBANCE

Tier 2

Construction phase

Magnitude of impact

302. The construction and operation and maintenance of the projects/plans/activities shown in Table 9.32 may lead to cumulative temporary subtidal habitat loss/disturbance within the fish and shellfish ecology CEA study area. Table 9.33 presents the areas of habitat loss for each project. This total area is highly conservative as the majority of the disturbance would not occur at the same time, rather small proportions of habitat loss would occur across the CEA study area over the construction phase for the Proposed Development.

303. Table 9.32 and Figure 9.11 shows all projects/plans/activities considered in the Tier 2 assessment which are Inch Cape Offshore Wind Farm, Neart na Gaoithe Offshore Wind Farm, Seagreen 1, Seagreen 1A Project, Seagreen 1A Export Cable Corridor, Eastern Link 1, Eastern Link 2 and Eyemouth disposal site. There is small overlap between construction phase for the Proposed Development and Inch Cape Offshore Wind Farm and Seagreen 1A Project as well as the operation and maintenance phases once construction has completed. The remaining projects will be in their operation and maintenance phase during the Proposed Development construction phase. The total cumulative temporary subtidal habitat loss is 145,325,450 m^2, however this number is highly conservative as habitat loss associated operation and maintenance will be spread over the entirety of the phase, and therefore there will only be a small proportion of this habitat loss happening at any one time.

304. Table 9.33 shows the cumulative temporary habitat loss/disturbance within a 25 km buffer for all projects in the Tier 2 assessment, noting that the Seagreen 1A assessment does not provide estimates for temporary habitat loss/disturbance associated with operation and maintenance (Seagreen Wind Energy, 2012). The values for temporary habitat disturbance/loss during the construction of the Seagreen 1A Project are presented in Table 9.33 and have been produced by undertaking a separate assessment to determine the maximum design scenario for this project using the following publicly available datasets (Seagreen Wind Energy, 2012b[6]; Seagreen Wind Energy, 2022[7]; and Seagreen Wind Energy 2020[8]). These values have then been subtracted from those provided in the Seagreen 1 assessment (Seagreen Wind Energy, 2012a) to calculate the maximum design scenario for Seagreen 1, to prevent double counting and to ensure these projects are assessed separately and proportionately.

305. There is also expected to be temporary habitat disturbance from the construction and operation and maintenance of Eastern Link 1 and 2. The environmental appraisal for Eastern Link 1 does not give a specific value for temporary habitat loss in the project however it is expected to include a pre-installation footprint of 50 m and a 30 m footprint for cable installation. Additionally, only 24% of the 176 km Eastern Link 1 cable will be within the Proposed Development fish and shellfish ecology study area therefore only a proportion of the overall impact will be cumulative. Table 9.33 shows that in the construction phase Eastern Link 2 will result in 15,200,000 m^2 of temporary habitat disturbance however only 18% of the 436 km cables will occur with the Proposed Development fish and shellfish ecology study area.

306. There is potential for cumulative impacts to arise with disposal activities at the Eyemouth disposal site. The total area of the site is 664,761 m^2 (see Table 9.33), however only a very small portion of this would be affected at any one time by an individual disposal event.

307. The maximum design scenario for habitat loss from the cumulative offshore wind farms, and the Eyemouth disposal site has been considered in this cumulative assessment. However, as noted above, this is considered to be highly precautionary as activities associated with the operation and maintenance phase of wind farms occur intermittently throughout the phase and therefore are unlikely to completely overlap with the construction phase of the Proposed Development.

308. The cumulative impact is predicted to be of regional spatial extent, short term duration, intermittent and high reversibility. It is predicted that the impact will affect the fish and shellfish IEFs directly. Given the minor temporal overlap in construction activities and that the operation and maintenance activities associated with the relevant projects will not add substantially to the total footprint associated with the Proposed Development and with only a proportion of the operation and maintenance operations occurring during the construction phase of the Proposed Development or overlapping during the operation and maintenance operations, the magnitude of the impact will not be greater than that assumed for the project alone. The magnitude is therefore, considered to be low.

Table 9.33: Total Area and Component Parts of Temporary Habitat Loss/Disturbance of the Relevant Cumulative Impact Projects in the Construction Phase of the Proposed Development

Project	Total Area of Temporary of Habitat/Loss (m^2)	Component Parts of Temporary Habitat Loss
Proposed Development	113,974,700	See Table 9.15
Inch Cape Offshore Wind Farm (Inch Cape Offshore Limited, 2018)	8,560,000 (construction)	Temporary habitat loss will result from: • seabed preparation for wind turbines, OSP/Offshore convertor substation platforms and met masts; • installation of inter-array cables; • jack up vessel footprints; • anchorage of inter-array cable installation vessels; • installation of offshore export cable; and • anchoring of offshore export cable installation vessels.
	3,675,000 (operation)	Temporary habitat loss will result from: • jack-up vessel footprints;

[6] Table 1 'Worst-case' scenario for Project Alpha assessment (includes Turbines, intra-array cables and ancillary structures and any activities to place maintain or remove these) (marine.gov.scot)

[7] A4 Report with Paragraph Numbering (marine.gov.scot)

[8] ota_construction_method_statement.pdf (marine.gov.scot)

Project	Total Area of Temporary of Habitat/Loss (m^2)	Component Parts of Temporary Habitat Loss
		• vessel anchorage footprint; • inter-array cable reburial; and • offshore export cable reburial.
Neart na Gaoithe Offshore Wind Farm (Mainstream Renewable Power, 2019)	50,000 (operation)	Temporary habitat loss will result from: • jack up vessel footprint; and • jack up vessel anchorage.
Seagreen 1	N/A (operation)	The environmental statement for this project did not quantify the temporary habitat loss footprint associated with maintenance activities.
Seagreen 1A Project (Seagreen Wind Energy, 2012)	689,394 (construction)	Temporary habitat loss will result from: • installation of array cables; and • gravity based structures for wind turbine foundations, meteorological masts and OSP/Offshore convertor substation platforms.
	N/A (operation)	The environmental statement for this project did not quantify the temporary habitat loss footprint associated with maintenance activities.
Eastern Link 1 (National Grid Electricity Transmission and Scottish Power Transmission, 2022)	No values provided by the environmental appraisal (construction)	No overall value is provided for temporary habitat disturbance for this project however it is expected to include a pre-installation footprint of 50 m and a 30 m footprint for cable installation.
	N/A (operation)	Temporary habitat disturbance will result from: • boulder clearance; and • cable installation.
Eastern Link 2 (National Grid Electricity Transmission and Scottish Hydro Electric Transmission plc, 2022)	15,200,000 m^2 (construction)	Temporary habitat disturbance will result from: • boulder clearance; and • cable installation.
	N/A (operation)	The environmental appraisal for this project does not quantify the temporary habitat disturbance footprint associated with maintenance activities. It does state that repair works are likely to be highly localised to the area of concern and therefore the spatial extent of any impacts would be small in extent.
Eyemouth Disposal Site (Marine Scotland, 2018)	664,761	Total area represents the area over which disposal activities can occur, noting that habitat loss/disturbance will only affect a small proportion of this area.
Total Cumulative Temporary Habitat Loss	142,813,855	N/A

Sensitivity of receptor

309. The sensitivity of fish and shellfish IEFs is summarised below, and is as described in section 9.11, paragraphs 70 to 89.

Marine Species

310. Most fish and shellfish ecology IEFs in the Proposed Development fish and shellfish ecology study area and wider Proposed Development northern North Sea fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and local to national importance. The sensitivity of the receptor is therefore, considered to be low.

311. European lobster and *Nephrops* are deemed to be of high vulnerability, medium to high recoverability and of regional importance. The sensitivity of these fish and shellfish receptors is therefore considered to be medium.

312. Herring are deemed to be of high vulnerability, medium recoverability and of regional importance. However, the sensitivity of herring to this impact is considered to be low, due to the limited suitable spawning sediments overlapping with the Proposed Development fish and shellfish ecology study area and the core herring spawning ground being located well outside the Proposed Development fish and shellfish ecology study area.

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

Diadromous Species

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

Significance of effect

Marine Species

315. Overall, the magnitude of the cumulative effect is deemed to be low and the sensitivity of most fish and shellfish IEFs (including herring) is considered to be low. The effect will, therefore, be of **negligible to minor** adverse significance, which is not significant in EIA terms.

316. For sandeel, the magnitude of the cumulative effect is deemed to be low and the sensitivity is considered to be medium. Given the minor temporal overlap in construction activities and the operation and maintenance activities associated with the relevant projects, these will not add substantially to the total footprint associated with the Proposed Development. With only a small proportion of the operation and maintenance operations occurring during the construction phase of the Proposed Development and spread over a much larger area than the Proposed Development alone, the significance of the effect will not be greater than that assumed for the project alone. The effect will, therefore, be of **minor** adverse significance which is not significant in EIA terms.

317. For *Nephrops* and European lobster, the magnitude of the cumulative impact is deemed to be low and the sensitivity is considered to be medium. However, the significance of effect will not be greater than that assumed for the Proposed Development alone for the reasons outlined above.

Diadromous Species

318. 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.

