Offshore Wind Power Limited

West of Orkney Windfarm Offshore EIA Report

Volume 1, Chapter 11 - Fish and Shellfish Ecology

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West of Orkney Windfarm

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11 FISH AND SHELLFISH ECOLOGY

Chapter summary

This chapter of the Offshore Environmental Impact Assessment (EIA) Report assesses the potential effects from the offshore Project on fish and shellfish ecology receptors. This includes direct, indirect, whole Project assessment, cumulative, inter-related effects, inter-relationships, and transboundary effects.

The baseline was characterised using a combination of desk-based studies and environmental DNA (eDNA) analysis of water samples collected throughout the offshore Project area. The results of the Project-specific seabed surveys were also used to understand the potential for fish spawning habitat in the offshore Project area. Onshore surveys of freshwater ecology habitat informed the fish characteristics of the Forss Water which is located adjacent to the Crosskirk landfall option.

A range of species potentially utilise the study area for spawning, foraging, migration, or as a nursery habitat. Key species of conservation importance include those with declining populations and/or those that are protected through national or international legislation and policy, such as Atlantic salmon (*Salmo salar*), flapper skate (*Dipturus intermedius*), cod (*Gadus morhua*), herring (*Clupea harengus*) and sandeel (*Ammodytes* spp.). Additionally, the North West Orkney Nature Conservation Marine Protected Area (NCMPA), designated for sandeels, is located approximately 11 km from the OAA. Other species in the study area are of commercial value, such as mackerel (*Scomber scombrus*), haddock (*Melanogrammus aeglefinus)*, brown crab (*Cancer pagurus*) and scallops (*Pectinidae* spp.), and certain species are important as prey for other fish, marine mammals and birds, including sandeel, herring, mackerel and sprat (*Sprattus sprattus*). Available tagging studies for brown crab also indicate the potential for brown crab migratory routes to intersect the offshore Project area. The following impacts were identified as requiring assessment:

- Construction and decommissioning:
  - Temporary habitat disturbance and loss;
  - Underwater noise;
  - Indirect effects related to changes in availability or distribution of prey species;
- Operation and maintenance:
  - Habitat loss and disturbance;
  - Electromagnetic field (EMF) effects;
  - Potential fish or predator aggregation;
  - Barrier effects to diadromous fish; and
  - Indirect effects related to changes in availability or distribution of prey species.

The assessment has taken account of embedded mitigation measures for the assessment of potential effects. No significant impacts to any fish and shellfish ecology receptors are predicted, either for the offshore Project alone, or cumulatively with other plans or developments. This includes any effects on sandeels designated within the North-West Orkney NCMPA, as well as underwater noise impacts from piling, Unexploded Ordnance (UXO) clearance and other noise-generating activities (e.g. Horizontal Direction Drilling (HDD) at the landfall), informed by underwater noise modelling, and electromagnetic field effects (informed by Project specific data). Therefore, no secondary mitigation requirements are proposed. There are also no significant inter-related effects or transboundary effects predicted as a result of the offshore Project. There is the potential for diadromous fish also to be affected by the onshore Project, including those migrating to / from the Forss Water which is adjacent to the Crosskirk landfall option. However, considering embedded mitigations and standard industry practice, no adverse effects are anticipated that would exacerbate any of the effects assessed for the offshore Project in this chapter. Furthermore, no ecosystem effects are anticipated to occur in relation to fish and shellfish ecology receptors as predators or prey.

It is acknowledged that there are data gaps in the baseline for fish and shellfish ecology receptors, particularly the lack of empirical data on the origin, abundance and distribution of diadromous fish within the offshore Project area. The potential for monitoring of diadromous fish will be explored post consent, focussing on strategic monitoring opportunities to address the key data gaps identified in the Scottish Marine Energy Research (ScotMER) diadromous fish and fish and fisheries evidence maps.

11.1 Introduction

This chapter of the Offshore Environmental Impact Assessment (EIA) Report presents the fish and shellfish ecology receptors of relevance to the offshore Project and assesses the potential impacts from the construction (including pre-construction), operation and maintenance and decommissioning of the offshore Project on these receptors. Where required, mitigation is proposed, and the residual impacts and their significance are assessed. Potential cumulative and transboundary impacts are also considered.

Table 11-1 below provides a list of all the supporting studies which relate to and should be read in conjunction with the fish and shellfish ecology impact assessment. All supporting studies are appended to this Offshore EIA Report and issued on the accompanying Universal Serial Bus (USB).

Table 11-1 Supporting studies

DETAILS OF STUDY	LOCATIONS OF SUPPORTING STUDY
Fish and Shellfish Ecology Baseline Report	Offshore EIA Report, Supporting Study (SS) 7: Fish and shellfish ecology baseline report.
Underwater Noise Modelling Report	Offshore EIA Report, Supporting Study (SS) 11: Underwater noise modelling report.
West of Orkney Windfarm Benthic Environmental Baseline Report	Offshore EIA Report, Supporting Study (SS) 5: Benthic environmental baseline report.

The impact assessment presented herein draws upon information presented within other impact assessments within this Offshore EIA Report, including chapter 10: Benthic subtidal and intertidal ecology, which assesses impacts on benthic habitats and species, including potential fish and shellfish prey species and colonisation of hard structures by benthic habitats and species which could introduce artificial reefs and result in fish and predator aggregation. Equally, the fish and shellfish ecology impact assessment also informs other impact assessments. This interaction between the impacts assessed within different topic-specific chapters on a receptor is defined as an 'inter-relationship'. The chapters and impacts related to the assessment of potential effects on fish and shellfish ecology are provided in Table 11-2.

Indirect effects to commercial fisheries as a result of impacts on fish and shellfish ecology receptors are discussed in chapter 14: Commercial fisheries and are not considered within this chapter. In addition, any indirect effects as a result of changes in fish and shellfish prey species for marine mammals and other megafauna and offshore ornithology are discussed in chapter 12: Marine mammals and megafauna and chapter 13: Offshore and intertidal ornithology, respectively.

For ecological topics, inter-relationships form the basis of understanding wider ecosystems impacts, which are considered throughout this assessment and summarised in section 11.10.

Table 11-2 Fish and shellfish ecology inter-relationships

CHAPTER	IMPACT	DESCRIPTION
Marine physical and coastal processes (chapter 8, Offshore EIA Report)	Temporary increases in suspended sediment concentrations and associated sediment deposition.	Changes to seabed levels, sediment properties and suspended sediment concentrations can result in habitat disturbance or loss for fish and shellfish species directly, or for their prey. Changes to seabed levels, sediment properties and suspended sediment concentrations, both offshore and at the Crosskirk landfall (including in proximity to the Forss water river mouth), are considered in chapter 8: Marine physical and coastal processes. The impact of suspended sediment and associated deposition on fish and shellfish ecology was scoped out of the assessment (see section 11.5.2).
Water and sediment quality (chapter 9, Offshore EIA Report)	Indirect impacts on fish and shellfish associated with changes in water quality.	Changes in water and sediment quality can result in indirect impacts on fish and shellfish (including spawning habitats) which are sensitive to water quality, disturbance of sediment, and contamination. The impact of suspended sediment and associated deposition on fish and shellfish ecology was scoped out of the assessment (see section 11.5.2).
Benthic subtidal and intertidal ecology (chapter 10, Offshore EIA Report)	Indirect impacts to fish and shellfish ecology from changes to spawning and nursery ground habitats from loss/disturbance of benthic habitats.	Changes in benthic habitats can lead to an indirect impact on fish spawning and nursery grounds which rely on these habitats. Direct impacts to benthic habitats from the offshore Project are assessed within chapter 10: Benthic subtidal and intertidal ecology. Habitat loss of spawning and nursery grounds from the offshore Project are assessed within section 11.6.1.1 and 11.6.2.1 of this chapter.
	Indirect impacts to fish and shellfish from changes in the availability and distribution of benthic prey species.	Changes in the availability of benthic prey species may indirectly impact fish and shellfish ecology receptors. This indirect effect is assessed in sections 11.6.1.3 and 11.6.2.5.
	Colonisation of hard structures by benthic habitats and species.	Colonisation of benthic habitats and species may occur as a result of the offshore Project infrastructure (e.g. scour protection and cable protection). These impacts are assessed within chapter 10: Benthic subtidal and intertidal ecology. This can in-directly impact fish species by introduction artificial reefs and increasing food availability, resulting in fish and predator aggregations around these structures. This impact is assessed in section 11.6.2.3 of this chapter.

CHAPTER	IMPACT	DESCRIPTION
Marine mammals and megafauna (chapter 12, Offshore EIA Report)	Indirect impacts to marine mammals and other megafauna through changes in fish and shellfish prey species abundance or distribution.	Changes in fish and shellfish habitats can lead to an indirect impact on marine mammals and other megafauna due to changes in prey availability or distribution. Direct impacts to fish and shellfish ecology (including key prey species) from the offshore Project are assessed within section 11.6 of this chapter. Impacts on marine mammals and other megafauna from long term changes in prey distribution and abundance are assessed within chapter 12: Marine mammals and megafauna.
Offshore and intertidal ornithology (chapter 13, Offshore EIA Report)	Indirect impacts to offshore ornithology through changes in fish and shellfish prey species abundance or distribution.	Changes in fish and shellfish habitats can lead to an indirect impact on offshore ornithology receptors due to changes in prey availability or distribution. Direct impacts to fish and shellfish ecology (including key prey species) from the offshore Project are assessed within section 11.6 of this chapter. Impacts on offshore ornithology receptors from changes in prey availability and distribution are assessed within chapter 13: Offshore and intertidal ornithology.
Commercial fisheries (chapter 14, Offshore EIA Report)	Impacts on commercially important fish and shellfish species.	The impacts on fish and shellfish ecology receptors assessed within this chapter includes consideration of potential effects on species of commercial importance. Effects on these species could indirectly impact commercial fisheries.
Socio-economics (chapter 19, Offshore EIA Report)	Impacts on commercially important fish and shellfish species.	The impacts on fish and shellfish ecology receptors assessed within this chapter includes consideration of potential effects on species of commercial importance. Effects on these species could indirectly impact commercial fisheries receptors with downstream socio-economic impacts.

Effects on Annex II diadromous fish and associated features, including Atlantic salmon (*Salmo salar*), sea lamprey (*Petromyzon marinus*), river lamprey (*Lampetra fluviatilis*), and Freshwater Pearl Mussel (FWPM) (*Margaritifera margaritifera*), as qualifying features of Special Areas of Conservation (SACs) have been considered through the Habitats Regulation Appraisal (HRA) process, undertaken alongside this EIA. The HRA screening process, undertaken in consultation with NatureScot and Marine Scotland[1], concluded that there will be no potential for Likely Significant Effects (LSE) in relation to effects on sea lamprey or river lamprey as qualifying features of European sites, and therefore no further assessment is required under Stage 2 of the HRA process within the Offshore Report to Inform the Appropriate Assessment (RIAA). Furthermore, as outlined in section 11.3 and in the Offshore RIAA, feedback from

[1] *Now Marine Directorate.*

NatureScot stipulated that impacts on Atlantic salmon and FWPM should be considered within the EIA only and not as part of the HRA. For full details, please see the Offshore HRA Screening Report (OWPL, 2022) and the Offshore RIAA.

The following specialists have contributed to the assessment:

- Xodus Group Limited (Xodus) – baseline description, impact assessment and Offshore EIA Report chapter write up; and
- Trex Ecology – diadromous fish specialist advice and review.

11.2 Legislation, policy and guidance

Over and above the legislation presented in chapter 3: Planning policy and legislative context, the following legislation, policy and guidance are relevant to the assessment of impacts from the offshore Project on fish and shellfish ecology:

- Legislation:
  - International:
    - The Convention for the Protection of the Marine Environment of the North East Atlantic ('OSPAR Convention'; 1992);
    - The Convention on the Conservation of European Wildlife and Natural Habitats ('the Bern Convention'; 1979);
    - Convention on Biological Diversity ('CBD') (1992); and
    - The Convention on the Conservation of Migratory Species of Wild Animals ('the Bonn Convention'; 1979)
  - National:
    - Wildlife & Countryside Act 1981 (as amended);
    - Nature Conservation (Scotland) Act 2004;
    - Wildlife and Natural Environment (Scotland) Act 2011;
    - Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003;
    - The Conservation of Salmon (Scotland) Regulations 2016 (as amended);
    - The Conservation (Natural Habitats, &c.) Regulations 1994 (as amended) ('Habitats Regulations') (as amended);
    - The Conservation of Habitats and Species Regulations 2017 ('Habitats Regulations') (as amended); and
    - The Conservation of Offshore Marine Habitats and Species Regulations 2017 ('Habitats Regulations') (as amended).
- Policy:
  - Scotland's National Marine Plan (Marine Scotland, 2015):
    - Prepared in accordance with the United Kingdom (UK) Marine Policy Statement, 2010, which outlines the framework for marine plans for the UK marine environment. Policies relevant to the fish and shellfish ecology chapter include:
      - GEN 9 Natural Heritage;
      - GEN 13 Noise; and
      - WILD FISH 1; and
      - FISHERIES 1 – 4.

  - Orkney Islands Regional Marine Plan: Consultation Draft (Orkney Islands Council, 2022):
    - The Plan sets out an integrated planning policy framework to guide marine development and activities, whilst ensuring the quality of the marine environment is protected, and where appropriate, enhanced. It supports the delivery of a vision for Orkney's coastal and marine environment, economy and communities.
  - Pilot Pentland Firth and Orkney Waters Marine Spatial Plan (Marine Scotland, 2016):
    - This non-statutory plan sets out an integrated planning policy framework to guide marine development, activities and management decisions, whilst ensuring the quality of the marine environment is protected.
  - The National Islands Plan (Scottish Government, 2019):
    - The Plan sets out 13 objectives to address crucial sectors within island communities. Under Strategic Objective 8: To improve and promote environmental wellbeing and deal with biosecurity, there is a commitment to protect island biodiversity.
  - International Union for Conservation of Nature (IUCN) Red List of Threatened Species:
    - The list was established in 1964 and is the world's most comprehensive information source on the global extinction risk status of animal, fungus and plant species, including fish and shellfish;
  - Scottish Biodiversity Strategy (Scottish Government, 2022a):
    - The Scottish Biodiversity strategy is made up of two documents: Scotland's Biodiversity: It's in Your Hands and the 2020 Challenge for Scotland's Biodiversity. The aims of the strategy are to: protect and restore biodiversity on land and in our seas, and to support healthy ecosystems, connect people with the natural world, for their health and well-being, and to involve them more in decision making and maximise the benefits for Scotland of a diverse natural environment and the services it provides, contributing to sustainable economic growth;
  - Priority Marine Features (PMFs):
    - Scotland adopted a list of 81 PMFs in 2014, representing species and habitats on existing conservation lists that were assessed against a set of criteria, including the abundance of the feature in Scottish seas, the conservation status and the functional role played by the feature. Several fish and shellfish species are listed as PMFs;
  - Scottish Wild Salmon Strategy (Scottish Government, 2022b):
    - Published in January 2022, the Scottish Wild Salmon Strategy outlines the objectives, actions to improve the conditions of Scotland's rivers and better manage salmon stocks;
  - Eel Management plans for the United Kingdom: Scotland River Basin District (Defra, 2010):
    - Established in 2010 in response to the Eel Recovery Plan (formed under European Commission Council Regulation No 1100/2007) with the aim of improving the European eel stocks.
- Guidance:
  - Guidance note for Environmental Impact Assessment in respect of FEPA and CPA requirements (Cefas, 2004);
  - Guidance on Environmental Considerations for Offshore Wind Farm Development (OSPAR, 2008);
  - Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects (Cefas, 2012); and
  - Impacts from Piling on Fish at Offshore Wind Sites: Collating Population Information, Gap Analysis and Appraisal of Mitigation Options (Boyle and New, 2018).

All available relevant guidance at the time of the assessment has been utilised. It was agreed in writing with Marine Scotland - Licensing Operations Team (MS-LOT)[2] that any guidance published up to five months prior to the consent application would be included within the Offshore EIA Report.

11.3 Scoping and consultation

Stakeholder consultation has been ongoing throughout the EIA and has played an important part in ensuring the scope of the baseline characterisation and impact assessment are appropriate with respect to the Project and the requirements of the regulators and their advisors.

The Scoping Report, which covered the onshore and offshore Project, was submitted to Scottish Ministers (via MS-LOT) and The Highland Council on 1st March 2022[3]. MS-LOT circulated the Scoping Report to consultees relevant to the offshore Project, and a Scoping Opinion was received from MS-LOT on 29th June 2022. Relevant comments from the Scoping Opinion to fish and shellfish ecology are provided in Table 11-4 below, which provides a high-level response on how these comments have been addressed within the Offshore EIA Report. Floating foundations are no longer being considered for this current application and neither are the offshore export cables in Scapa Flow to the Flotta Hydrogen Hub. Therefore, comments relating to floating foundations and the Flotta Hydrogen Hub are not included in Table 11-4.

Further consultation has been undertaken throughout the pre-application stage. Table 11-3 summarises the consultation activities carried out relevant to fish and shellfish ecology.