Further mitigation and residual effect

319. No additional fish and shellfish ecology mitigation is considered necessary as the likely effect in the absence of further mitigation (beyond the designed in measures outlined in section 9.10) is not significant in EIA terms.

Operation and maintenance phase

Magnitude of impact

320. The operation and maintenance activities of the cumulative projects will overlap with the operation and maintenance phase of the Proposed Development and may lead to temporary subtidal habitat loss/disturbance of up to 32,276,397 m^2.

321. Table 9.32 and Figure 9.11 shows all projects/plans/activities considered in the Tier 2 assessment which are Inch Cape Offshore Wind Farm, Neart na Gaoithe Offshore Wind Farm, Seagreen 1, Seagreen 1A Project, Seagreen 1A Export Cable Corridor, Eastern Link 1, Eastern Link 2 and Eyemouth disposal site.

322. During the operation and maintenance phase of the Proposed Development, the other Tier 2 wind farms will reach their decommissioning age before the Proposed Development reaches its decommissioning age in 2066. The operation lifetime of Inch Cape is expected to be up to 35 years, with construction ending in 2025 and decommissioning expected in 2060 (Inch Cape Offshore Limited, 2018). The operation lifetime of Neart na Gaoithe is expected to be 25 years, with construction ending in 2023 and decommissioning expected in 2048 (Mainstream Renewable Power, 2019). Seagreen 1 and Seagreen 1A Project has an operation and maintenance phase of 25 – 30 years which will lead to its decommissioning in 2048 – 2053 (Seagreen Wind Energy, 2012).

323. The maximum design scenario for habitat loss from the cumulative offshore wind farms has been considered in this cumulative assessment, with the total areas of seabed affected by this impact presented in Table 9.34. However, this is considered to be precautionary as activities associated with the operation and maintenance of the Proposed Development (and the other developments considered here) will occur intermittently throughout the lifetime of the Proposed Development and therefore are unlikely to completely overlap with the decommissioning periods of the other offshore wind farms. Furthermore, Inch Cape Offshore Wind Farm and Neart na Gaoithe Offshore Wind Farm assume in their environmental statements that the decommissioning process will produce similar levels of temporary habitat disturbance to their construction phase however this is likely to be an over estimation because not all of the infrastructure is likely to be removed from the seabed in the final plans (Inch Cape Offshore Limited, 2018; Mainstream Renewable Power, 2019). The EIA for Seagreen 1 however does not make this assumption and provide specific values (Seagreen Wind Energy, 2012). Values for the Seagreen 1A Project have been determined by the project specific assessment undertaken by RPS (further detail in paragraph 304).

324. The environmental assessment for Seagreen 1A Export Cable Corridor provides no values for the operation and maintenance of the cable; however, it is expected to be small in comparison with the Proposed Development and the other offshore wind farms considered. The impacts during decommissioning are expected to be similar, and less significant, than those predicted during installation (Seagreen Wind Energy Ltd., 2021).

325. The environmental appraisals for Eastern Link 1 (National Grid Electricity Transmission and Scottish Power Transmission, 2022) and Eastern Link 2 (National Grid Electricity Transmission and Scottish Hydro Electric Transmission plc, 2022) do not provide detail regarding the temporary habitat disturbance of their maintenance activities. They do however expect it to be highly reduced from the construction phase and repair works are likely to be highly localised to the area of concern and therefore the spatial extent of any impacts would be small in extent.

326. Currently it is unknown when the Eyemouth disposal site may close therefore to ensure the worst-case scenario it has been assumed it will still be open and the area of temporary habitat loss can be seen in Table 9.34 (Marine Scotland, 2018).

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

Table 9.34: Total Area and Component Parts of Temporary Habitat Loss/Disturbance of the Relevant Cumulative Projects in the Operation and Maintenance Phase of the Proposed Development

Project	Total Area of Temporary Habitat/Loss (m^2)	Component Parts of Temporary Habitat Loss
Proposed Development	989,000	See Table 9.15
Inch Cape Offshore Wind Farm (Inch Cape Offshore Limited, 2018)	12,249,636	Temporary habitat loss will result from: • operation and maintenance activities in Table 9.33; • removal of wind turbines, OSP/Offshore convertor substation platform and meteorological masts; • removal of Inter-array cables and offshore export cables; • jack up vessels and anchorage; and • removal of intertidal cable. The total habitat loss area presented in this table is based on the 2014 Environmental Statement. It is noted that the 2018 Environmental Statement assessed a smaller project (i.e. fewer wind turbines), although the total area associated with this assessment of effects was not updated from 2014. Therefore, the numbers presented here are considered to be conservative.
Neart na Gaoithe Offshore Wind Farm (Mainstream Renewable Power, 2019)	2,910,000	Temporary habitat loss will result from: • operation and maintenance activities in Table 9.33; • wind turbines and OSP/Offshore convertor substation platform removal; and • inter-array cable and offshore export cable removal.
Seagreen 1(Seagreen Wind Energy, 2012)	14,774,406 (not including Operation and Maintenance Phase activity)	Temporary habitat loss will result from: • removal of wind turbines, OSP/Offshore convertor substation platform and met masts; • jack up vessels and anchorage; and • removal of inter-array and offshore export cables.
Seagreen 1A Project	689,394 (not including operation and maintenance phase activity)	Temporary habitat loss will result from: • operation and maintenance activities in Table 9.33; • removal of wind turbines and OSP/Offshore convertor substation platforms/Offshore convertor station platforms; • jack up vessels and anchorage; and • removal of array and offshore export cables.
Eastern Link 1 (National Grid Electricity Transmission and Scottish Power Transmission, 2022)	N/A (operation)	The environmental appraisal for this project does not quantify the temporary habitat disturbance footprint associated with maintenance activities. It does state that repair works are likely to be highly localised to the area of concern and therefore the spatial extent of any impacts would be small in extent.
Eastern Link 2 (National Grid Electricity Transmission and Scottish Hydro Electric Transmission plc, 2022)	N/A (operation)	The environmental appraisal for this project does not quantify the temporary habitat disturbance footprint associated with maintenance activities. It does state that repair works are likely to be highly localised to the area of concern and therefore the spatial extent of any impacts would be small in extent.
Seagreen 1A Export Cable Corridor	N/A	The environmental statement for this project was unable to quantify the temporary habitat loss footprint associated with maintenance activities,

Project	Total Area of Temporary Habitat/Loss (m^2)	Component Parts of Temporary Habitat Loss
		however it states that the localised ZoI of disturbance is 6 m to 10 m, with an approximate cable length of 110 km.
Eyemouth Disposal Site (Marine Scotland, 2018)	664,761	Total area represents the area over which disposal activities can occur.
Cumulative Temporary Habitat Loss	32,277,197	N/A

Sensitivity of the receptor

328. The sensitivity of fish and shellfish IEFs is summarised below, and is as described in section 9.11, paragraphs 70 to 89.

Marine Species

329. Most fish and shellfish ecology IEFs in the Proposed Development fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and local to national importance. The sensitivity of the receptor is therefore, considered to be low.

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

331. Herring are deemed to be of high vulnerability, medium recoverability and of regional importance. However, the sensitivity of herring to this impact is considered to be low, due to the limited suitable spawning sediments overlapping with the Proposed Development fish and shellfish ecology study area and the core herring spawning ground being located well outside the Proposed Development fish and shellfish ecology study area.

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

Diadromous Species

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

Significance of the effect

Marine Species

334. Overall, the magnitude of the cumulative effect is deemed to be low and the sensitivity of most fish and shellfish IEFs (including herring) is considered to be low. The effect will, therefore, be of **negligible to minor** adverse significance, which is not significant in EIA terms.

335. For *Nephrops* and European lobster, the magnitude of the cumulative impact is deemed to be low and the sensitivity is considered to be medium. However, the significance of effect will not be greater than that assumed for the Proposed Development alone for the reasons outlined above.

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

Diadromous Species

337. 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.

Further mitigation and residual effect

338. No additional fish and shellfish ecology mitigation is considered necessary as the likely effect in the absence of further mitigation (beyond the designed in measures outlined in section 9.10) is not significant in EIA terms.

Decommissioning phase

339. There are no Tier 2 projects active in the Proposed Development decommissioning phase to consider for cumulative impacts based on current knowledge. Any programme changes resulting in decommissioning overlap with the Proposed Development are considered in paragraph 294.

Tier 3

Construction phase

Magnitude of impact

340. The only Tier 3 project which has been identified in the CEA with the potential to result in cumulative temporary habitat loss with the Proposed Development is the Cambois connection.

341. Values for the temporary habitat disturbance/loss associated with the construction of the Cambois connection are detailed in Table 9.35. The values for the Cambois connection are based on information presented in the Scoping Report submitted in September 2022.

Table 9.35: Total Area and Component Parts of Temporary Habitat Loss/Disturbance of the Relevant Tier 3 Cumulative Impact Projects in the Construction Phase of the Proposed Development

Project	Total Area of Temporary Habitat/Loss (m^2)	Component Parts of Temporary Habitat Loss
Tier 2	See Table 9.33	
Cambois connection	17,000,000	This temporary habitat disturbance/loss assumes that 680 km (4 HVAC or HVDC cables each 170 km long) of offshore export cable will be installed in trenches with a width of temporary ZoI of 25 m. Installation via jet trencher, deep jet trencher, mechanical trencher, cable plough (displacement and non-displacement), mass flow excavator (MFE) or similar.
	N/A (operation)	There is currently no information on the potential maintenance activities which will occur for this offshore export cable, however they are assumed to be minimal.