Table 11-3 Consultation activities for fish and shellfish ecology

CONSULTEE AND TYPE OF CONSULTATION	DATE	SUMMARY
Northern District Salmon Fisheries Board (NDSFB) – written letter	25th May 2022	The NDSFB were not formally consulted by THC or Marine Scotland as part of the Scoping process. However, a letter was received separately from NDSFB directly with comments on the Scoping Report. Comments have been incorporated into Table 11-4.
NatureScot and Orkney Islands Council (OIC) – meeting	29th June 2022	Meeting to introduce the Project, and to discuss data availability and Scoping Opinion feedback.

[2] MS-LOT have since been renamed Marine Directorate - Licensing Operations Team (MD-LOT).

[3] The Scoping Report was also submitted to the Orkney Islands Council (OIC), as the scoping exercise included consideration of power export to the Flotta Hydrogen Hub, however, this scope is not covered in the Offshore EIA Report and will be subject to separate Marine Licence and onshore planning applications.

CONSULTEE AND TYPE OF CONSULTATION	DATE	SUMMARY
Fisheries Management Scotland (FMS), NDSFB and Caithness District Salmon Fisheries Board (CDSFB) – meeting	30th August 2022	Meeting to introduce the Project, discuss key data sources, assessment methodologies, monitoring and mitigation requirements and Scoping Opinion feedback.
Alan Youngson (on behalf of CDSFB) – email	September 2022	Information and detail supplied on Seasonal Sensitivity Tables (SST) via email.
MS-LOT – written letter	22nd September 2022	An underwater noise modelling method statement was circulated to NatureScot and MS-LOT on 25th August 2022 to set out the proposed approach for the underwater noise modelling. The methodology is also outlined within SS11: Underwater noise modelling report. The written response from NatureScot (received 22nd September 2022) to the underwater noise modelling method statement, included: • Agreement with the proposed underwater noise modelling methods; and • Further consultation about the expected information which should be provided in the report.
NatureScot and OIC – meeting	27th September 2022	Meeting to discuss key data gaps and uncertainties, key sensitivities, assessment methodologies and mitigation and monitoring requirements.
MS-LOT– written letter	16th November 2022	Clarifications were sought for topic-specific queries raised in the Scoping Opinion and consultation. The clarifications were sent in the form of a letter to MS-LOT on 7th October 2022. A written response from MS-LOT to the consultation letter was received on 16th November 2022. The response, included: • Agreement on data sources and guidance to inform the Offshore EIA Report; and • Clarification on the need / approach for site-specific diadromous fish survey.
Atlantic Salmon Trust – meeting	15th December 2022	Meeting to introduce the Project and discuss ongoing tracking projects and interim results.
NatureScot and OIC – meeting	24th May 2023	Meeting to discuss initial findings of EIA, focussing on key points raised in the Scoping Opinion on the assessment of effects on diadromous fish, elasmobranchs and consideration of effects on prey availability / distribution, and approach to monitoring.

CONSULTEE AND TYPE OF CONSULTATION	DATE	SUMMARY
		No concerns were raised by NatureScot during the meeting.
NatureScot – written letter	25th May 2023	On 4th April 2023, a letter was sent to NatureScot to clarify the approach for assessing adverse effects on Atlantic salmon and FWPM as qualifying features of SACs as part of the HRA process. A response was received on 25th May 2023. NatureScot confirmed that as effects on Atlantic salmon and FWPM cannot be apportioned to individual SACs, that the effects of the offshore Project on these features should be considered within the EIA only and through the HRA. Further details are provided in the Offshore RIAA.

Table 11-4 Comments from the Scoping Opinion response relevant to fish and shellfish ecology

CONSULTEE	COMMENT	RESPONSE
Scottish Ministers (via MS-LOT)	The Scottish Ministers are broadly content with the study areas defined in Section 2.4.2 of the Scoping Report and the baseline data detailed in Table 2-20 however advise the Developer to include the ScotMER research as highlighted in the MSS advice and NatureScot representation. In line with the MSS advice, site-specific surveys of suitable quality are required to characterise the site and where possible identify origins of populations of diadromous fish within the site boundary. Additionally, the Developer is directed to the data sources highlighted by MSS and advise these are considered within the EIA Report. Further to this, the Scottish Ministers advise that the impacts on diadromous fish must be assessed separately within the EIA Report in line with MSS advice.	The study area is presented in section 11.4.1 and the data sources used to inform the assessment is provided in section 11.4.2. Site-specific surveys for diadromous fish will be considered further during the post-consent stage, and Offshore Wind Power Limited (OWPL) will engage with all relevant stakeholders to identify appropriate monitoring opportunities. The potential monitoring opportunities for fish and shellfish ecology receptors is presented in section 11.12. Diadromous fish have been assessed separately from other fish and shellfish receptors in section 11.6.
Scottish Ministers (via MS-LOT)	In Section 2.4.4.1.5 of the Scoping Report, identifies the River Thurso, Naver and Borgie Special Areas of Conservation ("SAC") which discharge in the vicinity of the Proposed Development. The Scottish Ministers advise that in addition to those identified, there is potential connectivity with other SACs including Berriedale and Langwell Waters, Foinaven, Little Gruinard River, River Spey, River Oykel and River Moriston which must be considered in the EIA Report. The Developer must address in full, the NatureScot and MSS advice in relation to diadromous fish. MSS highlight the significant knowledge gaps in relation to diadromous fish in the Pentland Firth and Orkney waters area. The Developer should note the MSS advice in relation to the value of completing site specific surveys for diadromous fish and the limitations of desk-based studies. If site specific surveys are not undertaken justification must be included on how the information used to inform the EIA Report provides a robust assessment, noting that a lack of evidence is insufficient justification to conclude no impact.	It is acknowledged that there is the potential for connectivity for the SACs listed, as described in section 11.4.4.7. Following feedback on the HRA Screening Report, all SACs designated for Atlantic salmon were initially screened into the Offshore RIAA (MS-LOT, 2022). However, subsequent feedback from NatureScot stipulated that impacts on diadromous fish should be considered within the EIA alone and not as part of the HRA. Further details are provided within the Offshore RIAA. The data gaps and uncertainties in relation to diadromous fish are outlined in section 11.4.7. The assessment of potential effects in section 11.6 has been undertaken in the context of these uncertainties and the impact assessment has been conducted using the most up to date scientific evidence. OWPL propose to address key data gaps during the post-consent stage and adequate mitigation measures will be developed through consultation with stakeholders to reduce or avoid significant environmental effects once this data is gathered.

CONSULTEE	COMMENT	RESPONSE
Scottish Ministers (via MS-LOT)	In regards to key species, the Scottish Ministers advise that the Developer must consider and fully implement the advice contained in the NatureScot representation and MSS advice in relation to diadromous fish, PMF, shellfish and spawning and nursery grounds within the EIA Report. Diadromous fish should be included within each of the impact pathways identified in table 2-24 of the Scoping Report. Additionally, the Scottish Ministers highlight the representation from the Scottish Fishermen's Federation (SFF) and OIC and advise that the Developer must consult with the SFF and Orkney Sustainable Fisheries (OSF) to inform the fish and shellfish ecology impact assessment.	The advice from NatureScot with regards to diadromous fish, PMF, shellfish and spawning and nursery grounds is noted, as outlined in the responses above. Effects on diadromous fish have been considered for each impact scoped into the assessment, as outlined in section 11.5.1. SFF and OSF have been consulted as part of the EIA process.
Scottish Ministers (via MS-LOT)	Table 2-24 of the Scoping Report the Developer summarises the potential impacts on fish and shellfish during different phases of the Proposed Development. The Scottish Ministers broadly agree with the impacts scoped into and out of the EIA Report. However, in regards to habitat loss and disturbance, the Scottish Ministers advise that all appropriate pre-construction seabed preparation works must be scoped into the EIA Report. The Scottish Ministers do not agree that barrier effects to migratory fish from the presence of turbine installation should be scoped out and therefore this must be scoped in for further assessment in the EIA Report. The MSS advice in this regard must be fully addressed by the Developer.	The impacts requiring assessment are outlined in section 11.5.1. An assessment of the effects of habitat disturbance and loss on fish and shellfish ecology receptors is provided in section 11.6 and the assessment of construction effects includes the consideration of pre-construction seabed preparation. Furthermore, an assessment of potential barrier effects on diadromous fish has been scoped back in and is presented in section 11.6.
Scottish Ministers (via MS-LOT)	In regards to diadromous fish the Scottish Ministers highlight the concerns from MSS regarding the broad design envelope specifically the large cable search area and multiple landfall options. For each landfall location impacts on diadromous fish will vary, therefore specific concerns for each individual site should be assessed within the EIA Report.	The Project Design Envelope has been further refined since Scoping, as outlined in chapter 5: Project description. The site selection process is detailed in chapter 4: Site selection and alternatives. The effects of construction activities at the cable landfall options have been assessed, specifically the potential impacts on diadromous fish associated with the Forss Water (located adjacent to the Crosskirk landfall option) in this chapter and the underwater sound impacts of the Horizontal Directional Drilling (HDD) works at the landfall are considered in SS10: Underwater noise modelling report.

CONSULTEE	COMMENT	RESPONSE
Scottish Ministers (via MS-LOT)	In regards to underwater noise, the Scottish Ministers advise that impacts from UXO clearance must be explicitly considered within the EIA Report. Additionally, noise disturbance from construction activities must also be scoped into the EIA report. The Scottish Ministers do not agree that underwater noise during the operations and maintenance phases should be scoped out and in line with the NatureScot representation and MSS advice, this impact pathway must be scoped into the EIA Report if floating infrastructure is selected. Finally, the Scottish Ministers advise that the NatureScot advice in relation to noise impacts on Atlantic salmon is addressed in full by the Developer.	The effects of Unexploded Ordnance (UXO) clearance and other underwater noise effects from construction are considered in section 11.6. It should be noted that UXO clearance requirements will depend on the results of the pre-construction surveys that will be conducted post-consent. Therefore, it is not possible to quantify the exact number of UXO that will require disposal. In the absence of this data, estimates have been made on the number of pUXO from a review of magnetometer data. If UXO clearance is required, this may be consented separately through a Marine Licence and European Protected Species (EPS) licence. As floating foundations no longer form part of the Project Design Envelope, underwater noise effects during the operation and maintenance stage have been scoped out of the assessment. However, the potential for underwater noise effects to result in a barrier effect to diadromous fish is considered in section 11.6.
Scottish Ministers (via MS-LOT)	With regards to Electromagnetic Fields ("EMFs") the Scottish Ministers advise, in line with the NatureScot advice, that the EMF impact on all relevant fish species including elasmobranch species, *Nephrops* and diadromous fish, including migratory fish are included in the assessment. As advised by MSS, the paper on 'The Effect of Anthropogenic EMF on the Early Development of Two Commercially Important Crustaceans, European Lobster, Homarus gammarus and Edible Crab, Cancer pagurus by Harsanyi et al. 2022, should be considered within the EIA Report.	EMF effects are assessed in section 11.6 for all fish and shellfish ecology receptors. The suggested research report, amongst others, has been reviewed for the assessment of potential EMF effects during the operation and maintenance stage in section 11.6.
Scottish Ministers (via MS-LOT)	In relation to changes in prey species availability, the Scottish Ministers advise that table 2-24 does not adequately capture changes in prey availability as a result of habitat loss or disturbance. Further consideration is required in the EIA Report to ensure impacts to key prey species and their habitats are considered for the Proposed Development and in combination with other projects. The NatureScot representation in this regard must be fully addressed by the Developer in the EIA Report.	The assessment of indirect effects associated with changes in prey distribution and abundance is provided in section 11.6 and section 11.7 considers the potential for cumulative effects with other developments. Furthermore, other ecological receptors at higher trophic levels (e.g. ornithology and marine mammals) have also considered the indirect effects related to changes in availability or distribution of prey species, including fish and shellfish species.

CONSULTEE	COMMENT	RESPONSE
Scottish Ministers (via MS-LOT)	Potential cumulative impacts are summarised by the Developer in section 2.4.7 of the Scoping Report. The Scottish Ministers advise that the EIA Report should consider cumulative effects of key impacts such as habitat loss and change, EMF impacts and the potential for cumulative impacts with existing fish farm developments as detailed in the representations from NatureScot and OIC and the Orkney Fisheries Association (OFA). In line with representation from NatureScot and advice given by MSS, impacts of the Proposed Development in combination with other developments should be assessed against all the designated features of the North-West Orkney NCMPA including sandeel.	The cumulative effects assessment is presented in section 11.7, including habitat loss and disturbance and EMF, and an assessment of potential cumulative effects on sandeel (*Ammodytes* spp.) designated within the North-West Orkney Nature Conservation Marine Protected Area (NCMPA) is provided. The North-West Orkney NCMPA is also designated for the geomorphological feature of sandbanks, sand wave fields and sediment wave fields representative of the Fair Isle Strait Marine Process Bedforms Key Geodiversity Area. However, as no work will be undertaken within the North-West Orkney NCMPA, there will not be any impacts to this geomorphological feature and it has not been considered further (see chapter 8: Marine physical and coastal processes). As described in chapter 20: Other sea users, the closest aquaculture site is approximately 17.4 km from the offshore Project. Considering this distance and the localised nature of any effects associated with aquaculture sites, the potential for a cumulative effect is considered to be low. Therefore, no aquaculture sites have been identified as potentially acting cumulatively with the offshore Project.
Scottish Ministers (via MS-LOT)	In agreement with the NatureScot and the OFA representations and MSS advice, the Scottish Ministers advise the Developer that transboundary impacts on fish and shellfish ecology should be considered further.	The assessment of potential transboundary effects is considered in section 11.10. NatureScot were consulted on this approach during the consultation meeting in September 2022.
Scottish Ministers (via MS-LOT)	In regards to mitigation and monitoring, the full range of mitigation measures and published guidance must be considered within the EIA Report and the advice on monitoring approach, as recommended in the NatureScot representation, must be fully addressed within the EIA Report.	Potential monitoring opportunities for fish and shellfish ecology receptors is presented in section 11.12. OWPL will consider monitoring of fish and shellfish ecology receptors further during the post-consent stage and will engage with all relevant stakeholders to identify appropriate monitoring opportunities. This will focus on key data gaps identified in the Scottish Marine Energy Research (ScotMER) diadromous fish and fish and fisheries evidence maps. Relevant embedded mitigation measures are discussed in section 11.5.4 and additional (secondary) mitigation requirements are discussed in section 11.12.

CONSULTEE	COMMENT	RESPONSE
		Relevant guidance used to inform the assessment is listed in section 11.2.
Marine Scotland Science (MSS)	MSS are content with the study area for fish and shellfish ecology.	Noted.
MSS	MSS are content that all of the potential impacts have been identified for fish and shellfish ecology. MSS broadly agree with the impacts scoped in and out of the offshore EIA, however MSS agree with NatureScot that operational noise impacts should be scoped in for consideration for floating wind turbines. MSS also advise that UXO clearance activities should be considered as an underwater noise impact to marine fish species.	Noted, the study area is presented in section 11.4.1. The effects of UXO clearance and other underwater noise effects are considered in section 11.6. It should be noted that UXO clearance requirements will depend on the results of the pre-construction surveys that will be conducted post-consent. Therefore, it is not possible to quantify the exact number of UXO that will require disposal. If UXO clearance is required, this may be consented separately through a Marine Licence and EPS licence. As floating foundations no longer form part of the Project Design Envelope, underwater noise effects during the operation and maintenance stage have been scoped out of the assessment, with the exception of the potential for underwater noise effects to result in a barrier effect to diadromous fish.
MSS	In addition to the Coull *et al.* (1998), Ellis *et al*. (2010) and Aires *et al.* (2014) data, MSS recommend reference to the following papers regarding the spawning areas of cod, haddock and whiting (González-Irusta and Wright 2016; González-Irusta and Wright 2016; González-Irusta and Wright 2017). These papers provide updates to fish spawning areas as well as insights into optimum temperature, depth, salinity and seabed type conditions for spawning. Map layers showing information for all three species is now available on the Marine Scotland MAPS National Marine Plan interactive.	The spawning areas of cod (*Gadus morhua)*, haddock (*Melanogrammus aeglefinus*) and whiting (*Merlangius merlangus*) are presented in SS7: Fish and shellfish ecology baseline report and in section 11.4. The González-Irusta and Wright (2016a); González-Irusta and Wright (2016b) and González-Irusta and Wright (2017) reference papers have been reviewed for this assessment. National Marine Plan Interactive (NMPI) spawning ground maps for cod, haddock and whiting have been used as part of the assessment.