342. Figure 9.11 shows that the Cambois connection extends far beyond the fish and shellfish ecology cumulative study area, therefore the majority of this disturbance will not spatially overlap with the Proposed

Development. Up to 180 km of Cambois connection cables (i.e. four cables each up to 45 km in length) may however be installed within the Proposed Development array area which could result in up to 4.5 km^2 of repeat disturbance within the Proposed Development array area previously impacted during the construction of the Proposed Development. The disturbance associated with the Cambois connection cable installation will however be highly localised (25 m width of potential disturbance) and so the potential for repeat disturbance is considered low and unlikely to lead to an increase in the magnitude than predicted for the Proposed Development alone.

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

Sensitivity of the receptor

344. The sensitivity of fish and shellfish IEFs is as described in section 9.11, paragraphs 67 to 85.

Significance of the effect

Marine Species

345. Overall, the magnitude of the cumulative effect is deemed to be low and the sensitivity of most fish and shellfish IEFs (including herring) is considered to be low. The effect will, therefore, be of **negligible to minor** adverse significance, which is not significant in EIA terms.

346. For *Nephrops* and European lobster, the magnitude of the cumulative impact is deemed to be low and the sensitivity is considered to be medium. However, the significance of effect will not be greater than that assumed for the Proposed Development alone for the reasons outlined above.

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

Diadromous Species

348. 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.

Further mitigation and residual effect

349. No additional fish and shellfish ecology mitigation is considered necessary as the likely effect in the absence of further mitigation (beyond the designed in measures outlined in section 9.10) is not significant in EIA terms.

Operation and maintenance phase

350. The only Tier 3 project which has been identified in the CEA with the potential to result in cumulative temporary habitat loss with the operation and maintenance of the Proposed Development is the Cambois connection. There are no specific values for the operation and maintenance phase of Cambois connection as the assessment of habitat loss which will occur during the operation and maintenance phase of the Proposed Development has not yet been completed, therefore values are unavailable. No quantification of Tier 3 cumulative impacts is possible at this stage and as a result, no assessment of the cumulative impacts of these projects can be made.

Decommissioning phase

351. There are no Tier 3 projects active in the Proposed Development decommissioning phase to consider for cumulative impacts based on current knowledge. Any programme changes resulting in decommissioning overlap with the Proposed Development are considered in paragraph 294.

CUMULATIVE INCREASED SUSPENDED SEDIMENT CONCENTRATIONS AND ASSOCIATED SEDIMENT DEPOSITION

352. Increased SSC and associated deposition may arise due to the seabed preparation, installation of the wind turbines and OSP/Offshore convertor substation platform foundations, the installation and/or maintenance of inter-array cables and the offshore export cables and associated decommissioning activities. Should the other projects cited take place concurrently with the Proposed Development construction or maintenance, there is potential for cumulative increased turbidity levels.

Tier 2

Construction phase

Magnitude of impact

353. The magnitude of the increase in SCC and associated deposition arising from the installation of wind turbines and OSP/Offshore convertor substation platform foundations, inter-array cables and offshore export cables during the construction phase, has been assessed as low for the Proposed Development alone, as described above in paragraph 113 *et seq*.

354. The construction phase of the Proposed Development coincides with the construction phases for Seagreen 1A Project. Construction of its 36 wind turbines will be completed by the end of 2025, which will lead to an overlap with the construction phase of the Proposed Development.

355. The Inch Cape Offshore Wind Farm will be in the final year of construction, with the installation of the offshore export cable being programmed for the period of overlap. The cable path is located to the east of the Proposed Development and should trenching activities be undertaken simultaneously the sediment plumes would not interact with those from the Proposed Development.

356. During the Proposed Development's construction phase the Neart na Gaoithe Offshore Wind Farm and the Seagreen 1A Export Cable Corridor will be in operation and maintenance phase and maintenance activities may result in increased SCC, however these activities would be of limited spatial extent and frequency and unlikely to interact with sediment plumes from the Proposed Development.

357. The Eastern Link 1 Cable has Scottish landfall near Thorntonloch Beach, East Lothian. The landfall installation is proposed to be by HDD and although it is not yet confirmed which subsea trenching techniques will be used to install the cables, it is anticipated that mechanical ploughing or cutting and/or water jetting or Mass Flow Excavation (MFE) techniques will be used at different points along the route, in response to the seabed sediment conditions. Installation of the cables into soft sediments will seek to achieve a target burial depth of at least 1.5 m to 2 m and below the depth of mobile sediments depending on the nature of the seabed and potential hazards. Significant impacts of sediment plumes arising from cable laying activities are not anticipated. These installation parameters are similar to those for the Proposed Development offshore export cable installation and therefore the magnitude of the impact on the fish and shellfish receptors is anticipated to be low.

358. The Eastern Link 2 Cable runs to the east of the Proposed Development, skirting the FFBC MPA. For the extent of the overlap with the fish and shellfish ecology cumulative study area this is an offshore marine

cable. The preferred subsea cable protection method is burial through trenching. It is not yet confirmed what subsea trenching equipment will be used to install the cables; however, it is anticipated similar methods to those proposed for Eastern Link 1 may be required, but this is dependent on the seabed conditions present within the offshore export cable corridor: It is anticipated that the magnitude of the impact on the fish and shellfish receptors would be low.

359. The CEA considers sea disposal of dredged material at the Eyemouth disposal site, located 31 km and 16.5 km from the Proposed Development array area and Proposed Development export cable corridor respectively. If offshore cable installation and dredge material dumping coincided, both resultant plumes would be advected on the tidal currents. The plumes would travel in parallel, and not towards one another, and are unlikely to interact in the event that offshore cables installation coincides with the use of the licensed sea disposal site (see volume 3, appendix 7.1).

360. The cumulative impact is predicted to be of local spatial extent, short term duration and intermittent and of high reversibility. The magnitude is therefore, considered to be low.

Sensitivity of the receptor

361. The sensitivity of fish and shellfish IEFs is summarised below and is as described in section 9.11, paragraphs 120 to 128.

Marine Species

362. Based on the increase in sensitivity of herring eggs to the smothering effects of increased sediment deposition, herring is deemed to be of medium vulnerability, high recoverability and of regional importance, and therefore the sensitivity of this receptor is considered to be medium.

363. Most fish and shellfish ecology IEFs in the Proposed Development fish and shellfish ecology study area are deemed to be of low to medium vulnerability, high recoverability and local to national importance. The sensitivity of these IEFs is therefore considered to be low.

Diadromous Species

364. Diadromous fish species IEFs in the Proposed Development fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is therefore, considered to be low.

Significance of the effect

Marine Species

365. For most fish and shellfish IEFs, 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.

366. For herring, 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.

Diadromous Species

367. 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.

Further mitigation and residual effect

368. No additional fish and shellfish ecology mitigation is considered necessary as the likely effect in the absence of further mitigation (beyond the designed in measures outlined in section 9.10) is not significant in EIA terms.

Decommissioning phase

369. As per the maximum design scenario, during the decommissioning phase all structures above the seabed would be removed. It is proposed to remove all export, inter-array and inter-connector cables and scour protection where possible and appropriate to do so. During decommissioning cables would be removed by similar processes as undertaken during installation therefore increases in suspended sediment concentrations would be of a similar form and magnitude. Following decommissioning, changes in suspended sediments concentration and sedimentation would return to baseline levels as it is anticipated that all structures above the seabed level will be completely removed and no further operation to disturb the seabed would be required. Therefore, refer to the assessment undertaken for the construction phase.

Tier 3

Construction phase

Magnitude of Impact

370. During the construction phase of the Proposed Development there is the potential for cumulative impacts with three Tier 3 cable installations. The Cambois connection is a 170 km offshore cable route extending southwards from the Proposed Development array area. Scoping indicates the project will consist of up to four cables installed in 2 m wide trenches up to 3 m in depth. Installation techniques may include jet trenching or cable ploughing, as ground conditions dictate. Site preparation will be required, such as boulder and sand wave clearance as part of the 36-month construction programme.

371. The cumulative impact is predicted to be of local spatial extent, short term duration, intermittent and of high reversibility. The magnitude is therefore, considered to be low.

Sensitivity of the receptor

372. The sensitivity of fish and shellfish IEFs is as described in section 9.11, paragraphs 120 to 128.

Significance of the effect

Marine Species

373. For most fish and shellfish IEFs, 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.

374. For herring, 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.

Diadromous Species

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.

Further mitigation and residual effect

376. No additional fish and shellfish ecology mitigation is considered necessary as the likely effect in the absence of further mitigation (beyond the designed in measures outlined in section 9.10) is not significant in EIA terms.