CONSULTEE	COMMENT	RESPONSE
MSS	A recent study has also been published on 'A verified distribution model for the lesser sandeel *Ammodytes marinus*' by Langton *et al.* (2021). In this study, species distribution models were developed to predict the occurrence and density of sandeels in parts of the North Sea and Celtic Seas regions. It provides information on environmental requirements for sandeel habitat and indicates potential areas where anthropogenic impacts on sandeel populations should be considered. It is important to note that the report identifies some depth biases in the data that was used to train the model, which results in a less accurate prediction of suitable sandeel habitat presence in deeper areas (>70 m) where sandeel are known to occur. This may therefore underestimate probabilities in these deeper areas, which should be highlighted when referring to the data. The spatial layers associated with the report showing the predicted probability of presence of suitable sandeel habitat and predicted sandeel density may be viewed on NMPi: https://marine.gov.scot/node/21413. MSS recommend that the developer considers this new research in the EIA.	Noted, the lesser sandeel (*Ammodytes marinus*) species distribution model has been reviewed as part of the environmental baseline characterisation and is presented in the Fish and Shellfish Ecology Baseline Report and in section 11.4.
MSS	MSS highlight the new paper on 'The effects of Anthropogenic Electromagnetic Fields (EMF) on the Early Development of Two Commercially Important Crustaceans, European Lobster, *Homarus gammarus* and Edible Crab, *Cancer pagurus* by Harsanyi *et al.* 2022. MSS recommends consideration of this new research within the EIA.	Noted, this research report, amongst others, has been reviewed for the assessment of potential EMF effects during the operation and maintenance stage in section 11.6.
MSS	MSS also highlight that Marine Scotland have commissioned a project on 'Essential Fish Habitat Maps for Fish and Shellfish Species in Scotland' through the Scottish Marine Energy Research (ScotMER) programme. This report and the associated modelling and maps are due to be published shortly and MSS recommends inclusion on this work when it is published.	Noted. The publication of the report on 'Essential Fish Habitat Maps for Fish and Shellfish Species in Scotland' was delayed until 22nd May 2023. It was agreed with MS-LOT that all guidance published over five months prior to the application date would be considered within the Offshore EIA Report. As the publication of the Essential Fish Habitat Maps was within this five month window it has not been considered within the Offshore EIA Report.
MSS	MSS note that the project overlaps with spawning and nursery grounds for several species, including sandeel, whiting, sprat, cod and herring. These marine species may	The assessment of potential effects from habitat loss and underwater noise involves the listed species and is provided in section 11.6, and this includes an

CONSULTEE	COMMENT	RESPONSE
	be sensitive to impacts from offshore wind farm developments through habitat disturbance or destruction and underwater noise emissions. MSS also note that the project overlaps with the North-West Orkney Nature Conservation Marine Protected Area (NCMPA) of which sandeel are a designated feature. The different types of offshore wind turbine foundation will have different impacts on seabed habitats and their associated species for example, gravity base foundation occupy a larger spatial footprint and would therefore cause more destruction to sandeel and herring habitat.	assessment of the potential effects on the North-West Orkney NCMPA and sandeel and herring (*Clupea harengus)* spawning habitat. The worst case scenario for the offshore Project has been used for the assessment of potential effects, as laid out in section 11.5.5.
MSS	MSS are content with the proposal to use benthic ecology surveys such as habitat maps and particle size analysis to understand the suitability of seabed habitat for sandeel and herring spawning.	The habitat maps and Particle Size Analysis (PSA) results have been used to understand the potential suitability of the offshore Project area for spawning by sandeel and herring. These results are summarised in SS7: Fish and shellfish ecology baseline report and in section 11.4.4.
MSS	MSS agree with NatureScot in that the EIA Report should make a clear assessment of the specific impacts of the proposed development on its own and in combination with other developments against all the designated features of the North-West Orkney NCMPA, including sandeel.	An assessment of the potential effects on sandeel designated within the North-West Orkney NCMPA is included in section 11.6. Cumulative effects on the North-West Orkney NCMPA are assessed in section 11.7. The North-West Orkney NCMPA is also designated for the geomorphological feature of sandbanks, sand wave fields and sediment wave fields representative of the Fair Isle Strait Marine Process Bedforms Key Geodiversity Area. However, as no work will be undertaken within the North-West Orkney NCMPA, there will not be any impacts to this geomorphological feature and it has not been considered further (see chapter 8: Marine physical and coastal processes).
MSS	MSS are pleased to see that cod maturity, herring larval and sandeel surveys have been proposed for this development given the development area overlap with fish spawning grounds. MSS recommend following the approach used by other windfarms who have undertaken fish surveys such as Beatrice Offshore Wind Farm in the Moray Firth.	OWPL will consider monitoring of fish and shellfish ecology receptors further during the post-consent stage and will engage with all relevant stakeholders to identify appropriate monitoring opportunities. This will focus on key data gaps identified in the ScotMER diadromous fish and fish and fisheries evidence maps.

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MSS	The broad project envelope makes it difficult to provide detailed response to the Scoping Report. The large extent of the cable search area with multiple landfall options is likely to include specific locations that are more sensitive than others. MSS advise that each landfall location is carefully considered given potential site specific concerns in relation to diadromous fish.	The Project Design Envelope has been further refined since Scoping, as outlined in chapter 5: Project description. The site selection process is detailed in chapter 4: Site selection and alternatives. The effects of construction activities at the cable landfall options have been assessed, specifically the potential impacts on diadromous fish associated with the Forss Water (located adjacent to the Crosskirk landfall option) in this chapter and the underwater sound impacts of the HDD works at the landfall are considered in SS10: Underwater noise modelling report.
MSS	Diadromous fish have been included within section 2.4 Fish and Shellfish Ecology. It is not clear if all aspects within this section include or relate to diadromous fish. MSS advise that it should be made clear which potential impacts relate to diadromous fish and those which don't. Given the biology and migratory behaviour of diadromous fish, MSS advise they should be assessed separately to other fish species within the EIA.	The impacts requiring assessment are listed in section 11.5.1. Diadromous fish have been assessed separately from other fish and shellfish receptors in section 11.6.
MSS	MSS agree that the main diadromous fish species which should be considered have been correctly identified as Atlantic salmon, sea trout and European eel. MSS agree with NatureScot, that sea lamprey should also be considered due to the relative close proximity of the River Spey Special Area of Conservation (SAC).	Sea lamprey and river lamprey are discussed in section 11.4 and in SS7: Fish and shellfish ecology baseline report. Effects on sea lamprey and river lamprey are assessed in section 11.6. It should be noted that designated sites with sea lamprey and river lamprey as qualifying features were screened out for further assessment through the HRA screening process (MS-LOT 2022).
MSS	MSS agree with NatureScot that there is potential for connectivity to other SACs. In addition to those outlined by NatureScot, MSS advise SACs within the Moray firth should also be considered: River Spey, River Oykel, and River Moriston. Also the River Evelix is a SAC for <Redacted> which are potentially dependent on the salmon population and should be considered in a future Habitats Regulations Appraisal. Returning adult salmon migrations in the area are not well defined, however	It is acknowledged that there is the potential for connectivity for the SACs listed, as described in section 11.4.4.7. Following feedback on the HRA Screening Report, all SACs designated for Atlantic salmon were initially screened into the Offshore RIAA (MS-LOT, 2022). However, subsequent feedback from NatureScot stipulated that impacts on diadromous fish should be considered within the EIA alone and not as part of the HRA. Further details are provided within the Offshore RIAA.

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	historical tagging work shows evidence of the use of the Pentland Firth by these populations (Malcolm *et al*, 2010; Cauwelier *et al*, 2015; Downie *et al.* 2018).	
MSS	No site-specific surveys have been proposed by the developer to inform the baseline characterisation or impact assessment on diadromous fish species. There is a lack of survey data on diadromous fish in the region of the Pentland Firth and Orkney waters. MSS advise site-specific surveys of suitable quality are required to characterise the site and where possible identify origins of populations of diadromous fish within the site boundary. Such surveys would substantially fill gaps in knowledge of diadromous fish in the area and inform the EIA/HRA process.	The limited information on diadromous fish in the north of Scotland is acknowledged, as outlined in section 11.4.7. The baseline presented in section 11.4 the SS7: Fish and shellfish ecology baseline report and the Offshore RIAA utilises available literature on migratory fish behaviours and acknowledges that data gaps remain on migratory fish patterns / behaviours. Site-specific environmental DNA (eDNA) has also been used to supplement available literature, as outlined in section 11.4.3. Potential monitoring opportunities for fish and shellfish ecology receptors are presented in section 11.12. OWPL will consider monitoring of fish and shellfish ecology receptors further during the post-consent stage and will engage with all relevant stakeholders to identify appropriate monitoring opportunities. This will focus on key data gaps identified in the ScotMER diadromous fish and fish and fisheries evidence maps.
MSS	One example of an impact pathway identified within the ScotMER evidence map is the change in abundance and distributions of predators at windfarm developments. Research within the Baltic sea (Friedland *et al.*, 2017) suggest that shifts in the distribution and intensity of predators in the Baltic has reduced post–smolt survival, primarily as a result of change in cod (*Gadus morhua*) distributions. Aggregations of predators (mainly cod) have resulted in mortality of up to 24.8% for the rivers Surna and Orkla in Norway (Hvidsten and Mokkelgjerd, 1987; Hvidsten and Lund, 1988). Reubans *et al* (2013) report higher catch per unit effort of Atlantic cod at wind turbines, catches at turbines were 2 to 12 times higher than at wrecks and up to 100 times higher than in surrounding sandy areas. Thus a baseline estimate of the distribution of diadromous fish within the site and their rivers of origin, and how this population might	An assessment of the potential effect of fish and predator aggregation around new offshore Project infrastructure is provided in section 11.6. The potential for diadromous fish to migrate through the offshore Project area has been established through a desk-based review, as presented in 11.4 and in SS7: Fish and shellfish ecology baseline report.

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	be impacted by aggregations of predatory fish in wind farm sites, would substantially inform the EIA/HRA process.	
MSS	There should be consideration that there are difficulties in sampling diadromous fish at sea which is why some evidence maybe lacking as opposed to there being evidence of no effect on a receptor. However, there are now new proven methods to achieve this. Surface trawls (Holst & McDonald, 2000) have been used to estimate abundance in pacific Coho salmon at sea (Beamish *et al.*, 2000) and to survey Atlantic salmon in the Gulf of Maine (Sheehan *et al*, 2011, Renkawitz and Sheehan, 2011). Surface trawls are regularly used to sample salmonids in the marine environment in Norway (Andreassen *et al.*, 2005; Holm *et al*, 2006). In addition the advancement of telemetry has enabled the tracking of both juveniles and adults further into the marine environment than previously capable (Newton *et al.*, 2021; Barry *et al.*, 2022). Thus, sampling methods now exist that are able to sample both adult and juvenile diadromous fish at sea allowing for baseline characterisation. MSS advise there is a major need for improved information on the spatial and temporal distribution of diadromous fish, including particularly salmon and sea trout, in the general vicinity of proposed offshore wind developments (see ScotMER diadromous fish evidence map: Streamlined ScotMER evidence map – gov.scot (www.gov.scot).	The need to better understand the migratory patterns of diadromous fish is acknowledged, as outlined in section 11.4.7. Available literature on surface trawls for diadromous fish (e.g. Gilbey *et al.*, 2021) and tracking studies (e.g. Newton *et al.*, 2017; 2021) for diadromous fish have been reviewed to understand the potential for diadromous fish to migrate through the offshore Project area. The baseline for diadromous fish is presented in section 11.4 and in SS7: Fish and shellfish ecology baseline report.
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 at the EIA stage, including the use of site-specific surveys.	A Project-specific eDNA survey has been undertaken to supplement available literature, as outlined in section 11.4.3. Potential monitoring opportunities for fish and shellfish ecology receptors is presented in section 11.12. OWPL will consider monitoring of fish and shellfish ecology receptors further during the post-consent stage and will engage with all relevant stakeholders to identify appropriate monitoring opportunities. This will focus on key data gaps identified in the ScotMER diadromous fish and fish and fisheries evidence maps.
MSS	MSS welcome the embedded mitigation. MSS advise that the effectiveness of these measures should be assessed prior to implementation. MSS advise that piling ramp up	The embedded mitigations are presented in section 11.5.4

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	and soft start are unlikely to be effective mitigation for salmon and sea trout. Harding *et al.* (2016) found that salmon did not show immediate avoidance behaviour in the presence of piling noise, despite the sound level being greatly above that which salmon can detect.	The research by Harding *et al.*, (2016) has been considered within section 11.6 for the assessment of underwater noise on Atlantic salmon. A Piling Strategy will be developed post-consent which will detail the requirement for underwater noise mitigation measures including those specific to Atlantic salmon and sea trout, as required. The development of mitigation measures will consider the best available measures at the time.
MSS	It is not clear which, if any, of the diadromous fish species are included in the scoping of each factor within table 2-24. MSS advise that diadromous fish should be included within each of the scoped in impact pathways within table 2-24. MSS advise that the timing of activities and subsequent impact should be considered carefully throughout the EIA process in relation to migration timing of anadromous fish species.	Effects on diadromous fish have been considered for each impact scoped into the assessment, as outlined in section 11.5.1. Migratory patterns, timing and behaviour of diadromous fish are described in section 11.4 and within SS7: Fish and shellfish ecology baseline report. These aspects of diadromous fish ecology and behaviour have been considered within the assessment of potential effects presented in section 11.6.
MSS	MSS do not agree that barrier effects to migratory fish from the presence of turbine installation should be scoped out due to there being limited evidence of a barrier effect. Barrier effects are not only physical objects but may also occur from cumulative sound sources. The effect of single point source sounds on salmonid behaviour is relatively unknown. Recent modelling indicates cumulative noise levels maybe elevated up to a few kilometres from a wind farm under low ambient noise (Tougaard, *et al.* 2020). MSS are also in agreement with NatureScot 'floating structures may act as a resonating chamber.' MSS advise that the barrier effect of sound should be scoped in.	Potential barrier effects on diadromous fish are assessed in section 11.6, including from EMF, underwater noise and the presence of infrastructure. As floating foundations no longer form part of the Project Design Envelope, the potential for floating structures to act as a resonating chamber is not considered within this assessment.
MSS	The exclusion of barrier effects also contradicts section 2.4.9.1 that states 'The assessment will focus on noise-sensitive species, including sprat, herring, gadoids (e.g. whiting and cod) and diadromous fish, and will consider the potential for underwater noise to act as a barrier to diadromous fish migration.' and section 2.4.7, 'therefore, underwater noise will form the focus of the Cumulative Effects Assessment for fish and shellfish ecology.'	Noted, potential barrier effects on diadromous fish are assessed in section 11.6.

CONSULTEE	COMMENT	RESPONSE
MSS	In section 2.4.8 Potential Transboundary Effects and 2.4.7 Potential Cumulative Effects, only underwater noise is identified as a potential impact pathway. MSS advise the that changes in predator distributions and abundance, such as seabirds, marine mammals and fish, may subsequently impact on migrating or foraging diadromous fish and should also be considered. There is evidence for numerous populations of diadromous fish utilising the study area where potential changes in predator distributions could impact on wider populations.	The cumulative effects assessment for potential fish and predator aggregation is included in section 11.7. Transboundary effects are considered in section 11.10.
MSS	MSS recommend that the applicant considers the resilience of salmon and sea trout populations to loss of fish, in any assessment of impacts for diadromous fish.	The indirect effects of changes in prey distribution and abundance, including for Atlantic salmon and sea trout, are assessed in section 11.6.
MSS	2.4.9.1 MSS suggest that the Atlantic Salmon Trust (AST), who have been undertaking large scale tagging work of juvenile Atlantic Salmon on the west coast of Scotland and Outer Hebrides, should also be consulted.	OWPL consulted AST in December 2022, at which further detail on their ongoing tagging work was discussed.
MSS	2.4.9.1 should also include the North and West District Salmon Fishery Board (DSFB), which has statutory responsibility for salmon fisheries in northern Scotland, adjacent to the development site.	Noted, the North and West DSFB were consulted in August 2022.
MSS	Desk-based studies are extremely limited in determining the impacts of developments on diadromous fish. Unlike other receptors, where impacts can be more clearly evident, it has previously been difficult to monitor diadromous fish. However, technology has been recently developed that changes this. MSS do not consider it appropriate for an EIA/HRA to conclude there is no or negligible impact just because no evidence exists of the impact. MSS advise that impacts to diadromous fish must be adequately investigated, rather than relying on a lack of evidence to claim there is no impact. The precautionary principle states that the lack of full scientific certainty should not be used	The data gaps and uncertainties are provided in section 11.4.7. It is acknowledged that data gaps and uncertainties exist with regards to the migratory patterns and river of origin for diadromous fish. The assessment of potential effects in section 11.6 has been undertaken in the context of these uncertainties and the impact assessment has been conducted using the most up to data scientific evidence.