Decommissioning phase

377. As per the maximum design scenario, during the decommissioning phase all structures above the seabed would be removed. It is proposed to remove all export, inter-array and inter-connector cables and scour protection where possible and appropriate to do so. Therefore, there is no contact with the seabed during decommissioning and subsequently no impact on the changes of SCC and sedimentation for cumulative impacts. During decommissioning cables would be removed by similar processes as undertaken during installation therefore increases in suspended sediment concentrations would be of a similar form and magnitude. Following decommissioning, changes in suspended sediments concentration and sedimentation would return to baseline levels as it is anticipated that all structures above the seabed level will be completely removed and no further operation to disturb the seabed would be required. Therefore, refer to the assessment undertaken for the construction phase.

CUMULATIVE INJURY AND/OR DISTURBANCE TO FISH AND SHELLFISH FROM UNDERWATER NOISE AND VIBRATION

Tier 2

Construction phase

Magnitude of impact

378. The Proposed Development, together with the projects and plans identified in Table 9.32, may lead to injury and/or disturbance to fish and shellfish from underwater noise and vibration. The other projects and plans screened into the assessment are: Inch Cape Offshore Wind Farm and Seagreen 1A Project. Cumulative effects of underwater noise on fish and shellfish IEFs have the potential to occur as a result of the Proposed Development, together with the Inch Cape Offshore Wind Farm and Seagreen 1A.

379. These projects include similar construction activities as those described for the Proposed Development alone including piling of wind turbine and OSP/Offshore convertor substation platform foundations. As outlined in paragraph 187, all other noise sources including cable installation and foundation drilling will result in much lower noise levels than piling and will not represent a risk to injury or cause significant disturbance to fish and shellfish, such that they would result in cumulative effects with or from other projects. As such, the scope of this assessment focusses on piling noise, which represents the greatest risk to fish and shellfish receptors. The construction phases of Inch Cape Offshore Wind Farm and Seagreen 1A Project overlap the construction phase of the Proposed Development with construction for Inch Cape Offshore Wind Farm predicted to end in 2025 and Seagreen 1A Project predicted to end in 2025. However, during the time where construction phases overlap, there is the potential for cumulative effects. The construction figures for the Seagreen 1A Project in Table 9.36 accounts for piling associated with 36 wind turbines which make up Seagreen 1A Project.

Table 9.36: Piling Parameters of the Relevant Cumulative Projects in the Construction Phase of the Proposed Development

Project	Maximum no. piles	Max hours per pile	Max Hammer energy (kJ)
Proposed Development	1432 (for 179 wind turbine foundations) 256 (for 10 OSP/Offshore convertor substation platform foundations)	8	4,000
Inch Cape Offshore Wind Farm (Inch Cape Offshore Limited, 2018)	74 (monopile option) 304 (piled jackets option)	2.6	4,500
Seagreen 1A Project (Seagreen Wind Energy, 2012)	144 (4 jacket foundations per wind turbine foundation))	1.5	2,300

380. Seagreen Alpha/Bravo Offshore Wind Farm Environmental Statement (Seagreen Wind Energy, 2012) reported that the maximum range for auditory injury for the most sensitive fish species (group 4 species) was 260 m. The Inch Cape Offshore Wind Farm Environmental Statement (Inch Cape Offshore Limited, 2018) reported injury ranges from piling activity on the most sensitive fish species (group 4 species) as follows:

- mortality and mortal injury: approximately 5 km^2;
- recoverable injury: approximately 17 km^2; and
- TTS: approximately 1,738 km^2.

381. Neither Inch Cape Offshore Wind Farm nor Seagreen Alpha/Bravo Offshore Wind Farm Environmental Statements predicted significant effects on fish and shellfish receptors. Any effects were predicted to be temporary and reversible following cessation of piling activities. Additionally, the injury ranges reported are likely to be conservative as soft start measures will be implemented as part of the Inch Cape Offshore Wind Farm and Seagreen 1A Project construction programmes, which will reduce the risk of injury considerably. Due to the minor overlap in construction phases of the Proposed Development and Inch Cape Offshore Wind Farm and Seagreen 1A Project, it is unlikely that cumulative effects will result in effects of greater significance than as assessed for the Proposed Development alone (see paragraph 152 *et seq*.).

382. The cumulative impact is predicted to be of regional spatial extent, short term duration and intermittent and of high reversibility. The magnitude is therefore, considered to be low.

Sensitivity of the receptor

383. The sensitivity of fish and shellfish IEFs is summarised below and is as described in section 9.11, paragraphs 159 to 196.

Marine Species

384. Based on the increase in sensitivity of herring eggs to underwater noise, herring is deemed to be of medium vulnerability, high recoverability and of regional importance, and therefore the sensitivity of this receptor is considered to be medium.

385. Sprat, cod and sandeel are deemed to be of medium vulnerability, high recoverability and regional to national importance. The sensitivity of the receptor is therefore, considered to be medium.

386. Most fish and shellfish ecology IEFs in the Proposed Development fish and shellfish ecology study area are deemed to be of low to medium vulnerability, high recoverability and local to national importance. The sensitivity of these IEFs is therefore considered to be low.

Diadromous Species

387. Diadromous fish species IEFs in the Proposed Development fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is therefore, considered to be low.

Significance of the effect

Marine Species

388. For most fish and shellfish IEFs, 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.

389. For herring, sprat, cod and sandeel, 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.

Diadromous Species

390. 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.

Further mitigation and residual effect

391. No additional fish and shellfish ecology mitigation is considered necessary as the likely effect in the absence of further mitigation (beyond the designed in measures outlined in section 9.10) is not significant in EIA terms.

CUMULATIVE LONG-TERM SUBTIDAL HABITAT LOSS

Tier 2

Construction and Operation and Maintenance Phase

Magnitude of impact

392. Long-term habitat loss will occur directly under all structures on the seabed, associated scour protection and cable protection, where this is required. Magnitude has been considered for the construction and operation and maintenance phases combined as the structures will be placed during construction and will be in place, with habitat loss continuing during the operation and maintenance phase. The installation of the projects outlined in Table 9.32Table 9.32: Maximum Design Scenario Considered for Each Impact as Part of the Assessment of Likely Significant Cumulative Effects on Fish and Shellfish Ecology may lead to long-term subtidal habitat loss of up to 15,014,156 m² within the fish and shellfish ecology CEA study area. Table 9.32: Maximum Design Scenario Considered for Each Impact as Part of the Assessment of Likely Significant Cumulative Effects on Fish and Shellfish Ecology Table 9.32 shows all projects/plans/activities considered in the Tier 2 assessment which are Inch Cape Offshore Wind Farm, Neart na Gaoithe Offshore Wind Farm, and Seagreen 1 and Seagreen 1A. The Seagreen 1A Export Cable Corridor Environmental Statement does not present a specific value for long term habitat loss, however, it is assumed that 20% of the cable length will require rock protection as a maximum design scenario.

The presence of offshore infrastructure at the Inch Cape Offshore Wind Farm may result in 2,470,000 m² of long-term subtidal habitat loss (Inch Cape Offshore Limited, 2018). The presence of offshore infrastructure at Neart na Gaoithe Offshore Wind Farm may result in a total of 361,000 m² of long-term habitat loss (Mainstream Renewable Power, 2019) The long term habitat loss values for the Seagreen 1A Project have been produced as part of the project specific assessment which was undertaken by RPS (further detail in paragraph 304). The presence of offshore infrastructure at Seagreen 1 may result in a total of 2,026,045 m² of long-term habitat loss (Seagreen Wind Energy, 2012) and the Seagreen 1A Project may result in a total of 158,055 m² of long-term habitat loss. The Seagreen 1A Export Cable Corridor Environmental Statement does not present a specific value for long term habitat loss, however, it is assumed that cable protection will be 6 m wide and may be required for up to 20% of the 110 km offshore export cable (Seagreen Wind Energy Ltd., 2021). Eastern Link 1's environmental appraisal does not provide specific values for long term habitat loss except to state rock berm of a 7 m width will be installed. The cables installed as a result of Eastern Link 2 (National Grid Electricity Transmission and Scottish Hydro Electric Transmission plc, 2022) will result in 2,200,200 m² of long term habitat loss. Additionally, only 24% of the 176 km Eastern Link 1 cable and only 18% of the 436 km Eastern Link 2 cables will be within the Proposed Development fish and shellfish study area therefore only a proportion of the overall impact will be cumulative. The details of the activities resulting in long-term subtidal habitat loss from each wind farm can be found in Table 9.37. The total cumulative habitat loss would represent only a small proportion (i.e. <1%) of the fish and shellfish habitats within the area considered in this CEA.

393. The cumulative impact is predicted to be of local spatial extent, long term duration, continuous and not reversible during the construction and operation and maintenance phase of the relevant projects. It is predicted that the impact will affect the fish and shellfish receptors directly. The magnitude is therefore, considered to be low.

Table 9.37: Total Area and Component Parts of Long-Term Subtidal Habitat Loss of the Relevant Cumulative Projects in the Construction and Operation and Maintenance Phases of the Proposed Development

Project	Total Area of Long-Term Subtidal Habitat Loss (m²)	Component Parts of Long-Term Subtidal Loss
Proposed Development	7,798,856	See Table 9.15.
Inch Cape Offshore Wind Farm (Inch Cape Offshore Limited, 2018)	2,470,000	Long-term habitat loss will result from: • wind turbine foundations; • OSP/Offshore convertor substation platform foundations; • meteorological mast foundations; • inter-array cable scour protection; and • offshore export cable protection. Numbers presented in this table are based on the 2014 Environmental Statement. It is noted that the 2018 Environmental Statement assessed a smaller project (i.e. fewer wind turbines), although the total area associated with this assessment of effects was not updated from 2014. Therefore, the numbers presented here are considered to be conservative.
Neart na Gaoithe Offshore Wind Farm (Mainstream	361,000	Long-term habitat loss will result from: • gravity base foundation wind turbines; • OSP/Offshore convertor substation platform jacket foundations; • inter-array cable scour protection, and

Project	Total Area of Long-Term Subtidal Habitat Loss (m^2)	Component Parts of Long-Term Subtidal Loss
Renewable Power, 2019)		• offshore export cable scour protection.
Seagreen 1 (Seagreen Wind Energy, 2012)	2,026,045	Long-term habitat loss will result from: • gravity base foundation wind turbines; • tubular jacket suction pile foundation wind turbines; • OSP/Offshore convertor substation platforms; • meteorological masts; • rock placement or mattress cable protection for the inter-array cables; and • rock placement or mattress cable protection for the offshore export cable.
Seagreen 1A Project (Seagreen Wind Energy, 2012)	158,055	Long-term habitat loss will result from: • gravity base foundation wind turbines, • tubular jacket suction pile foundation wind turbines • OSP/Offshore convertor substation platforms; and • rock placement or mattress cable protection for the inter-array and interconnector cables.
Eastern Link 1 (National Grid Electricity Transmission and Scottish Power Transmission, 2022)	No values provided in the environmental appraisal.	Long term habitat loss will result from: • remedial or planned rock berm.
Eastern Link 2 (National Grid Electricity Transmission and Scottish Hydro Electric Transmission plc, 2022)	2,200,200	Long term habitat loss will result from: • remedial or planned rock berm; • pipeline crossings; and • pock protection at landfall.
Seagreen 1A Export Cable Corridor	Not presented in Environmental Statement	It is assumed that 20% of the cable length will require rock protection (6 m wide), with an approximate cable length of 110 km.
Cumulative long-term subtidal habitat loss	15,014,156	N/A

Sensitivity of the receptor

394. The sensitivity of fish and shellfish IEFs is summarised below, and is as described in section 9.11, paragraphs 207 to 218.

Marine Species

395. Most fish and shellfish ecology IEFs in the Proposed Development fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and local to national importance. The sensitivity of the receptor is therefore, considered to be low.

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

397. Sandeel are deemed to be of high vulnerability, high recoverability and of national importance. The sensitivity of these fish and shellfish receptor is therefore considered to be medium.

398. Herring are deemed to be of high vulnerability, medium recoverability and of regional importance. However, the sensitivity of herring to this impact is considered to be low, due to the limited suitable spawning sediments overlapping with the Proposed Development fish and shellfish ecology study area and the core herring spawning ground being located well outside the Proposed Development fish and shellfish ecology study area and project boundaries for other projects considered in the CEA.

Diadromous Species

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

Significance of the effect

Marine Species

400. For most fish and shellfish ecology IEFs (including herring) 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.

401. For European lobster and *Nephrops,* 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.

402. For sandeel, 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

Diadromous Species

403. 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.

Further mitigation and residual effect

404. No additional fish and shellfish ecology mitigation is considered necessary as the likely effect in the absence of further mitigation (beyond the designed in measures outlined in section 9.10) is not significant in EIA terms.

Tier 3

Magnitude of impact

405. The only Tier 3 project which have been identified in the CEA with the potential to result in cumulative long-term habitat loss with the Proposed Development is the Cambois connection.

406. The values for the Cambois connection and the predicted extent of long term habitat loss associated with this project is presented in Table 9.38 and are based on information presented in the Cambois connection Scoping Report (SSER, 2022e) submitted in October 2022.

407. The installation of the Tier 2 and 3 projects may lead to cumulative long term subtidal habitat loss of up to 13,119,956 m^2 or 0.16% of the fish and shellfish ecology CEA study area.

408. 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.

Table 9.38: Total Area and Component Parts of Long Term Subtidal Habitat Loss of the Relevant Cumulative Projects in Tier 3 the Construction and Operation and Maintenance Operation and Maintenance Phases of the Proposed Development

Project	Total Area of Long Term Subtidal Habitat Loss (m^2)	Component Parts of Long-Term Subtidal Loss
Tier 1 and Tier 2	12,813,956	See Table 9.37.
Cambois connection	306,000	This long-term habitat loss is assumed to come from the installation of 102 km (15% of the total cable length) of cable protection with a width of 3 m in the form of rock/mattress protection.
Total cumulative long term habitat loss	13,119,956	N/A

Sensitivity of the receptor

409. The sensitivity of fish and shellfish IEFs is summarised below, and is as described in section 9.11, paragraphs 207 to 218.

Significance of the effect

Marine Species

410. For most fish and shellfish ecology IEFs (including herring) 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.

411. For European lobster and *Nephrops,* 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.

412. For sandeel, 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.

Diadromous Species

413. 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.

Further mitigation and residual effect

414. No additional fish and shellfish ecology mitigation is considered necessary as the likely effect in the absence of further mitigation (beyond the designed in measures outlined in section 9.10) is not significant in EIA terms.

CUMULATIVE ELECTROMAGNETIC FIELDS FROM SUBSEA ELECTRICAL CABLING

Tier 2

Operation and maintenance phase

Magnitude of impact

415. The operation and maintenance activities of the cumulative projects will overlap with the operation and maintenance phase of the Proposed Development and may impact fish and shellfish IEFs. Table 9.32 shows all projects/plans/activities considered in the Tier 2 assessment which are Inch Cape Offshore Wind Farm, Neart na Gaoithe Offshore Wind Farm, Seagreen 1, Seagreen 1A Project, Seagreen 1A Export Cable Corridor, Eastern Link 1 and Eastern Link 2. As outlined in Table 9.15, the Proposed Development may use a combination of HVAC and HVDC cables.

416. Inch Cape Offshore Wind Farm has the potential to produce EMF from 553 km of inter-array cables suitably buried and protected where burial is not possible. Additionally, the offshore export cables are approximately 83 km for each six cables, therefore the offshore export cables total length is 498 km. In combination with the Proposed Development this equates to 3,084 km of subsea cabling. This project will use a combination of HVAC and HVDC, however the design was not yet finalised in the environmental statement.

417. Neart na Gaoithe Offshore Wind Farm has the potential to produce EMF from 66 km of offshore export cables as well as 140 km of inter-array cables. In combination with the Proposed Development this equates to 2,506 km of subsea cabling. This project will use a combination of HVAC and HVDC, however the design was not yet finalised in the environmental statement.

418. Seagreen 1 and Seagreen 1A Project has the potential to produce EMF from 710 km of inter-array cables and 530 km of offshore export cables resulting in 1,240 km of subsea cabling. This arrangement included HVAC and HVDC however the design was not yet finalised in the environmental statement. Seagreen 1A Export Cable Corridor Environmental Statement does not provide details of the cable specifications used, but provides an approximate cable length of 110 km, which will have the potential to cause EMF effects

419. Eastern Link 1 has the potential to produce EMF from two 176 km HVDC cables resulting in up to 352 km of subsea cabling (National Grid Electricity Transmission and Scottish Power Transmission, 2022). Eastern Link 2 has the potential to produce EMF from two 436 HVDC cables resulting in up to 872 km of subsea cabling structures (National Grid Electricity Transmission and Scottish Hydro Electric Transmission plc, 2022).

420. The potential for cumulative impact of EMF on fish and shellfish IEFs during the Proposed Development operation and maintenance phase results from up to 6,112 km of subsea cabling, including the cables in the Proposed Development fish and shellfish ecology study area.

421. The cumulative impact is predicted to be of local spatial extent, long term duration, continuous and not reversible during the operation and maintenance phase (only at the decommissioning stage) of the relevant projects. It is predicted that the impact will affect the fish and shellfish IEFs directly. The magnitude is therefore, considered to be low. This can be concluded as EMF effects are confined to the close vicinity of cables. While the sediments in which cables are buried will not reduce the strength of EMF, the burial of cables does increase the distance between cables and fish and shellfish IEFs, with greater attenuation of EMFs with greater distance from the cable, thereby potentially reducing the effect of EMFs on those IEFs (see paragraph 233 *et seq*.).

Table 9.39: Total Cable Length of the Relevant Cumulative Projects in the Operation and Maintenance Phases of the Proposed Development (Seagreen 1A Export Cable Corridor not Included in Cumulative Length)

Project	Total Length of Inter-array Cables (km)	Total Length of Offshore Export Cables (km)	Interconnector	Total Cable Length within Project
Proposed Development	1,225	872	94	2,391
Inch Cape	553	498	N/A	1,051
Neart na Gaoithe	140	66	N/A	206
Seagreen 1	655	530	N/A	1,240
Seagreen 1A Project	55	N/A	3	58
Seagreen 1A Export Cable Corridor	N/A	Approx. 110	N/A	N/A
Eastern Link 1	N/A	N/A	N/A	352
Eastern Link 2	N/A	N/A	N/A	872
Cumulative length	**2,628**	**1,966**	**97**	**6,170**

Sensitivity of the receptor

422. The sensitivity of fish and shellfish IEFs is summarised below, and is as described in section 9.11, paragraphs 241 to 254.