CONSULTEE	COMMENT	RESPONSE
	as a reason for postponing cost-effective measures to prevent environmental degradation.	
MSS	With no baseline information from the West of Orkney Wind Farm (WOWF) site (sectoral plan option N1) it is not possible to determine a level of impact arising from the development. For other receptors (such as birds and mammals), this reasoning indicates a requirement for baseline characterisation surveys. It is possible that salmon from multiple SACs are present in the WOWF, according to historical evidence (e.g. Godfrey *et al*. 2015), and yet the number of fish (and from which SACs they originate) is unknown and could not be determined from a desk-based analysis. The potential scale of impact varies with the numbers of fish present: 100,000 salmon transiting the windfarm site could have a very different potential for population-level impact than a few thousand salmon transiting the site. MSS has successfully completed trawling work for smolts from which densities of salmon in offshore areas can be estimated (these data are currently being analysed), and pelagic sampling is undertaken for other species. MSS could provide advice to the developer on suitable sampling designs.	Available literature on diadromous migratory patterns, timing and behaviour have been reviewed to understand the potential for diadromous fish to migrate through the offshore Project area. It is acknowledged in section 11.4.7 that the potential presence, abundance and genetic origin of diadromous fish within the offshore Project area is unknown. Potential monitoring opportunities for fish and shellfish ecology receptors is presented in section 11.12. OWPL will consider monitoring of diadromous fish further during the post-consent stage and will engage with all relevant stakeholders to identify appropriate monitoring opportunities. This will focus on key data gaps identified in the ScotMER diadromous fish and fish and fisheries evidence maps.
MSS	Strategic post-consent monitoring could be beneficial if appropriate conditions regarding time and financial cost were put on this, to deliver timely evidence.	Potential monitoring opportunities for fish and shellfish ecology receptors are presented in section 11.12. OWPL will consider monitoring of fish and shellfish ecology receptors further during the post-consent stage and will engage with all relevant stakeholders to identify appropriate monitoring opportunities. This will focus on key data gaps identified in the ScotMER diadromous fish and fish and fisheries evidence maps.
MSS	Our advice is that if strategic monitoring is considered more appropriate than site-specific baseline characterisation surveys at this site, then we advise that this should be defined through consent conditions, specifically in relation to time of delivery. We welcome further discussion with MS-LOT about how best to establish strategic	Noted - OWPL will remain engaged with MS-LOT with respect to future strategic monitoring opportunities.

CONSULTEE	COMMENT	RESPONSE
	diadromous fish research, and can provide input into designing research projects to address important knowledge gaps.	
NatureScot	We are content with the study areas defined in Section 2.4.2.	Noted, the study area is presented in section 11.4.1.
NatureScot	We are content that Table 2-20 (Section 2.4.3) captures relevant baseline datasets but recommend the inclusion of 'Essential Fish Habitat Maps for Fish and Shellfish Species in Scotland' developed by the Scottish Marine Energy Research (ScotMER) programme, which is due for publication shortly.	Noted. The publication of the report on 'Essential Fish Habitat Maps for Fish and Shellfish Species in Scotland' was delayed until 22nd May 2023. It was agreed with MS-LOT that all guidance published over five months prior to the application date would be considered within the Offshore EIA Report. As the publication of the Essential Fish Habitat Maps was within this five month window it has not been considered within the Offshore EIA Report.
NatureScot	Section 2.4.4.1.5 correctly identifies the Rivers Thurso, Naver and Borgie Special Areas of Conservation (SAC) as all discharging along the north coast in the vicinity of the development. It also notes that the Pentland Firth and the waters around Orkney are potentially important migratory routes for Atlantic salmon. Therefore, we highlight at this stage that there is the potential for connectivity with other SACs, including Berriedale and Langwell Waters, Foinaven and Little Gruinard River. There may be relevant information on the routes some of the adult salmon use to and from these SACs, particularly from the Atlantic Salmon Trust (Moray Firth and Laxford tracking projects), that could help inform connectivity assessments.	It is acknowledged that there is the potential for connectivity for the SACs listed, as described in section 11.4.4.7. Following feedback on the HRA Screening Report, all SACs designated for Atlantic salmon were initially screened into the Offshore RIAA (MS-LOT, 2022). However, subsequent feedback from NatureScot stipulated that impacts on diadromous fish should be considered within the EIA alone and not as part of the HRA. Further details are provided within the Offshore RIAA.
NatureScot	It is noted in Section 2.4.4.1.2 that migratory movements of Atlantic salmon around the north of Scotland are still not well known. Timing of fish migration is an important element that will require careful consideration in the impact assessment and in what mitigation may be necessary and when it should be applied.	The migratory patterns, timing and behaviour of Atlantic salmon are described in SS7: Fish and shellfish ecology baseline report and has been considered throughout the assessment of potential effects in section 11.6.

CONSULTEE	COMMENT	RESPONSE
NatureScot	In addition to being qualifying features of European sites, Atlantic salmon are PMFs along with European eel and sea trout, which are identified in Section 2.4.4.1.5.	Noted, this has been reflected in SS7: Fish and shellfish ecology baseline report and in section 11.6.
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 IUCN Red list. However, very little is known about their migration pathways, either as juveniles or adults. Malcolm *et al.*, (2010) contains a review of available data in relation to migration routes and behaviour, and Gill & Bartlett (2010) on effects of noise and electromagnetic fields (EMF) on European eel as well as sea trout. Sea trout support a number of fisheries in Scotland and many of these fisheries have undergone declines in the last 25 years. Note that sea trout can also be a host species for freshwater pearl mussel (FWPM).	The migratory routes and behaviour of European eel and sea trout are presented in SS7: Fish and shellfish ecology baseline report. The Malcom *et al.* (2010) paper has been reviewed as part of this assessment. Effects of EMF and barrier effects to diadromous fish are assessed in section 11.6.
NatureScot	We would also suggest that more of the anadromous fish species, which are correctly identified within the onshore sections of the Scoping Report, are included, such as sea lamprey and river lamprey.	Sea lamprey and river lamprey are discussed in section 11.4 and in SS7: Fish and shellfish ecology baseline report. Effects on sea lamprey and river lamprey are assessed in section 11.6.
NatureScot	We welcome the approach to consider the importance of fish species (such as herring, sandeels, mackerel, whiting, cod and sprat) as key prey species to better inform the impact assessment for seabirds and marine mammals, noting that many of these are also PMFs.	Noted, an assessment of the potential change in distribution or abundance of prey, including fish and shellfish species, is included in chapter 13: Offshore and intertidal ornithology and chapter 12: Marine mammals and megafauna.
NatureScot	The shellfish species identified within Sections 2.4.4.1 and 2.4.4.2 of the Scoping Report focus on a limited number of commercial species with no information provided on other species likely to be present within the project area such as flame shell, horse mussel etc., which are PMFs and will also require consideration.	Horse mussel and flame shell are considered within the benthic and intertidal chapter along with other PMF habitats and species are considered in chapter 10: Benthic subtidal and intertidal ecology.

CONSULTEE	COMMENT	RESPONSE
NatureScot	We support the consideration of FWPM given that Atlantic salmon (and other salmonids) are integral to the life cycle of this species. Therefore, any impacts to salmonids that prevent them from returning to their natal rivers may have a resulting effect on FWPM.	Indirect effects on FWPM resulting from any impacts on salmonids are assessed in section 11.6.
NatureScot	As noted in Section 2.4.4.1.4 the project overlaps with spawning and nursery grounds for several species, including sandeel, whiting, sprat, cod and herring, all of which are sensitive to impacts caused by offshore wind farm developments. In addition, as identified in the Scoping Report, Sandeel is a feature of the North-West Orkney NC MPA, which overlaps with the project area	Spawning and nursery grounds of fish and shellfish species within the fish and shellfish ecology offshore study area are discussed in section 11.4. Impacts on nursery and spawning grounds for all relevant fish species have been assessed within the impact assessment and within SS7: Fish and shellfish baseline report. An assessment of the potential effects on sandeel designated within the North-West Orkney NCMPA is included in section 11.6. Cumulative effects on the North-West Orkney NCMPA are assessed in section 11.7.
NatureScot	As mentioned in our benthic advice (Appendix D) we are aware that flapper skate and their eggs, may be present in the project area due to the large number of empty egg cases that wash up on the west coast of Orkney (Shark Trust, Great Egg Case Hunt, Orkney Skate Trust). Female flapper skate are thought to lay eggs on cobble/boulder habitat in 20-50m but may lay in shallower or deeper water than this. Flapper skate on the west coast of Scotland exhibit high occupancy of the deep trenches (100-150m) in the seabed in the summer with a seasonal trend of (large females especially, which suggests an associated with egg laying) moving into shallow water (25-75m) over winter months (Thorburn *et al.* 2021). Therefore, potential impacts to flapper skate should be included in the EIA Report.	Flapper skate (*Dipturus intermedius*) are discussed in section 11.4 and an assessment of potential effects on flapper skate is provided in section 11.6.
NatureScot	Habitat loss and disturbance (both temporary and long-term) is a key impact pathway identified for construction, operation and maintenance and decommissioning activities. All appropriate pre-construction seabed preparation works should also be included.	An assessment of the effects of habitat disturbance and loss on fish and shellfish ecology receptors is provided in section 11.6 and the assessment of construction effects includes the consideration of pre-construction seabed preparation.

CONSULTEE	COMMENT	RESPONSE
NatureScot	Unexploded Ordnance (UXO) clearance should be explicitly considered in the assessment as should disturbance from construction related noisy activities, depending on the foundation type/installation method proposed.	The effects of UXO clearance and piling operations are considered in section 11.6. It should be noted that UXO clearance requirements will depend on the results of the pre-construction surveys that will be conducted post-consent. For the assessment, estimates have been made on the number of pUXO from a review of magnetometer data. If UXO clearance is required, this may be consented separately through a Marine Licence and EPS licence. Additionally, the Piling Strategy (PS) and Marine Mammal Mitigation Protocol (MMMP) will be finalised post consent, at which point final mitigation and monitoring requirements can be confirmed.
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. Available research on Atlantic salmon behaviour at sea indicates that ceasing relevant noisy activities (such as piling) during the hours of darkness could help to mitigate potential impacts. Consideration should also 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.	The research by Harding *et al.*, (2016) has been considered within section 11.6 for the assessment of underwater noise on Atlantic salmon. Embedded mitigation measures to reduce the potential effects of underwater noise are discussed in section 11.5.4. However, the assessment of effects did not indicate that ceasing noisy activities during hours of darkness is necessary.
NatureScot	Impacts from EMF from subsea electromagnetic cabling must consider all relevant fish species, including elasmobranch species, *Nephrops* and diadromous fish, including migratory fish.	EMF effects are assessed in section 11.6 for all fish and shellfish ecology receptors.
NatureScot	The potential creation and dispersal/settlement of fine sediments may vary with differing foundation types and/or construction/decommissioning methods, which can be an issue for some migratory fish. However, given the incredibly open, and generally turbulent location of this development we agree that this impact pathway can be scoped out for further assessment as detailed in Table 2-24.	Noted, the effect of increased suspended sediment is scoped out of the assessment for fish and shellfish ecology.

CONSULTEE	COMMENT	RESPONSE
NatureScot	We are content that the colonisation of hard structures has been scoped into the fish and shellfish section for assessment.	Noted, the introduction of new structures and potential fish and predator aggregation is considered in section 11.6.
NatureScot	Table 2-24 (Section 2.4.6) doesn't capture changes in prey availability as a result of habitat loss or disturbance in adequate detail. More consideration is required in the EIA Report to ensure that impacts to key prey species (such as sandeel, herring, mackerel and sprat) and their habitats are considered for this development and in combination with other wind farms. As mentioned above we recognise that most EIA Reports concentrate on receptor specific impacts. However, increasingly we need to understand impacts at the ecosystem scale. Therefore, consideration across key trophic levels will enable better understanding of the consequences (positive or negative) of any potential changes in prey distribution and abundance on marine mammal (and other top predator) interests and how this may influence population level impacts. Thus, consideration of how this loss and or disturbance may affect the recruitment of key prey (fish) species through impacts to important spawning or nursery ground habitats should also be assessed. In addition, the PrePARED (Predators and Prey Around Renewable Energy Developments) project will also assist in the understanding of predator-prey relationships in and around offshore wind farms which will start in January 2022 and run for five years.	The indirect effects related to changes in availability or distribution of prey species are assessed in section 11.6. Furthermore, the assessments for other ecological receptors at higher trophic levels (e.g. ornithology and marine mammals) have also considered the indirect effects related to changes in availability or distribution of prey species, including fish and shellfish species. Further consultation with MS-LOT indicated that preliminary results of the PrePARED research project would be available in early 2023 and the full analysis would not be completed until 2025. However, these interim results are not available at the time of writing.
NatureScot	We welcome the intention as noted in Section 2.4.3.1 that benthic ecology surveys e.g. habitat maps and particle size analysis will be used to understand the suitability of the seabed habitat for sandeel and herring spawning.	The habitat maps and Particle Size Analysis (PSA) results have been used to understand the potential suitability of the offshore Project area for spawning by sandeel and herring. These results are summarised in SS7: Fish and shellfish ecology baseline report and in section 11.4.4.
NatureScot	The EIA Report should make a clear assessment of the specific impacts of the proposed development on its own and in combination with other developments against all the designated features of the North-West Orkney (NCMPA) including for sandeel.	An assessment of the potential effects on sandeel designated within the North-West Orkney NCMPA is included in section 11.6. Cumulative effects on the North-West Orkney NCMPA are assessed in section 11.7.

CONSULTEE	COMMENT	RESPONSE
		The North-West Orkney NCMPA is also designated for the geomorphological feature of sandbanks, sand wave fields and sediment wave fields representative of the Fair Isle Strait Marine Process Bedforms Key Geodiversity Area. However, as no work will be undertaken within the North-West Orkney NCMPA, there will not be any impacts to this geomorphological feature and it has not been considered further (see chapter 8: Marine physical and coastal processes).
NatureScot	We advise that the assessment should 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.	Effects on key fish and shellfish ecology PMF species for the fish and shellfish ecology offshore study area are assessed in section 11.6.
NatureScot	The EIA Report should consider the cumulative effect of key impacts such as habitat loss/change especially in relation to diadromous fish as well as key fish and shellfish species that contribute ecological importance as a prey resource. This may differ depending on the life stage being considered.	Noted, cumulative effects of habitat loss and Indirect effects related to changes in availability or distribution of prey species are assessed in section 11.7 and includes the various life stages of the relevant species.
NatureScot	We advise that the full range of mitigation measures and published guidance is considered and discussed in the EIA Report.	Embedded mitigation measures are presented in section 11.5.4. The requirement for secondary mitigation measures has been informed by the conclusions of the assessments provided in section 11.6. A summary of any proposed secondary mitigation measures is provided in section 11.12 Published guidance used to inform the fish and shellfish ecology assessment is listed in section 11.2. Consultation with MS-LOT in November 2022 confirmed that all guidance published up to five months prior to the consent application should be considered within the Offshore EIA Report.
NatureScot	Monitoring of sandeels is a welcomed approach. However, consideration will be needed as to when the surveys take place post construction as well as the methodology. Survey post construction should be based on expected recovery time, this could be informed by other wind farms that have undertaken sandeel surveys such	The results of the impact assessment have not identified any significant effects on sandeel, and thus, at this stage pre- and post-construction monitoring of

CONSULTEE	COMMENT	RESPONSE
	as Beatrice in the Moray Firth. In addition, further consideration over survey methods and whether it can be undertaken using non-invasive methods such as using a drop down camera should be explored. It would also be beneficial to look at sandeel recovery in relation to fishing pressures as it may be possible to look at potential recovery post construction prior to fishing returning to the site and then again post fishing.	sandeel populations at the offshore Project is not considered necessary or proportionate to the results of the impact assessment. OWPL will consider alternatives to site-specific monitoring, such as a review of ongoing national surveys and research, during the post-consent stage and will engage with all relevant stakeholders as required. This approach was discussed with NatureScot on 24th May 2023.
NatureScot	We also welcome the cod maturity and herring larval site specific surveys as noted in Section 2.4.3.1 in the Scoping Report. Although as above, the duration of the survey (before and after construction) should be considered further.	The results of the impact assessment have not identified any significant effects on cod or herring, and thus, at this stage pre- and post-construction monitoring of cod and herring populations at the offshore Project is not considered necessary or proportionate to the results of the impact assessment. OWPL will consider alternatives to site-specific monitoring, such as a review of ongoing national surveys and research, during the post-consent stage and will engage with all relevant stakeholders as required. This approach was discussed with NatureScot on 24th May 2023.
NatureScot	There is the potential for transboundary impacts as noted in Section 2.4.8 and this will require further discussion and agreement with NatureScot and Marine Scotland.	The assessment of potential transboundary effects is considered in section 11.10. NatureScot were consulted on this approach during the consultation meeting in September 2022.
Northern District Salmon Fishery Board (NDSFB)	For the NDSFB rivers, the marine component of the development – turbine array and export cables – poses greater risks than the onshore component. This will be the case in both the construction and operational phases of development. This is because it is highly likely that some, or all, of the salmon from some, or all, of the NDSFB rivers will attempt to pass through the West of Orkney development area. This will happen as smolts leave their rivers for the northern ocean and/or as adult fish return to the same rivers.	Noted. Section 11.4 provides a description of diadromous fish baseline within the fish and shellfish ecology offshore study area, including the potential for Atlantic salmon to migrate through the offshore Project area. Section 11.6 assesses the potential effects of the offshore Project on diadromous fish, including Atlantic salmon.

<table>
<tr><th>CONSULTEE</th><th>COMMENT</th><th>RESPONSE</th></tr>
<tr><td>NDSFB</td><td>Development of the West of Orkney Windfarm will expose migrating salmon (smolts and adults) to activities and effects such as -
Piling during the marine construction stage;
Predator aggregation around new structures;
Electromagnetic fields around horizontal or vertical power cables;
Ghost-fishing by discarded nets caught in turbine moorings and power export cables;
Noise and low frequency vibrations around active turbines;
Disturbance due to the effects of shadow flicker from moving turbine blades; and
Disturbance due to the dynamism of turbine blades observed through the ocean surface.</td><td>The effects on Atlantic salmon have been assessed in section 11.6, including:
Construction and decommissioning:
Underwater noise;
Indirect effects related to changes in availability or distribution of prey species;
Operation and maintenance:
EMF effects;
Potential fish or predator aggregation;
Barrier effects to diadromous fish; and
Indirect effects related to changes in availability or distribution of prey species.
As floating foundations no longer form part of the Project Design Envelope, the impact of ghost-fishing on fish and shellfish ecology receptors has been scoped out of the assessment.</td></tr>
<tr><td>NDSFB</td><td>Despite the obvious risks, the Scoping Report has scoped out consideration of barrier effects on diadromous fish arising from changes associated with windfarm construction and operation (p 148). The validity of this position cannot be supported with evidence and barrier effects on diadromous fish, due to any or all of the effects listed above, must be scoped back in.</td><td>Barrier effects have now been scoped back in, as suggested, and are assessed in section 11.6.</td></tr>
<tr><td>NDSFB</td><td>The cumulative effects of the West of Orkney development should be considered in the context of the increasing incursion of renewables developments – wind and tidal - into the probable coastal migration routes for salmon. The resulting increase in scope for serial interactions between development and diadromous fish should be</td><td>The cumulative effects assessment is considered in section 11.7. This considers other renewables developments within 100 km of the offshore Project. Other ScotWind developments, Offshore Wind Leasing Round 4 developments, and Innovation and Targeted Oil and Gas (INTOG) leasing round developments have</td></tr>
</table>

CONSULTEE	COMMENT	RESPONSE
	considered, particularly in the expanded context that will result from future uptake of the recently granted ScotWind leases.	been considered where there is sufficient publicly available information to conduct a meaningful assessment of cumulative effects. However, if sufficient detail is not available, it is not possible to conduct a meaningful assessment of potential cumulative effects, and therefore, these developments have not been considered within the cumulative effects assessment.
NDSFB	NDSFB considers that the major risks to its local salmon populations arise from the offshore construction works and from the subsequent operation of the windfarm. Any negative effects on migratory fish will be most clearly evident some distance away as changes in population abundance in local rivers. The Scoping Report does not disclose any plan to monitor local salmon populations in the pre-construction phase in order to establish a baseline for detecting within-river changes during and after windfarm construction. This omission should be rectified in the very near future in order to ensure that the predevelopment time series is sufficient to support analysis.	Potential monitoring opportunities for fish and shellfish ecology receptors are presented in section 11.12. No specific commitments to particular monitoring approaches have been made at this stage. However, OWPL will consider monitoring of fish and shellfish ecology receptors further during the post-consent stage and will engage with all relevant stakeholders to identify the most appropriate monitoring opportunities. This will focus on key data gaps identified in the ScotMER diadromous fish and fish and fisheries evidence maps.
North & East Coast - Regional Inshore Fisheries Group (NECRIFG)	With regard to section 2.4.10 we would answer yes to all the questions.	Noted.
Orkney Fisheries Association	Do you agree with the study area for the fish and shellfish ecology EIA? There is mention of migratory fish species, but no mention of other commercially important migratory species, such as brown crab.	Noted. Details on brown crab migration and other migratory species have been included in section 11.4.4 and in SS7: Fish and shellfish ecology baseline report.
Orkney Fisheries Association	Do you agree with the approach for the cumulative effects assessment and for transboundary effects? Yes, but EMF impacts should be included as well as noise.	EMF effects have been considered as part of the cumulative and transboundary effects assessment in sections 11.7 and 11.10.

CONSULTEE	COMMENT	RESPONSE
Orkney Fisheries Association	Do you agree with the approach to the analysis and assessment that will inform the EIA Section 2.4.9.1 identifies key consultees- including "Orkney Fisheries Society". Orkney Fisheries Society does not exist- there is Orkney Fisheries Association, Orkney Sustainable Fisheries, Orkney Fishermen's Society, and the Orkney Trout Fishing Association.	Noted, the correct names for these associations have been used throughout.
Orkney Islands Council	The Environmental Report should clearly quantify the area of natural and semi-natural habitat that would be damaged or lost to each alternative route under consideration. Where possible, opportunities to incorporate benefits for biodiversity should be identified.	The impact of temporary habitat disturbance during construction and decommissioning and long-term habitat loss during operation and maintenance on fish and shellfish ecology receptors is assessed in section 11.6.
Orkney Islands Council	Consider potential for cumulative impacts of the proposed development with existing fish farm development on Fish and Shellfish Ecology.	As described in chapter 20: Other sea users, the closest aquaculture site is approximately 17.4 km from the offshore Project. Considering this distance and the localised nature of any effects associated with aquaculture sites, the potential for a cumulative effect is considered to be low. Therefore, no aquaculture sites have been identified as potentially acting cumulatively with the offshore Project.
Orkney Islands Council	Include Orkney Sustainable Fisheries (IFG equivalent) as a consultee to inform the fish and shellfish ecology impact assessment.	Orkney Sustainable Fisheries (OSF) have been consulted with regards to brown crab (*Cancer pagarus*). As described in chapter 14: Commercial fisheries, OSF were also involved in the Fisheries Working Group, and were asked to provide further information on the validity of the ScotMap data during a meeting held on 25th October 2022.
Orkney Islands Council	Table 2.40 scopes out the risk associated with electromagnetic field (EMF) emissions with regard to impacts on elasmobranchs, but given the concentrations of PMFs in Scapa Flow, consideration should be given to potential changes in species composition/impacts along the corridor route. Section 2.4.4.3, Table 2.22 does include	The potential effects of EMF on flapper skate have been assessed in section 11.6. Please note that the offshore export cables in Scapa Flow to the Flotta Hydrogen Hub do not form part of this consent application and are not considered within this Offshore EIA Report.

CONSULTEE	COMMENT	RESPONSE
	consideration of potential EMF interactions; the EIAR should include these potential impacts on Flapper Skate.	
Orkney Islands Council	It should be noted that Orkney Islands Council (OIC) are preparing the Orkney Islands Regional Marine Plan (OIRMP) which is scheduled to be deposited for public consultation, as a consultation draft, in Summer 2023. Following this consultation, and subject to approval by Scottish Ministers, the OIRMP is scheduled to be adopted in 2024.	Noted, details on the draft Orkney Islands Regional Marine Plan are included in section 11.2. Further detail is included in chapter 3: Planning policy and legislative context.
Orkney Islands Council	When the West of Orkney Wind Farm development proposal is submitted and determined for the various statutory consents, the OIRMP is likely to be adopted. Authorisation or enforcement decisions made by a public authority need to be made in accordance with the appropriate marine plan(s), unless relevant considerations indicate otherwise.	Noted, details on the draft Orkney Islands Regional Marine Plan are included in section 11.2. Further detail is included in chapter 3: Planning policy and legislative context.
Orkney Islands Council	The Orkney onshore export cable corridor search area includes many sites that are designated for their natural heritage interest – internationally, nationally, and locally. The environmental effects of the project on the interests of these sites should therefore be assessed and the findings presented in the Environmental Statement. The assessment should address both direct and indirect effects, e.g., disturbance, displacement, and loss of breeding / foraging habitat, as well as effects that may result in accumulation with other development that affects these sites. Careful consideration should also be given to the timing of each stage of the project.	It is acknowledged that there is the potential for connectivity for the SACs listed, as described in section 11.4.4.7. Following feedback on the HRA Screening Report, all SACs designated for Atlantic salmon were initially screened into the Offshore RIAA (MS-LOT, 2022). However, subsequent feedback from NatureScot stipulated that impacts on diadromous fish should be considered within the EIA alone and not as part of the HRA. Further details are provided within the Offshore RIAA. Potential effects of the offshore Project on relevant NCMPAs are assessed in section 11.6.
Orkney Islands Council	As the current draft National Planning Framework 4 is likely to be published during the progress of this proposed offshore wind farm development, opportunities should be explored as to how the proposal will contribute to the conservation and enhancement of biodiversity (draft NPF4L Policy 3: Nature Crisis).	Opportunities to contribute towards conservation and enhancement of biodiversity have been considered at all stages of the Project. See chapter 3: Planning policy and legislative context which provides further details on NPF4.

CONSULTEE	COMMENT	RESPONSE
		In addition, OWPL have prepared a Biodiversity Enhancement Plan to ensure that any proposed enhancements are suited to the environment that they are situated in benefit not only the primary species but the wider ecosystem.
Scottish Fishermen's Federation (SFF)	In 2.4.10 our response would be yes to all questions.	Noted.

11.4 Baseline characterisation

This section outlines the current baseline for fish and shellfish ecology within the fish and shellfish ecology offshore study area. The characterisation of the current baseline environment has been informed by a combination of a site-specific survey and desk-based sources and has been augmented through consultation with key stakeholders.

11.4.1 Study area

The fish and shellfish ecology offshore study area is defined by the International Council for Exploration of the Sea (ICES) rectangles within which the offshore Project resides, including 46E5, 46E6 and 47E5, as shown on Figure 11-1. ICES rectangle 47E6 has also been considered within the study area due to its close proximity to the Option Agreement Area (OAA). Each ICES rectangle boundary extends over 1 degree longitude by 30′ latitude.

A wider regional context is also considered where this is ecologically relevant, for instance in relation to diadromous fish species and the availability of fish spawning and nursery grounds. In general, this wider regional context extends out to Scottish waters.

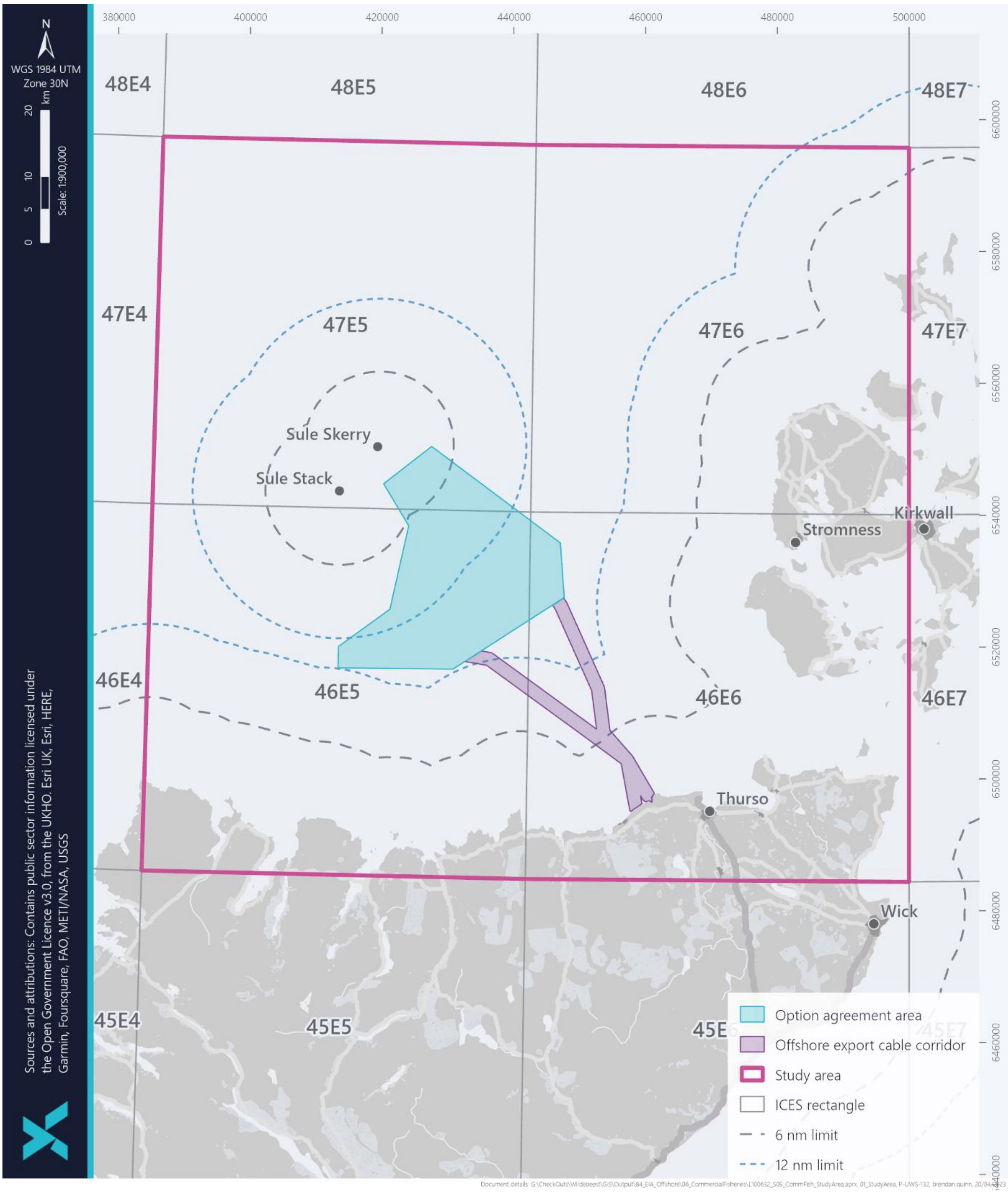

Figure 11-1 Fish and shellfish ecology offshore study area[4]

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[4] *Although ICES rectangles extend onshore, for the avoidance of doubt, the fish and shellfish ecology baseline focusses on marine species.*

11.4.2 Data sources

The existing data sets and literature with coverage relevant to the offshore Project, which have been used to inform the baseline characterisation for fish and shellfish ecology, are outlined in Table 11-5.

Table 11-5 Summary of key datasets and reports

TITLE	SOURCE	YEAR	AUTHOR
Fisheries Sensitivity Maps in British Waters	https://www.cefas.co.uk/media/o0fgfobd/sensi_maps.pdf	1998	Coull *et al.*
Spawning and Nursery Grounds of Selected Fish Species in UK Waters	https://www.cefas.co.uk/publications/techrep/TechRep147.pdf	2012	Ellis *et al.*
Spawning Grounds of Atlantic Cod (*Gadus Morhua*) in the North Sea	https://academic.oup.com/icesjms/article/73/2/304/2614292 (available to download via NMPi).	2016a	González-Irusta and Wright
Spawning Grounds of Haddock (*Melanogrammus aeglefinus*) in the North Sea and West of Scotland	https://research-scotland.ac.uk/handle/20.500.12594/10859?show=full (available to download via NMPi).	2016b	González-Irusta and Wright
Spawning Grounds of Whiting (*Merlangius merlangus*)	https://pubag.nal.usda.gov/catalog/5733845 (available to download via NMPi).	2017	González-Irusta and Wright
Updating Fisheries Sensitivity Maps in British Waters	https://www.gov.scot/publications/scottish-marine-freshwater-science-volume-5-number-10-updatingfisheries/ (available to download via NMPi).	2014	Aires *et al.*
International Herring Larvae Survey (IHLS) reports	https://www.ices.dk/data/dataset-collections/Pages/default.aspx	2019 - 2021	ICES
A Verified Distribution Model for the Lesser Sandeel *Ammodytes marinus*	https://spatialdata.gov.scot/geonetwork/srv/api/records/Marine_Scotland_FishDAC_12377 (available to download via NMPi).	2021	Langton *et al.*

TITLE	SOURCE	YEAR	AUTHOR
Landings Data (value and weight) by Species	https://www.gov.uk/government/statistics/uk-sea-fisheries-annual-statistics-report-2021	2022	Marine Management Organisation (MMO)
Shark Trust Sightings Database	https://www.sharktrust.org/sightings-database	2022a,b	Shark Trust
Review of Migratory Routes and Behaviour of Atlantic Salmon, Sea Trout and European eel in Scotland's Coastal Environment: Implications for the Development of Marine Renewables	https://data.marine.gov.scot/dataset/review-migratory-routes-and-behaviour-atlantic-salmon-sea-trout-and-european-eel-scotland%E2%80%99s	2010	Malcom *et al.*
Fishermen's Knowledge: Salmon in the Pentland Firth	https://www.fcrt.org/wp-content/uploads/2021/04/FCRTThe-Fishmongers-Company-reportfinal-version.pdf	2017	Youngson
Depth Use and Migratory Behaviour of Homing Atlantic Salmon (*Salmo salar*) in Scottish Coastal Waters	https://academic.oup.com/icesjms/article/72/2/568/2801299	2015	Godfrey *et al.*
Fish Tagging and Genetic Studies on Diadromous Fish Published by Marine Scotland (now Marine Directorate)	https://marine.gov.scot/data/marine-scotland-data-portal	Various	Various (e.g. Cauwelier *et al.*, 2015, Downie *et al.*, 2018 and Armstrong *et al.*, 2018)
Pentland Firth and Orkney Waters Enabling Actions Report: Pentland Firth and Orkney Waters Wave and Tidal Stream Projects and Migratory Salmonids	https://tethys.pnnl.gov/publications/pentland-firth-orkney-waters-enabling-actions-report-pentland-firth-orkney-waters-wave	2013	Slaski *et al.*

Additional data sources used to inform this chapter include:

- ICES publications;
- Marine Life Information Network (MarLIN);
- Environmental baseline (and associated appendices) of the UK Offshore Energy Strategic Environmental Assessment 4 (OESEA 4) (BEIS, 2022);
- Publications available through the Caithness DSFB;
- Sectoral Marine Plan for Offshore Wind Energy – regional locational guidance (Scottish Government, 2020);

- Publications available through OSF; and
- Other relevant peer-reviewed publications and assessments.