Marine Species

423. Marine fish and shellfish ecology IEFs in the Proposed Development fish and shellfish ecology study area are deemed to be of low to medium vulnerability, high recoverability and local to national importance. The sensitivity of the receptor is therefore, considered to be low (most fish and shellfish IEFs) to medium (decapod crustaceans and elasmobranchs).

Diadromous Species

424. Diadromous fish IEFs in the Proposed Development fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is therefore, considered to be low.

Significance of the effect

Marine Species

425. For most fish and shellfish ecology IEFs (including herring) 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.

426. For European lobster and *Nephrops* edible crab and elasmobranchs, 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.

Diadromous Species

427. 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.

Further mitigation and residual effect

428. No additional fish and shellfish ecology mitigation is considered necessary as the predicted effect in the absence of further mitigation (beyond the designed in measures outlined in section 9.10) is not significant in EIA terms.

Tier 3

<u>Operation and Maintenance Phase</u>

Magnitude of impact

429. The only Tier 3 project which have been identified in the CEA with the potential to result in cumulative EMF effects from subsea electrical cabling within the Proposed Development is the Cambois connection. The Cambois connection includes up to 680 km of cable therefore combining this with tier 2 projects and the Proposed Development would lead to a cumulative length of 6,792 km.

430. The cumulative impact is predicted to be of local spatial extent, long term duration, continuous and not reversible during the operation and maintenance phase (only at the decommissioning stage) of the relevant projects. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

Sensitivity of the receptor

431. The sensitivity of fish and shellfish IEFs is low as described in section 9.11, paragraphs 241 to 254.

Significance of the effect

Marine Species

432. For most fish and shellfish ecology IEFs (including herring) 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.

433. For European lobster and *Nephrops* edible crab and elasmobranchs, 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.

Diadromous Species

434. 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.

Further mitigation and residual effect

435. No additional fish and shellfish ecology mitigation is considered necessary as the likely effect in the absence of further mitigation (beyond the designed in measures outlined in section 9.10) is not significant in EIA terms.

CUMULATIVE COLONISATION OF FOUNDATIONS, SCOUR PROTECTION AND CABLE PROTECTION

Tier 2

Operation and maintenance phase

Magnitude of impact

436. The introduction of hard substrate into areas of predominantly soft sediments has the potential to alter community composition and biodiversity. This impact is only relevant to the operation and maintenance phase as it takes time for colonisation to establish post construction. The presence of the projects listed in Table 9.32 has the potential to lead to cumulative impacts arising from the colonisation of up to 17,513,271 m^2 of hard structures from wind turbines, OSP/Offshore convertor substation platforms, meteorological masts, cable protection, and cable crossings. Table 9.32 lists all projects/plans/activities considered in the Tier 2 assessment which are Inch Cape Offshore Wind Farm, Neart na Gaoithe Offshore Wind Farm, and Seagreen 1, Seagreen 1A Project Seagreen 1A Export Cable Corridor, Eastern Link 1 and Eastern Link 2. There are no values for long-term habitat loss provided in the Environmental Statement for Seagreen 1A Export Cable Corridor however 20% of the 110 km may require cable protection up to 6 m wide (Seagreen Wind Energy Ltd., 2021).

437. Inch Cape Offshore Wind Farm will contribute to cumulative impacts from the colonisation of hard structures through the presence of wind turbines, substations, and meteorological masts, as well as cable protection for the inter-array and offshore export cables. In the Inch Cape Environmental Statement it is stated that the amount of new hard substrate resulting from Inch Cape Offshore Wind Farm is equivalent to the amount of long-term habitat loss (Inch Cape Offshore Limited, 2018) which is described in Table 9.37 and equates to 2,470,000 m^2 of new hard structures (Inch Cape Offshore Limited, 2018).

438. At the Neart na Gaoithe Offshore Wind Farm, colonisation of hard substrate is predicted to result from the presence of gravity base foundations for the wind turbine foundations, substation foundations, scour protection and cable protection. The amount of new hard substrate equates to 460,000 m^2 of new hard structures as shown in Table 9.40 (Mainstream Renewable Power, 2019).

439. The Seagreen 1 Offshore Wind Farm maximum design scenario for the colonisation of hard structures, as stated in the Environmental Statement (Seagreen Wind Energy, 2012), show that the area available for colonisation is expected to be approximately the same area as is considered for as for long-term habitat loss, the components of which are described in Table 9.37 and equates to 2,026,045 m^2 of new hard structure (Seagreen Wind Energy, 2012).

440. The Seagreen 1A Project hard substrate values have been calculated through a project specific assessment by RPS (further detail in paragraph 304). This assessment showed that the area available for colonisation is expected to be approximately the same area as is considered for long term habitat loss, the components of which are described in Table 9.40 and equates to 158,055 m^2 of new hard structure.

441. The hard substrate installed for Eastern Link 1 includes rock berm with a maximum width of 7 m, no further values regarding hard substrate have been provided (National Grid Electricity Transmission and Scottish Power Transmission, 2022).

442. The hard substrate installed for Eastern Link 2 includes rock berms up to 138 km, six pipeline crossings, 18 cable crossings and rock protection at the landfall. The amount of new hard substrate available is equivalent to the amount of long term habitat loss which is described in Table 9.40 and equates to 2,200,200 m^2 of new hard structures (National Grid Electricity Transmission and Scottish Hydro Electric Transmission plc, 2022).

443. 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.

Table 9.40: Total Area and Component Parts of Introduced Hard Substrate of the Relevant Cumulative Projects in the Operation and Maintenance Phase of the Proposed Development

Project	Total Area of Introduced Hard Substrate (m^2)	Component Parts of Introduced Hard Substrate
Proposed Development	10,198,971	See Table 9.15.
Inch Cape Offshore Wind Farm (Inch Cape Offshore Limited, 2018)	2,470,000	See Table 9.37. Numbers presented in this table are based on the 2014 Environmental Statement. It is noted that the 2018 Environmental Statement assessed a smaller project (i.e. fewer wind turbines), although the total area associated with this assessment of effects was not updated from 2014. Therefore, the numbers presented here are considered to be conservative.
Neart na Gaoithe Offshore Wind Farm (Mainstream Renewable Power, 2019)	460,000	See Table 9.37.
Seagreen 1 (Seagreen Wind Energy, 2012)	2,026,045	See Table 9.37.
Seagreen 1A Project	158,055	See Table 9.37.
Eastern Link 1 (National Grid Electricity Transmission and Scottish Power Transmission, 2022)	No values provided in the environmental appraisal.	See Table 9.37.
Eastern Link 2 (National Grid Electricity Transmission and Scottish Hydro Electric Transmission plc, 2022)	2,200,200	See Table 9.37.
Seagreen 1A Export Cable Corridor	Not present in Environmental Statement	It is assumed that 20% of the cable length will require rock protection (6 m wide), with an approximate cable length of 110 km.
Cumulative colonisation of foundations, scour protection and cable protection	17,513,271	N/A

Sensitivity of the receptor

444. The sensitivity of fish and shellfish IEFs is summarised below, and is as described in section 9.11, paragraphs 263 to 279.

Marine Species

445. Marine fish and shellfish ecology IEFs in the Proposed Development fish and shellfish ecology study area are deemed to be of low vulnerability, and local to national importance (recoverability is not relevant to this

impact during the operation maintenance phase). The sensitivity of the receptor is therefore, considered to be low.

Diadromous Species

446. Most diadromous fish species are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of these IEFs is therefore, considered to be low.

447. Atlantic salmon and sea lamprey are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of these IEFs is therefore, considered to be low.

448. Sea trout are deemed to be of medium vulnerability, high recoverability and national importance. The sensitivity of this IEF is therefore, considered to be low.

Significance of the effect

Marine Species

449. Overall, the magnitude of the cumulative effect is deemed to be low and the sensitivity of the IEFs 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 Species

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

Further mitigation and residual effect

451. No additional fish and shellfish ecology mitigation is considered necessary as the likely effect in the absence of further mitigation (beyond the designed in measures outlined in section 9.10) is not significant in EIA terms.

Tier 3

Operation and maintenance phase

Magnitude

452. The only Tier 3 project which have been identified in the CEA with the potential to result in cumulative colonisation of foundations, scour protection and cable protection with the Proposed Development is the Cambois connection.

453. The Cambois connection has the potential to create 306,000 m^2 of new hard habitat associated with rock/mattress cable protection which represents protection covering 15% the total length the four offshore export cables (See Table 9.38), therefore it is likely that only a proportion of the cable protection will occupy the fish and shellfish ecology CEA study area, or potentially none of it. The cable protection represents a change in seabed type, the effects of which are described in paragraph 263 *et seq.,* however as the cable protection does not extend into the water column the opportunity for colonisation by some species is reduced. The presence of the Tier 2 and 3 projects has the potential to lead to cumulative impacts arising from the colonisation of up to 15,313,071 m^2 of hard structures.

454. 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.