11.4.3 Project site-specific surveys

Site-specific eDNA and offshore benthic ecology surveys were conducted across the offshore Project area (including within the OAA and along the offshore Export Cable Corridor (ECC)) in August and September 2022. Nearshore benthic ecology surveys were also conducted in October 2022. Further details on these surveys are provided in SS5: Benthic environmental baseline report and further details on the analysis of the site-specific survey data are described in SS7: Fish and shellfish ecology baseline report.

11.4.3.1 eDNA surveys

eDNA surveys are a non-invasive sampling method used to determine the presence of species, based on the DNA found within water samples. Two water samples, one near the sea surface and one near the seabed, were collected at 20 locations across the offshore Project area, giving a total of 40 sample locations, as shown on Figure 11-2. The water samples were analysed to detect the DNA of:

- Fish and vertebrate communities (12S gene) (all samples);
- Marine mammals (16S gene) (near surface samples); and
- Invertebrates (18S gene) (near seabed samples).

The eDNA surveys have been used to indicate the presence of fish and shellfish species.

Further details are provided in SS5: Benthic environmental baseline report.

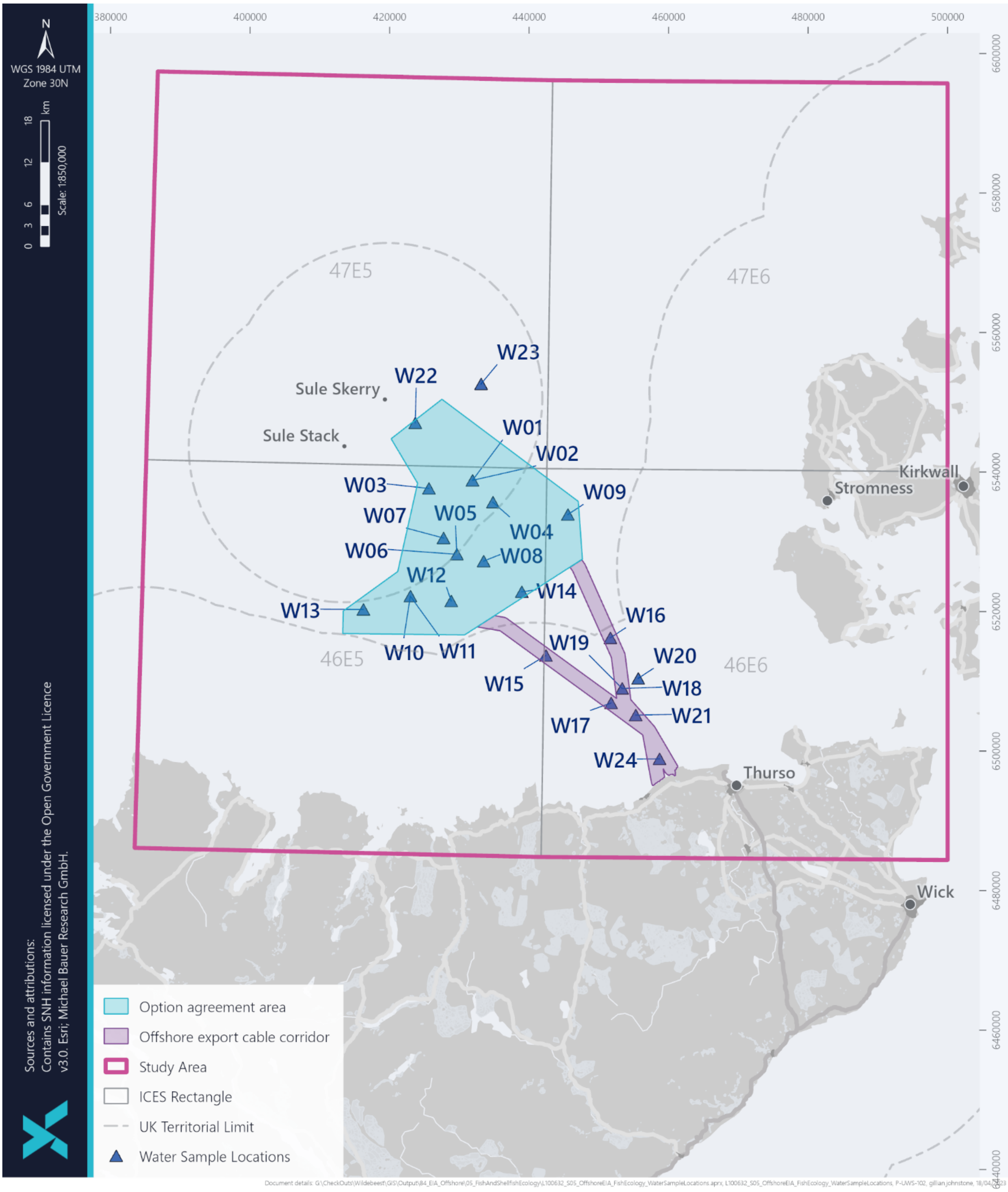

Figure 11-2 Water sampling locations for eDNA analysis

11.4.3.2 Benthic surveys

The offshore benthic ecology surveys included the use of grab sampling (primarily using 0.1 m^2 dual van Veen grabs, and 0.1 m^2 hamon grabs in areas of coarse sediment), Drop Down Video (DDV) and video transects. DDV and PSA data have been reviewed to understand the potential suitability for spawning habitat for sandeel (*Ammodytes* spp.), herring (*Clupea harengus*), and flapper skate.

11.4.3.3 Freshwater ecology surveys

As part of the freshwater ecology Onshore EIA, several surveys were undertaken to assess the quantity of available habitat for salmonids and lamprey species, including the Forss Water. The surveys were conducted in two phases:

- Phase 1 (May and June 2022): Reconnaissance walkover surveys to understand important areas for salmonids and lamprey species; and
- Phase 2 (July and September 2022): Detailed habitat walkover survey to ground-truth the desk-based baseline.

11.4.4 Existing baseline

A review of literature and available data sources, augmented by consultation and Project site-specific surveys, has been undertaken to describe the current baseline environment for fish and shellfish ecology.

11.4.4.1 Overview

Fish and shellfish ecology receptors relevant to the fish and shellfish ecology offshore study area include marine finfish[5] (pelagic and demersal teleost fish), elasmobranchs (sharks and rays), diadromous fish, and shellfish (crustaceans and molluscs).

A detailed description of the fish and shellfish ecology baseline environment is included in SS7: Fish and shellfish ecology baseline report and a summary is provided below.

11.4.4.2 Spawning and nursery grounds

Coull *et al.* (1998) and Ellis *et al.* (2012) established fish spawning and nursery grounds for the North Sea, and those that overlap with the fish and shellfish ecology offshore study area are summarised in Table 11-6, Figure 11-3, Figure 11-4, and Figure 11-5. Further detail on the potential spawning and nursery grounds that overlap the offshore Project area is provided in sections 11.4.4.2.1 and 11.4.4.2.2 respectively.

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[5] *Marine finfish are defined as non-diadromous marine teleosts, including pelagic teleost fish (fish that inhabit the water column) and demersal teleost fish (bottom dwelling). Demersal teleost fish are then further categorised into flatfish, gadoids and 'other' demersal teleost fish species.*

Table 11-6 Spawning and nursery grounds of fish and shellfish species within the fish and shellfish ecology offshore study area (Coull et al., 1998; Ellis et al., 2012)

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Herring	N	N	SN	SN	N	N	N	SN	SN	N	N	N
Lemon sole	N	N	N	SN	SN	SN	SN	SN	SN	N	N	N
Mackerel	N	N	SN	SN	S*N	S*N	SN	N	N	N	N	N
Nephrops	SN	SN	SN	S*N	S*N	S*N	SN	SN	SN	SN	SN	SN
Norway pout	SN	S*N	S*N	SN	N	N	N	N	N	N	N	N
Sandeel	SN	SN	N	N	N	N	N	N	N	N	SN	SN
Sprat	N	N	N	N	S*N	S*N	SN	SN	N	N	N	N
Whiting	N	SN	SN	SN	SN	SN	N	N	N	N	N	N
Anglerfish	N	N	N	N	N	N	N	N	N	N	N	N
Blue whiting	N	N	N	N	N	N	N	N	N	N	N	N
Cod	N	N	N	N	N	N	N	N	N	N	N	N
Common skate	N	N	N	N	N	N	N	N	N	N	N	N
Haddock'	N	N	N	N	N	N	N	N	N	N	N	N
Ling	N	N	N	N	N	N	N	N	N	N	N	N
Plaice	N	N	N	N	N	N	N	N	N	N	N	N
Saithe	N	N	N	N	N	N	N	N	N	N	N	N
Spotted ray	N	N	N	N	N	N	N	N	N	N	N	N
Spurdog	N	N	N	N	N	N	N	N	N	N	N	N
Thornback ray	N	N	N	N	N	N	N	N	N	N	N	N
Tope shark	N	N	N	N	N	N	N	N	N	N	N	N

S = Spawning, N = Nursery, SN = Spawning and Nursery; * = peak spawning; Species = High intensity nursery ground as per Ellis *et al*., 2012; Species = High concentration spawning as per Coull *et al.* (1998).

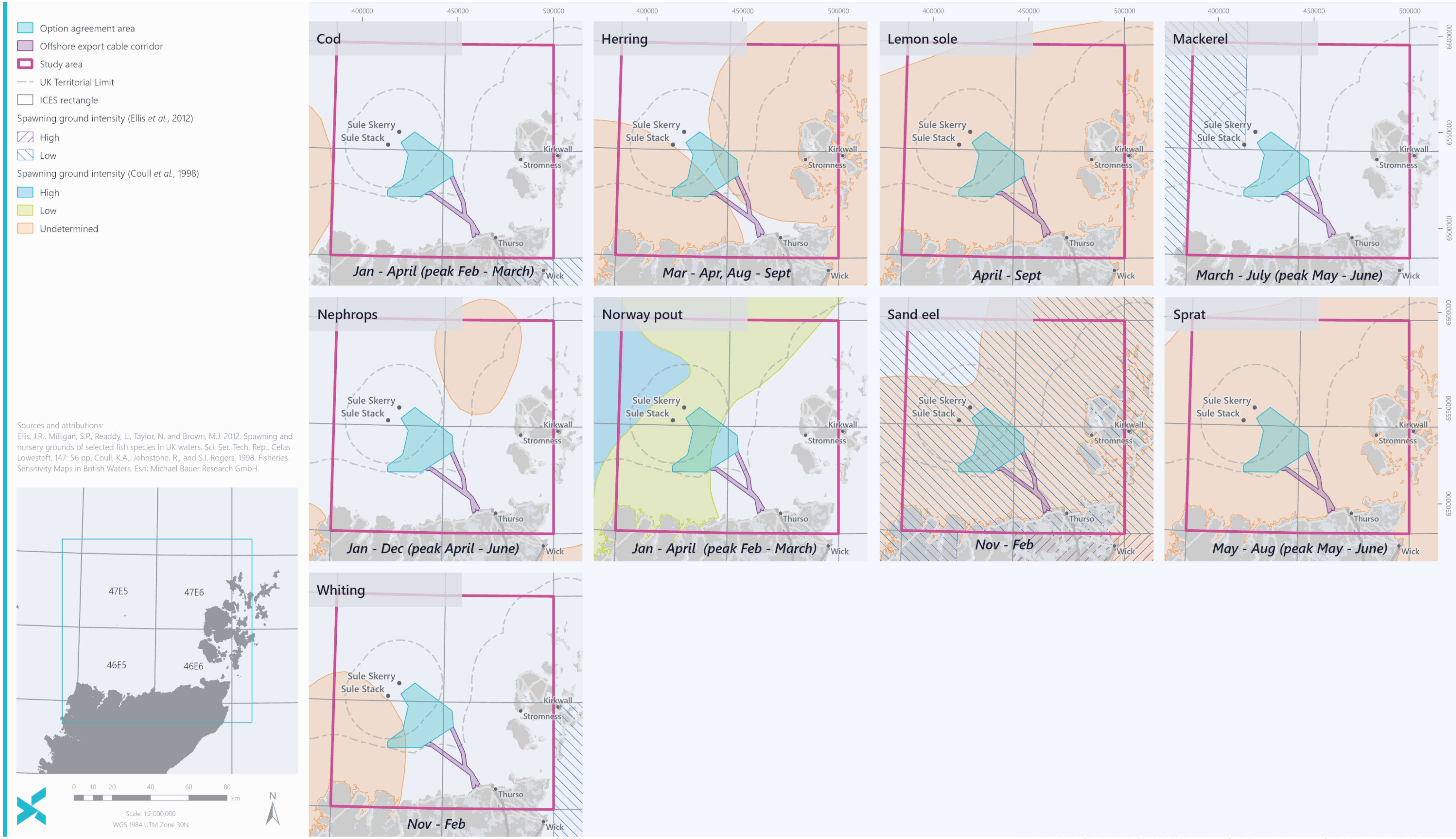

Figure 11-3 Spawning grounds within the fish and shellfish ecology offshore study area (Ellis et al., 2012 and Coull et al., 1998) (Note: Spawning period for each species is inclusive of the months listed)

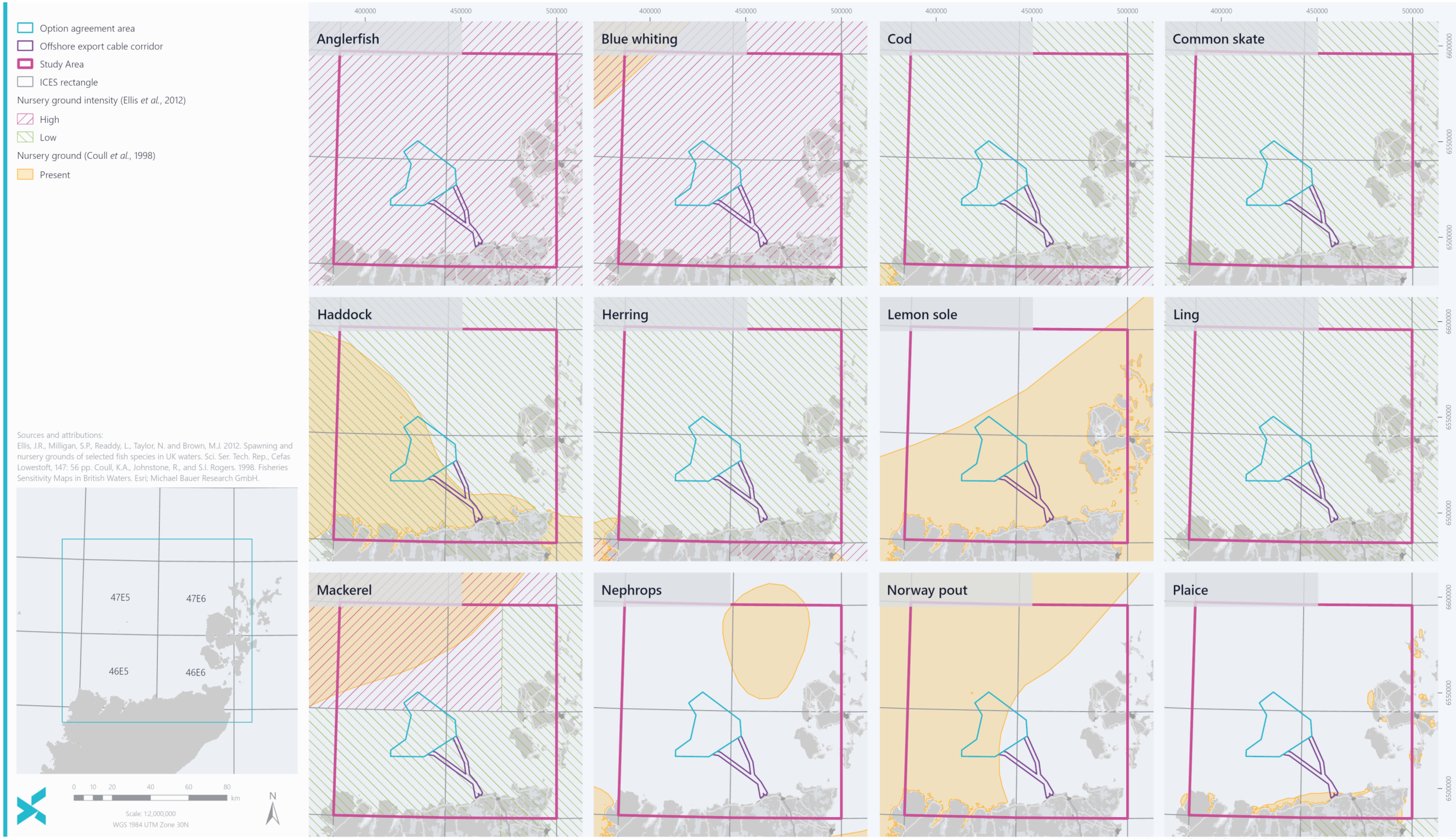

Figure 11-4 Nursery grounds within the fish and shellfish ecology offshore study area (Ellis et al., 2012 and Coull et al., 1998) (1 of 2)