Sensitivity of the receptor

455. The sensitivity of fish and shellfish IEFs is low as described in section 9.11, paragraphs 263 to 279.

Significance of the effect

Marine Species

456. Overall, the magnitude of the cumulative effect is deemed to be low and the sensitivity of the IEFs 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 Species

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

Further mitigation and residual effect

458. No additional fish and shellfish ecology mitigation is considered necessary as the likely effect in the absence of further mitigation (beyond the designed in measures outlined in section 9.10) is not significant in EIA terms.

9.12.4. PROPOSED MONITORING

459. Proposed monitoring measures for cumulative effects are the same as outlined in Table 9.30.

9.13. TRANSBOUNDARY EFFECTS

460. A screening of transboundary impacts has been carried out and has identified that there was no likely significant transboundary effects with regard to fish and shellfish ecology from the Proposed Development upon the interests of other European Economic Area (EEA) States. This was due to the relatively limited scale of effect and/or temporary nature of the impacts on fish and shellfish which would not result in effects occurring in other countries.

9.14. INTER-RELATED EFFECTS (AND ECOSYSTEM ASSESSMENT)

461. A description of the likely inter-related effects arising from the Proposed Development on fish and shellfish ecology is provided in volume 2, chapter 20 of the Offshore EIA Report.

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

- temporary and long-term subtidal habitat loss/disturbance;
- increased SSC and associated sediment deposition;
- EMFs from subsea electrical cabling;
- injury and/or disturbance to fish and shellfish from underwater noise and vibration; and
- colonisation of foundations, scour protection and cable protection.

463. Table 9.41 lists the inter-related effects (project lifetime effects) that are predicted to arise during the construction, operation and maintenance phase, and decommissioning of the Proposed Development and also the inter-related effects (receptor-led effects) that are predicted to arise for marine mammal, offshore ornithology and commercial fisheries receptors.

464. As noted above, effects on fish and shellfish ecology also have the potential to have secondary effects on other receptors and these effects are fully considered in the topic-specific chapters. These receptors and effects are:

- marine mammals:
  - changes in the fish and shellfish community resulting from impacts during construction, operation and maintenance, and decommissioning may lead to loss of prey resources for marine mammals resulting in effects of imperceptible significance (see volume 2, chapter 10);
- offshore ornithology:
  - One key stressor has been identified for offshore and intertidal ornithology. The assessment considers the overall effects on foraging seabirds from potential changes in prey communities that could be caused by disturbance, habitat loss, SSC, and therefore, in this respect, has taken an ecosystem-based approach. The assessment of effects, however, demonstrated that due to the high mobility of foraging seabirds and their ability to exploit different prey species, and the small scale of potential changes in context of wider available habitat, the changes to fish prey communities are unlikely to have a significant effect on foraging seabirds (see volume 2, chapter 11); and
- commercial fisheries:
  - changes in the fish and shellfish community resulting from impacts during construction, operation and maintenance, and decommissioning may affect commercial fisheries receptors by effects on target species, however as noted in this chapter there are negligible or minor effects on fish and shellfish receptors therefore negligible or minor effects are predicted for commercial fisheries (see volume 2, chapter 12), which are not significant in EIA terms.

Table 9.41: Summary of Likely Significant Inter-Related Effects on the Environment for Fish and Shellfish Ecology from Individual Effects Occurring across the Construction, Operation and Maintenance and Decommissioning Phases of the Proposed Development and from Multiple Effects Interacting Across all Phases (Receptor-led Effects)

Description of Impact	Phase			Likely Significant Inter-Related Effects
	C	O	D	
Temporary and long term subtidal habitat loss/disturbance	✓	✓	✓	When subtidal habitat loss (temporary and long term) is considered additively across all phases of the project, although the total area of habitat affected is larger than for the individual project stages, similar habitats are widespread across the UK and in the northern North Sea. During the operation and maintenance phase, the majority of the disturbance will be highly localised and the habitats affected are predicted to recover quickly following completion of maintenance activities with fish and shellfish IEFs recovering into the affected areas. In addition, many operation and maintenance activities will be affecting the same areas affected during construction (e.g. jack up operations adjacent to wind turbines, reburial of exposed cables). Therefore, across the project lifetime, the effects on fish and shellfish IEFs 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 phase.
Increased SSC and associated sediment deposition	✓	✓	✓	The majority of the seabed disturbance (resulting in highest SSC/deposition) will occur during the construction and decommissioning phases, with minor increased in SSC/deposition during the operation and maintenance phase. IEFs and associated spawning/nursery habitats potentially affected by increased SSC and deposition will recover quickly following impact exposure such that there will be no inter-related effects across the construction, operation and maintenance and decommissioning phases. Therefore, across the project lifetime, the effects on fish and shellfish IEFs 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 phase.
Injury and/or disturbance to fish and shellfish from underwater noise and vibration	✓	×	×	The majority of disturbance from underwater noise (resulting in greatest potential for injury or behavioural effects) is predicted to result from piling during the construction phase. Noise associated with the operation and maintenance and decommissioning phases was scoped out of the assessment, therefore, across the project lifetime, the effects on fish and shellfish receptors 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 assessment.
EMFs from subsea electrical cabling	×	✓	×	This effect will only arise during the operation and maintenance phase and as such there will be no interaction effects across the project phases.
Colonisation of foundations, scour protection and cable protection	×	✓	×	This effect will only arise during the operation and maintenance phase and as such there will be no interaction effects across the project phases.
Receptor Led Effects				

Potential exists for spatial and temporal interactions between habitat loss/disturbance, increased SSC/deposition, underwater noise, colonisation of foundations, scour protection and cable protection, and EMF effects and during the lifetime of the Project.

Based on current understanding, and expert knowledge, the greatest scope for potential interaction impacts is predicted to arise through the interaction of habitat loss (temporary and long term), increased SSC, underwater noise from piling during the construction phase and EMF effects during the operation phase.
These individual impacts were assigned a significance of negligible to minor as standalone impacts and although potential combined impacts may arise, it is important to recognise that the individual activities will not necessarily occur simultaneously or in the same area of the Proposed Development. Further, some construction related impacts are likely to result in effects on fish and shellfish over a much wider scale than others. For example, the majority of effects associated with an increase in SSC/deposition will arise from seabed preparation works installation of Proposed Development offshore export and inter-array cables with relatively limited effects on fish behaviour (e.g. avoidance over a relatively small range in the immediate proximity of cable installation operations), whereas for underwater noise impacts associated with foundation piling, these will affect fish behaviour over a much larger area, with avoidance predicted over the range of several km from the construction operations. In any case, all construction related impacts will be temporary and reversable following cessation of construction or decommissioning with fish and shellfish communities recovering into wind farm areas following cessation of construction (as indicated from monitoring reports of operation wind farms discussed throughout section 9.11). Furthermore, underwater noise will result in the displacement of mobile fish from areas around foundations which in turn will mean that these species will not be exposed to the greatest predicted increases in SSC. Any potential behavioural effects as a result of EMF would be likely to occur over the same area as habitat loss/change effects (i.e. within metres of the cable) and therefore habitat loss effects would not be additive to EMF effects. There may be localised changes in fish and shellfish communities in the areas affected by long term habitat loss, due to potential changes in substrate type, increased foraging opportunities, and behavioural effects associated with EMF as discussed in section 9.11. Any shifts in baseline assemblage will be limited to these areas, therefore, effects of greater significance than the individual impacts in isolation (i.e. negligible to moderate) are not predicted.

9.15. SUMMARY OF IMPACTS, MITIGATION MEASURES, LIKELY SIGNIFICANT EFFECTS AND MONITORING

465. Information on fish and shellfish ecology within the Proposed Development fish and shellfish ecology study area and the Proposed Development northern North Sea fish and shellfish ecology study area was collected through desktop review, site specific surveys, and consultation. These are summarised in Table 9.8 to Table 9.10. The baseline characterisation was used to inform the assessment of the fish and shellfish assemblage present within the vicinity of the Proposed Development fish and shellfish ecology study area. Full details of the baseline characterisation are provided in volume 3, appendix 9.1.

466. Table 9.42 presents a summary of the potential impacts, mitigation measures and the conclusion of likely significant effects in respect to fish and shellfish ecology in EIA terms. The impacts assessed include: temporary subtidal habitat loss/disturbance, increased SSC and associated sediment deposition, injury and/or disturbance to fish and shellfish from underwater noise and vibration, long-term subtidal habitat loss, EMFs from subsea electrical cabling, and colonisation of foundations, scour protection and cable protection. Overall, it is concluded there will be negligible adverse significant effects arising from the Proposed Development during the construction, operation and maintenance or decommissioning phases.

467. Table 9.43 presents a summary of the potential cumulative impacts, mitigation measures and the conclusion of likely significant cumulative effects on fish and shellfish ecology in EIA terms. The cumulative effects assessed include: temporary subtidal habitat loss/disturbance, increased SSC and associated sediment deposition, injury and/or disturbance to fish and shellfish from underwater noise and vibration, long-term subtidal habitat loss, EMFs from subsea electrical cabling, and colonisation of foundations, scour protection and cable protection. Overall, it is concluded that there will be negligible adverse significant cumulative effects from the Proposed Development alongside other projects/plans.