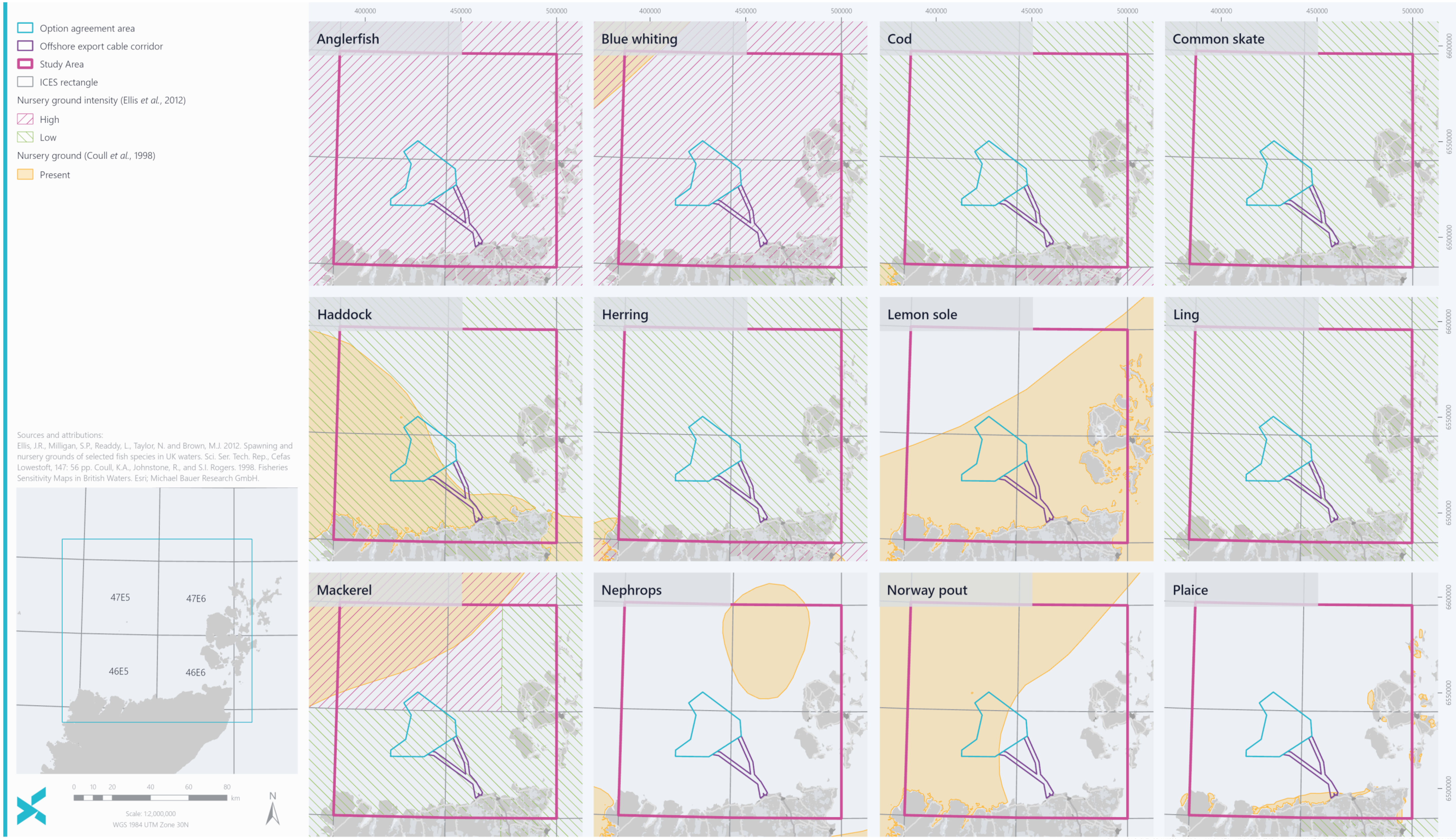

Figure 11-5 Nursery grounds within the fish and shellfish ecology offshore study area (Ellis et al., 2012 and Coull et al., 1998) (2 of 2)

11.4.4.2.1 Spawning grounds

Potential spawning grounds for herring, lemon sole (*Microstomus kitt*), Norway pout (*Trisopterus esmarkii*), sandeel, sprat (*Sprattus sprattus*) and whiting overlap with the offshore Project area (Coull *et al*., 1998; Ellis *et al*., 2012).

Spawning grounds for cod, haddock and whiting have been further updated by González-Irusta and Wright (2016a; 2016b; 2017). González-Irusta and Wright (2016a) characterised areas of the North Sea as "unfavourable", "rare", "occasional" and "recurrent" grounds for spawning cod. This data indicates that the offshore Project area mostly overlaps with areas of "occasional" grounds for spawning cod, with some patches of "rare" or "unfavourable" spawning grounds (González-Irusta and Wright, 2016a). González-Irusta and Wright (2016b; 2017) produced distribution models for spawning haddock and whiting, respectively, and categorised the preference for spawning by these species in the North Sea[6]. Areas within the offshore Project area are considered to be of low to moderate importance for both haddock and whiting spawning (González-Irusta and Wright, 2016b; 2017).

Whilst most species spawn into the water column of moving water masses over extensive areas, benthic spawners (e.g. sandeel, herring and flapper skate) have specific habitat suitability requirements, and as a consequence their spawning grounds are typically more spatially limited than those of pelagic spawners. Considering this, the potential presence of spawning habitat for sandeel, herring and flapper skate has been assessed in further detail below.

Herring spawning

Herring are demersal spawners, congregating together in shoals to lay dense sticky 'egg carpets' on gravel and other coarse sediments (Ellis *et al*., 2012). As described above, the offshore Project area overlaps with identified spawning grounds for herring, established by Coull *et al*. (1998). The potential for herring spawning has been further examined using site-specific PSA data to understand if the preferred spawning habitat for herring is present at the offshore Project area (see SS7: Fish and shellfish ecology baseline report for a detailed description of the methodology and analysis).

The suitability of the sediments in the offshore Project area for herring spawning habitat is shown in Figure 11-6. The majority of sediment samples across the offshore Project area were classified as being unsuitable for herring spawning, mainly as a result of a low gravel content. However, there are areas within the OAA and in the north-west of the offshore ECC that were classified as being preferred (sub-prime or prime).

Larval herring abundance can also provide an indication as to whether potential spawning grounds are in use. The ICES programme of IHLS in the North Sea and adjacent areas has been in operation since 1967. The main purpose of this programme is to provide quantitative estimates of herring larval abundance, which are used as a relative index of changes of the herring spawning-stock biomass. This dataset also provides information regarding the number of larvae present within the areas surveyed during the IHLS survey campaigns. The number of larvae < 10 mm in length

[6] *Please note that the distribution model of likely whiting spawning grounds produced by González-Irusta and Wright (2017) only covers the east of the offshore Project area.*

represent the number of 'newly hatched' larvae, and this can be used to inform the location or intensity of spawning grounds (ICES, 2022).

Overall, the larval abundance for the Orkney / Shetland area was low for the IHLS surveys conducted between 2018 and 2020, particularly on the west coast of Orkney in proximity to the offshore Project area (ICES, 2020; 2021; 2022). It is acknowledged that the abundance of herring larvae can vary considerably between years. However, the trend of low larval abundance, especially on the west coast of Orkney, can also be seen for previous years (2007 – 2016/2017) in the heat maps of newly hatched herring presented within Boyle and New (2018).

Taking the PSA data and IHLS data into account, it is likely that herring spawning may occur within some parts of the OAA, with the likelihood of herring spawning decreasing for the offshore ECC.

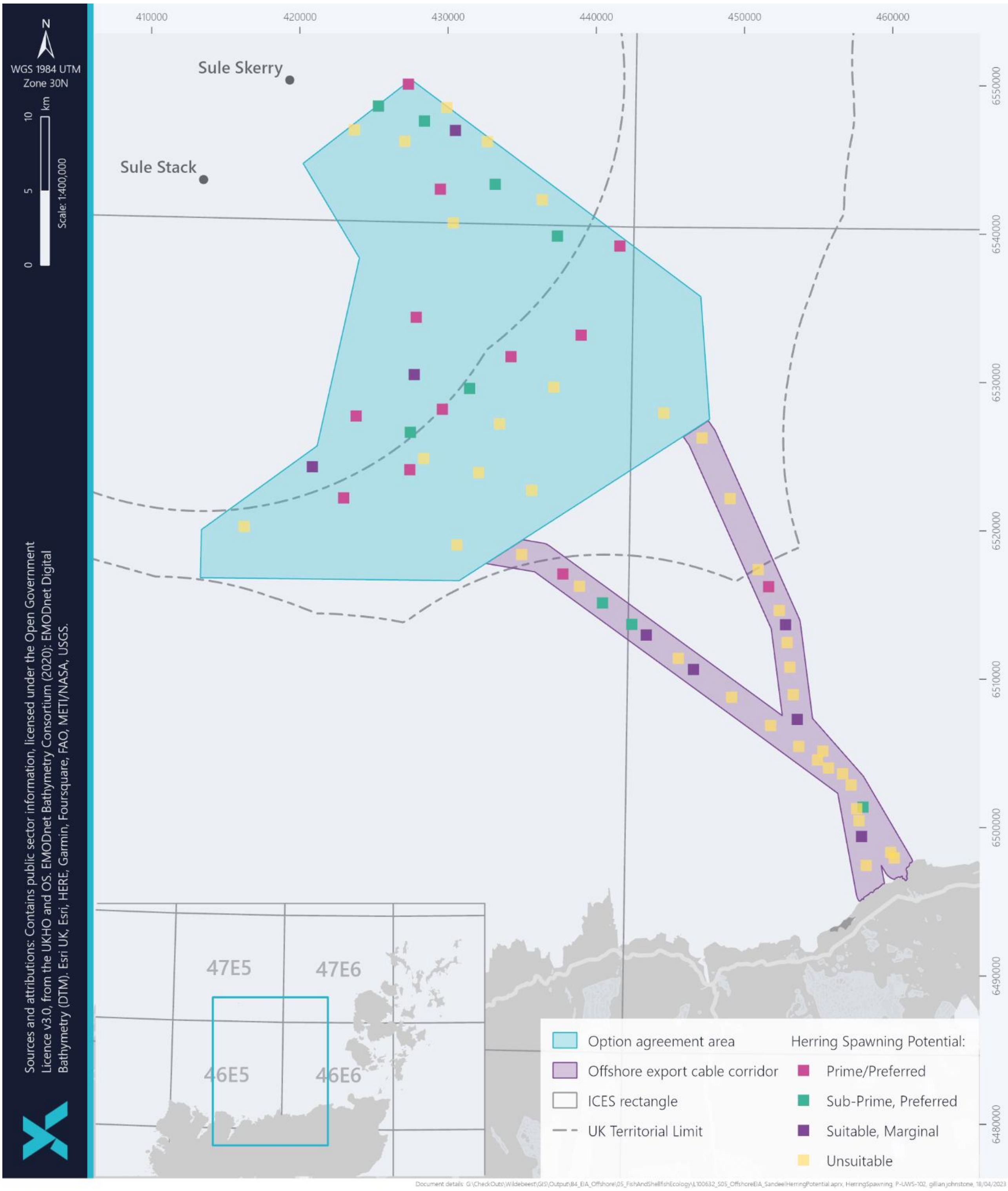

Figure 11-6 Herring spawning potential (herring spawning potential determined using the Project-specific PSA data (see SS5: Benthic environmental baseline report) and the methods within Marine Space, 2013a)

Sandeel spawning

Sandeel are seabed dependent for the vast majority of their adult and juvenile lives and inhabit burrows except when feeding and spawning (Van Deurs *et al.*, 2011; Tien *et al.*, 2017). Sandeel spawning usually occurs in sandy sediments with a high proportion of medium and coarse sand and a low silt content (BEIS, 2022; Holland *et al.*, 2005).

As described above, the offshore Project area overlaps with the spawning grounds for sandeel established by Coull *et al.* (1998) and Ellis *et al.* (2012). The suitability of the sediments in the offshore Project area for sandeel spawning habitat has been further investigated using the site-specific PSA data (see SS7: Fish and shellfish ecology baseline report for a detailed description of the methodology and analysis).

The suitability of the sediments in the offshore Project area for sandeel spawning habitat is shown in Figure 11-7. The sediment samples across the offshore Project area were classified as sandy gravel, slightly gravelly sand, gravelly sand or sand. The sediment samples contained a high proportion of medium to coarse sand (250 µm – 2 mm) (average of 60.2%) and a relatively low silt content (average of 1.53%), indicating that there is the potential for preferred sandeel habitat (Holland *et al.*, 2005; Greenstreet *et al.*, 2010). As shown, a high proportion of the samples in the offshore ECC are classified as preferred sandeel habitat (either prime or sub-prime), especially within the eastern corridor option. Areas of the OAA are also classified as preferred (prime) sandeel spawning habitat.

According to the recent distribution model developed by Langton *et al.* (2021) (which partially overlaps with the east of the offshore Project area), areas within the offshore Project area have a moderate to high probability of sandeel burrow presence, with a predicted density of buried sandeels which ranges from 0 to 42.5 per m^2, as shown on Figure 11-8.

Taking into account both the PSA data and the distribution model developed by Langton *et al.* (2021), it is likely that sandeel spawning grounds or burrowing habitat are present in both the offshore ECC and the OAA, although this distribution may be patchy and confined to areas of sandy substrate. It should be noted that the PSA data indicates the *potential* presence of sandeel spawning and burrowing habitat, rather than *actual* locations.

As described in section 11.4.4.7, the North-West Orkney NCMPA, designated for sandeel, lies approximately 11 km north-east of the OAA.