468. As noted in section 9.9.3, an assessment of the likely significant effects in EIA terms on the relevant features of sites that comprise part of the UK National Site Network or Natura 2000 network (i.e. European Sites) has been made in this chapter (in sections 0 and 9.12), The assessment of the potential impacts on the site itself are deferred to the RIAA (SSER, 2022c) for the Proposed Development. The RIAA concluded that no adverse effect on integrity was predicted to occur on any of the sites designated for Annex I habitats below MHWS, specifically:

- River Tay SAC;
- River Tweed SAC;
- Tweed Estuary SAC;
- River Teith SAC;
- River South Esk SAC; and
- River Dee SAC.

469. An assessment on the individual qualifying interest features of the sites relevant to fish and shellfish ecology has also been undertaken in this chapter.

470. No likely significant transboundary effects have been identified in regard to effects of the Proposed Development.

471. As noted in section 9.9.3, the full assessment of the potential impacts on the sites that comprise part of the UK National Site Network or Natura 2000 network (i.e. European Sites) has been deferred to the RIAA (SSER, 2022c) for the Proposed Development. An assessment on the individual qualifying interest feature(s) of these sites (e.g. Annex II species such as Atlantic salmon) is considered in this chapter (section 9.11 and 9.12.3), as summarised above. The RIAA concluded that no adverse effect on integrity was predicted to occur on any of the sites designated for fish and shellfish receptors, specifically.

Table 9.42: Summary of Likely Significant Environmental Effects, Mitigation and Monitoring

Description of Impact	Receptor Type	Phase C	Phase O	Phase D	Magnitude of Impact	Sensitivity of Receptor	Significance of Effect	Additional Measures	Residual Effect	Proposed Monitoring
Temporary habitat loss/disturbance	Marine Species	✓			Low	Low to Medium	Negligible to Minor	None	Negligible to Minor	None
			✓		Negligible	Low to Medium	Negligible to Minor	None	Negligible to Minor	None
				✓	Low	Low to Medium	Negligible to Minor	None	Negligible to Minor	None
	Diadromous Species	✓			Low	Low	Minor	None	Negligible to Minor	The Applicant has committed to engaging with Marine Scotland and the SNCBs post consent to identify opportunities for contributing to proportionate and appropriate strategic monitoring of diadromous fish species. This may include research priorities identified by ScotMER steering group.
			✓		Negligible	Low	Negligible	None	Negligible to Minor	
				✓	Low	Low	Negligible to Minor	None	Negligible to Minor	
Increased suspended sediment concentrations and associated sediment deposition	Marine Species	✓			Low	Low to Medium	Negligible to Minor	None	Negligible to Minor	None
			✓		Low	Low to Medium	Negligible to Minor	None	Negligible to Minor	None
				✓	Low	Low to Medium	Negligible to Minor	None	Negligible to Minor	None
	Diadromous Species	✓			Low	Low	Negligible to Minor	None	Negligible to Minor	The Applicant has committed to engaging with Marine Scotland and the SNCBs post consent to identify opportunities for contributing to proportionate and appropriate strategic monitoring of diadromous fish species. This may include research priorities identified by ScotMER steering group.
			✓		Low	Low	Negligible to Minor	None	Negligible to Minor	
				✓	Low	Low	Negligible to Minor	None	Negligible to Minor	
Injury and/or disturbance to fish and shellfish from underwater noise and vibration	Marine Species	✓			Low	Low to Medium	Minor	None	Minor	None
			×		N/A	N/A	N/A	N/A	N/A	N/A
				×	N/A	N/A	N/A	N/A	N/A	N/A
	Diadromous Species	✓			Low	Low	Negligible to Minor	None	Negligible to Minor	The Applicant has committed to engaging with Marine Scotland and the SNCBs post consent to identify opportunities for contributing to proportionate and appropriate strategic monitoring of diadromous fish species. This may include research priorities identified by ScotMER steering group.
			×		N/A	N/A	N/A	N/A	N/A	
				×	N/A	N/A	N/A	N/A	N/A	
Long-term subtidal habitat loss	Marine Species	✓			Low	Low to Medium	Minor	None	Minor	None
			✓		Low	Low to Medium	Minor	None	Minor	None
				✓	Low	Low to Medium	Minor	None	Minor	None
	Diadromous Species	✓			Low	Low	Minor	None	Minor	The Applicant has committed to engaging with Marine Scotland and the SNCBs post consent to identify opportunities for contributing to proportionate and appropriate strategic monitoring of diadromous fish species. This may include research priorities identified by ScotMER steering group.
			✓		Low	Low	Minor	None	Minor	
				✓	Low	Low	Minor	None	Minor	
EMFs from subsea electrical cabling	Marine Species	×			N/A	N/A	N/A	N/A	N/A	N/A
			✓		Low	Low to Medium	Negligible to Minor	None	Negligible to Minor	None
				×	N/A	N/A	N/A	N/A	N/A	N/A
	Diadromous Species	×			N/A	N/A	N/A	N/A	N/A	The Applicant has committed to engaging with Marine Scotland and the SNCBs post
			✓		Low	Low	Negligible to Minor	None	Negligible to Minor	

				×	N/A	N/A	N/A	N/A	N/A	consent to identify opportunities for contributing to proportionate and appropriate strategic monitoring of diadromous fish species. This may include research priorities identified by ScotMER steering group.
Colonisation of foundations, scour protection and cable protection	Marine Species	×			N/A	N/A	N/A	N/A	N/A	N/A
			✓		Low	Low	Negligible to Minor	None	Negligible to Minor	None
				✓	Low	Low	Negligible to Minor	None	Negligible to Minor	None
	Diadromous Species	×			N/A	N/A	N/A	N/A	N/A	The Applicant has committed to engaging with Marine Scotland and the SNCBs post consent to identify opportunities for contributing to proportionate and appropriate strategic monitoring of diadromous fish species. This may include research priorities identified by ScotMER steering group.
			✓		Low	Low	Negligible to Minor	None	Negligible to Minor	
				✓	Low	Low	Negligible to Minor	None	Negligible to Minor	

Table 9.43: Summary of Likely Significant Cumulative Environment Effects, Mitigation and Monitoring

Description of Impact	Receptor Type	Phase C	Phase O	Phase D	Cumulative Effects Assessment Tier	Magnitude of Impact	Sensitivity of Receptor	Significance of Effect	Additional Measures	Residual Effect	Proposed Monitoring
Temporary Subtidal Habitat loss/disturbance	Marine Species	✓	✓	×	Tier 2	Low	Low to Medium	Minor	None	Minor	None
	Diadromous Species	✓	✓	×	Tier 2	Low	Low	Negligible to Minor	None	Negligible to Minor	None
Temporary Subtidal Habitat loss/disturbance	Marine Species	✓	✓	×	Tier 3	Low	Low to Medium	Minor	None	Minor	None
	Diadromous Species	✓	✓	×	Tier 3	Low	Low	Negligible to Minor	None	Negligible to Minor	None
Increased SSC and associated sediment deposition	Marine Species	✓	×	×	Tier 2	Low	Low to Medium	Minor	None	Minor	None
	Diadromous Species	✓	×	×	Tier 2	Low	Low	Negligible to Minor	None	Negligible to Minor	None
Increased SSC and associated sediment deposition	Marine Species	✓	✓	×	Tier 3	Low	Low to Medium	Minor	None	Minor	None
	Diadromous Species	✓	✓	×	Tier 3	Low	Low	Negligible to Minor	None	Negligible to Minor	None
Injury and/or disturbance to fish and shellfish from underwater noise and vibration	Marine Species	✓	×	×	Tier 2	Low	Low to Medium	Minor	None	Minor	None
	Diadromous Species	✓	×	×	Tier 2	Low	Low	Negligible to Minor	None	Negligible to Minor	None
Long term subtidal habitat loss	Marine Species	✓	✓	×	Tier 2	Low	Low to Medium	Minor	None	Minor	None
	Diadromous Species	✓	✓	×	Tier 2	Low	Low	Negligible to Minor	None	Negligible to Minor	None
Long term subtidal habitat loss	Marine Species	✓	✓	×	Tier 3	Low	Low to Medium	Minor	None	Minor	None
	Diadromous Species	✓	✓	×	Tier 3	Low	Low	Negligible to Minor	None	Negligible to Minor	None
EMFs from subsea electrical cabling	Marine Species	×	✓	×	Tier 2	Low	Low to Medium	Minor	None	Minor	None
	Diadromous Species	×	✓	×	Tier 2	Low	Low	Negligible to Minor	None	Negligible to Minor	None
EMFs from subsea electrical cabling	Marine Species	×	✓	×	Tier 3	Low	Low to Medium	Minor	None	Minor	None
	Diadromous Species	×	✓	×	Tier 3	Low	Low	Negligible to Minor	None	Negligible to Minor	None
Colonisation of foundations, scour protection and cable protection	Marine Species	×	✓	×	Tier 2	Low	Low	Negligible to Minor	None	Negligible to Minor	None
	Diadromous Species	×	✓	×	Tier 2	Low	Low	Negligible to Minor	None	Negligible to Minor	None
Colonisation of foundations, scour protection and cable protection	Marine Species	×	✓	×	Tier 3	Low	Low	Negligible to Minor	None	Negligible to Minor	None
	Diadromous Species	×	✓	×	Tier 3	Low	Low	Negligible to Minor	None	Negligible to Minor	None

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