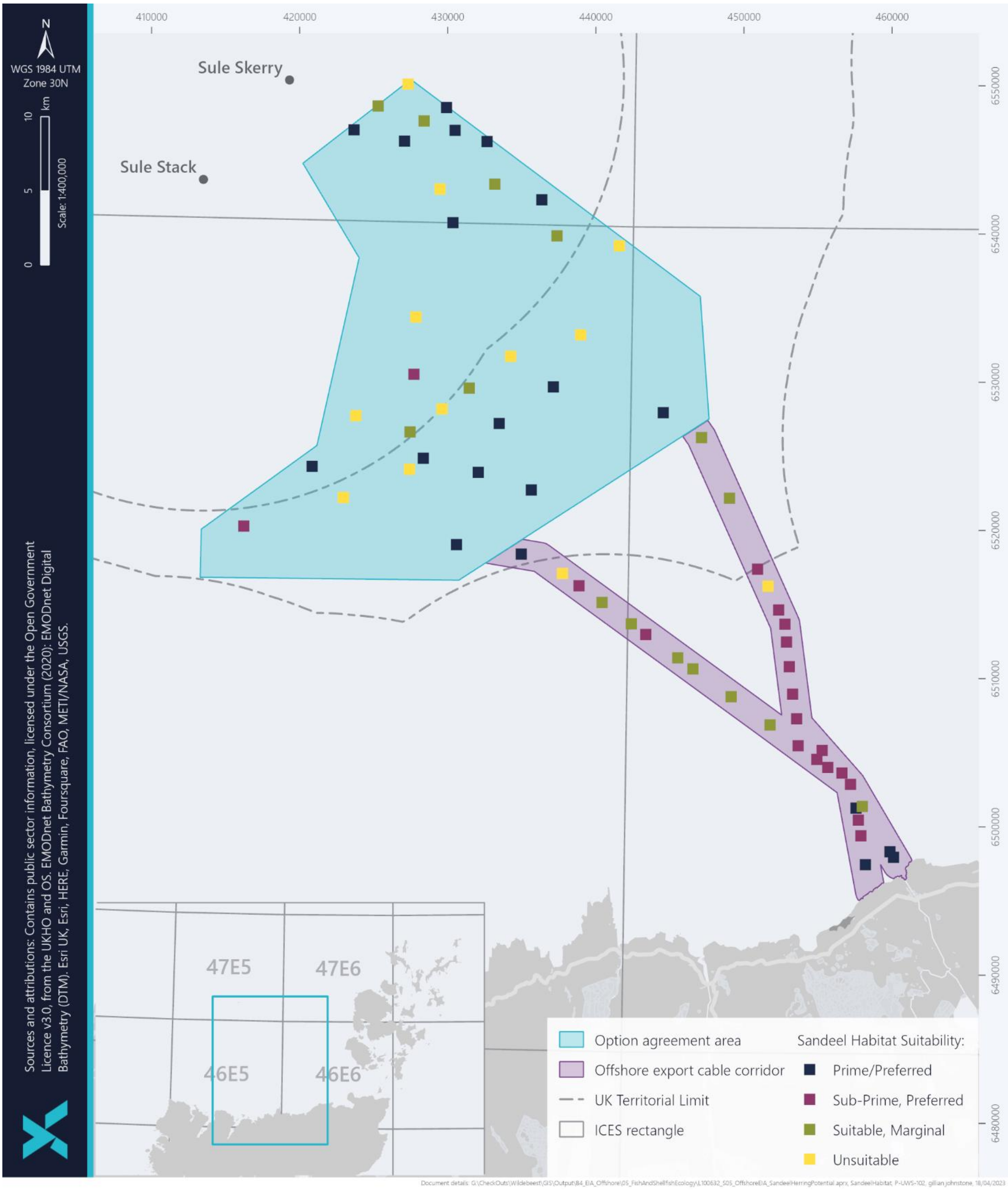

Figure 11-7 Sandeel habitat suitability (sandeel spawning potential determined (sandeel habitat suitability determined using the Project-specific PSA data (see SS5: Benthic environmental baseline report) and the methods within Marine Space, 2013b)

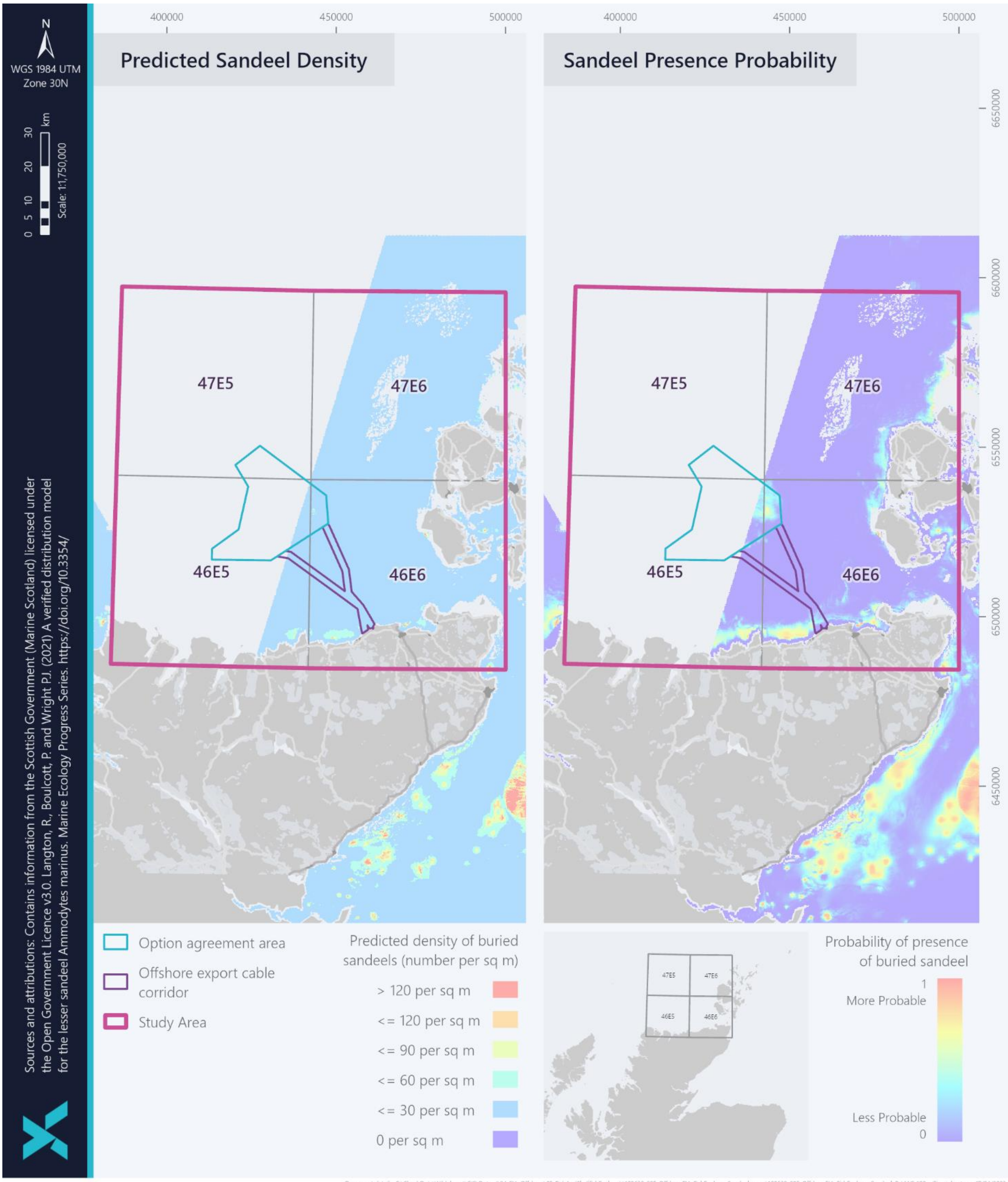

Figure 11-8 Sandeel predicted density of sandeel burrows (individuals per m^2) (left) and probability of presence (right) (Langton et al., 2021)

Flapper skate egg laying

The potential importance of the offshore Project area for flapper skate was highlighted in the Scottish Ministers (via MS-LOT) Scoping Opinion and during consultations with NatureScot (MS-LOT, 2022). Unlike herring and sandeel, a quantitative approach for identifying potential flapper skate egg laying habitat has not yet been devised. However, Phillips *et al*. (2021) characterised the habitat preferences for flapper skate egg laying in the waters around Orkney by analysing records of detached egg cases, diver observations and camera surveys. The preferred egg laying habitats identified by Phillips *et al*. (2021) were those with:

- Significant current flow (0.3 to 2.8 knots) with low sedimentation;
- Boulder or rocky substrates; and
- Water depth >20 m.

The benthic survey data have been compared with the habitat characteristics above to provide a qualitative assessment of the potential suitability of the offshore Project area for egg laying by flapper skate. A full description of this analysis is included in SS7: Fish and shellfish ecology baseline report.

1. Current flow

As described in SS3: Marine physical and coastal supporting study, for the majority of the OAA and the offshore ECC, mean peak flows at spring tide are expected to range between 0.5 m/s and 1.0 m/s, reducing to less than 0.5 m/s during neap tide. Therefore, the current flows are considered to be consistent with the preferred egg laying habitat characterised by Phillips *et al*. (2021) (0.15 m/s to 1.44 m/s).

2. Boulder or rocky substrates

Within the OAA, the seabed is characterised mainly by dense cobbles and boulders and rocky substrates (Atlantic circalittoral rock) which are consistent with potential flapper skate egg laying habitat. Areas with finer sediments (Atlantic circalittoral coarse sediment and Atlantic circalittoral sand) in the south-east and north-east of the OAA are likely to be less preferred for flapper skate egg laying.

Within the offshore ECC, there are patches of rocky substrate such as Atlantic infralittoral rock and Atlantic circalittoral rock interspersed with Atlantic circalittoral mixed sediment with dense cobbles and boulders which may potentially act as flapper skate egg laying habitat concentrated within the mid-sections of the offshore ECC. Areas of finer sandy sediment (Atlantic circalittoral coarse sediment and Atlantic circalittoral sand) are also present in the north-east, west and southern sections of the offshore ECC which may be less preferred by flapper skate.

Further detail on the seabed characteristics within the offshore Project area are described in SS3: Marine physical and coastal processes supporting study, SS5: Benthic environmental baseline report, and chapter 8: Marine physical and coastal processes.

3. Water depth >20 m

The site-specific surveys recorded depths within the OAA range from 45 to 99 m and those within the offshore ECC range from 45 to 110 m (see chapter 8: Marine physical and coastal processes), over the 20 m threshold for flapper skate egg laying habitat defined by Phillips *et al.* (2021). It has been indicated that flapper skate have a preference to lay eggs in water depths between 25 and 50 m with a preference for laying eggs in the deeper waters of this range, as this is adjacent to the deeper water waters that are preferred by adult flapper skate (100 – 200 m) (NatureScot, 2021; Thorburn *et al.*, 2021).

4. Summary

Both the OAA and offshore ECC contain rocky substrate or boulders at depths over 20 m and current flows which are considered suitable for flapper skate egg laying. Therefore, it is likely that flapper skate egg laying habitat may be present in some parts of the offshore Project area, particularly in the south-west of the OAA where larger areas of rocky substrate are present. However, it is important to re-iterate that the predicted habitat preferences of flapper skate, described by Phillips *et al*. (2021) and Nature Scot (2021), are relatively broad and indicate the *potential* presence of flapper skate egg laying grounds, rather than *actual* locations.

11.4.4.2.2 Nursery grounds

Potential nursery grounds for anglerfish (*Lophius* spp.), blue whiting (*Micromesistius poutassou*), cod, common skate (aka. flapper skate and blue skate (*Dipturus batis*)), haddock, herring, lemon sole, ling (*Molva molva*), mackerel (*Scomber scombrus*), Norway pout, plaice (*Pleuronectes platessa*), saithe (*Pollachius virens*), sandeel, whiting, spotted ray (*Raja montagui*), sprat, spurdog (*Squalus acanthias*), thornback ray (*Raja clavata*) and tope shark (*Galeorhinus galeus*) overlap with the offshore Project area, as detailed in Table 11-6 (Coull *et al*., 1998; Ellis *et al*., 2012). Aires *et al.* (2014) use the findings of Coull *et al.* (1998) and Ellis *et al.* (2012) together with International Beam Trawl Survey (IBTS) data, beam trawl survey data, IHLS and other standalone surveys to summarise the probability of aggregations of 0-group fish (i.e. those in the first year of their life) and/or larvae of key commercial species. The probability of aggregations of 0-group-fish occurring in the offshore Project area is low to moderate for anglerfish, blue whiting, cod, European hake (*Merluccius merluccius*), herring, horse mackerel (*Trachurus trachurus*), mackerel, plaice, sole (*Solea solea*) and moderate to high for haddock, Norway pout and whiting (Aires *et al.*, 2014).

11.4.4.3 Marine finfish

In the context of this chapter, marine finfish are defined as non-diadromous marine teleosts, including pelagic marine finfish (fish that inhabit the water column) and demersal teleost fish (bottom dwelling). Demersal marine finfish are then further categorised into flatfish, gadoids and 'other' demersal marine finfish species.

Commercial landings data provides an indication of the characteristic commercial marine finfish within the fish and shellfish ecology offshore study area. However, it is acknowledged that commercial landings do not provide an accurate representation of species composition, as landings will be influenced by the fishing methods used, seasonality, quotas, bycatch, discards, and Total Allowable Catch (TAC) limits.

Fifty different marine finfish species were landed, having been caught within the fish and shellfish ecology study area between 2017 and 2021. Table 11-7 displays the average live weights (2017 – 2021) for marine finfish within the fish and shellfish ecology offshore study area. Species are presented in descending order in terms of total live weights, and only the top 10 marine finfish species are listed.

Mackerel comprises the largest catch (by live weight), accounting for 27% of the average live weights across the fish and shellfish ecology study, followed by haddock, herring, cod and monkfish / anglerfish. Notably, there is considerable variability between the ICES rectangles within the fish and shellfish ecology offshore study area. Mackerel live weights are highest in ICES rectangle 47E5 with substantially lower landings weights in the other ICES rectangles. Cod and monkfish live weights are particularly high in ICES rectangle 47E6 and herring live weights are highest in ICES rectangle 46E5.

Table 11-7 Average live weights (tonnes, 2017 – 2021) of commercially exploited marine finfish within the fish and shellfish ecology offshore study area (MMO, 2022)

SPECIES	AVERAGE LIVE WEIGHTS (TONNES)				
	46E5	46E6	47E5	47E6	TOTAL
Mackerel (*Scrombus scrombus*)	4.9	7.0	2,180.0	254.0	2,445.9
Haddock (*Melanogrammus aeglefinus*)	242.2	451.0	367.6	316.7	1,377.6
Herring (*Clupea harengus*)	557.6	0.1	138.4	21.8	717.9
Cod (*Gadus morhua*)	16.5	212.8	67.1	365.0	661.4
Monks or anglers (*Lophius spp.*)	5.1	77.9	63.3	334.3	480.6
Whiting (*Merlangius merlangus*)	7.9	64.3	43.3	141.8	257.3
Saithe (*Pollachius virens*)	19.8	9.0	188.9	33.4	251.1
Megrim (*Lepidorhombus whiffiagonis*)	1.8	9.4	25.6	66.1	103.0
Plaice (*Pleuronectes platessa*)	5.4	25.7	27.3	28.3	86.6
Ling (*Molva molva*)	8.2	3.5	51.5	17.3	80.5

The project-specific eDNA surveys have also been used to inform the baseline characterisation for marine finfish, as detailed in SS7: Fish and shellfish baseline report. Mackerel, poor cod (*Trisopterus minutus*), haddock and other Gadidae spp. were the most frequently recorded taxa identified (Nature Metrics, 2022a,b). This is generally consistent with the landings data described above which identifies mackerel, cod and haddock as key commercial species. Ammodytidae spp. and Clupeids (e.g. sprat and herring) were also recorded relatively frequently (NatureMetrics, 2022a,b). Further details on the eDNA surveys are included in SS5: Benthic environmental baseline report.

11.4.4.4 Shellfish

The shellfish species considered within this chapter include larger crustaceans and molluscs, primarily those of commercial importance. Smaller crustaceans, including sedentary habitat forming species (e.g. flame shells), are considered within chapter 10: Benthic subtidal and intertidal ecology of the Offshore EIA Report.

Twenty shellfish species were landed from the ICES rectangles within the fish and shellfish ecology offshore study area. Table 11-8 displays the average live weights (2017 – 2021) for shellfish within the fish and shellfish ecology offshore study area. Species are presented in descending order in terms of total live weights and only the top 10 commercially exploited shellfish species are listed.

Brown crab make up the majority of the shellfish average live weights (69% of all shellfish average live weights), followed by scallops (*Pecten maximus*) (mainly within ICES rectangle 46E6 and to a lesser extent 46E5) and velvet crabs (*Necora puber*). Overall, shellfish account for a greater proportion of the average live weights within the coastal ICES rectangles 46E5, 46E6 and 47E6, with lower live weights associated with ICES rectangle 47E5.

Table 11-8 Average live weights (tonnes, 2017 – 2021) of commercially exploited shellfish within the fish and shellfish ecology offshore study area (MMO, 2022)

SPECIES	AVERAGE LIVE WEIGHTS (TONNES)				
	46E5	46E6	47E5	47E6	TOTAL
Crabs (C.P.Mixed Sexes) (*Cancer pagurus*)	357.6	557.2	155.7	429.9	1,500.4
Scallops (*Pecten maximus*)	93.6	144.0	9.4	7.4	254.3
Velvet crab (*Necora puber*)	6.1	75.4	0.0	46.5	128.0
Whelks (*Buccinum undatum*)	0.9	90.4	0.0	5.4	96.8
Squid (Cephalopoda spp.)	43.9	10.1	9.4	11.4	74.7
Lobsters (Nephropidae spp.)	7.9	43.0	0.2	6.0	57.2
Nephrops (Norway lobster) (*Nephrops norvegicus*)	8.6	4.0	0.5	11.8	24.9
Green crab (*Carcinus maenas*)	1.4	19.7	0.0	2.4	23.4
Queen scallops (*Aequipecten opercularis*)	0.0	10.7	0.0	0.6	11.2
Mixed squid and octopuses	1.5	0.2	0.7	1.0	3.3

The project-specific eDNA surveys identified a number of bivalve mollusc taxa, of which Pectinida spp. (e.g. scallops) were the most frequently detected (identified at 16 of the 20 sample locations) (NatureMetrics, 2022c). Furthermore, 61 juvenile scallops were found in the sediment samples collected in the offshore Project area as part of the benthic surveys (see SS5: Benthic environmental baseline report).

The reason for the lack of brown crab eDNA in the water samples is unknown. However, this may be caused by a sampling bias related to the fact that crustaceans shed less DNA that softer-body organisms. Furthermore, given the importance of the brown crab fishery for the fish and shellfish ecology, this species is considered to be the key shellfish species for consideration in the assessment for the offshore Project. Brown crab undertake wide-ranging migrations out to offshore overwintering grounds (Coleman and Rodrigues, 2017). Coleman and Rodrigues (2017) tagged male and female adult crabs within the 12 nautical mile (nm) limit around Orkney between 2010 and 2016, recording the location of the recapture. Female brown crabs were observed to undertake both short inshore migrations, as well as longer offshore migrations, out to 258 km from the original release site. Migrations were predominantly in a westward direction, along routes that potentially overlap with the offshore Project area.

11.4.4.5 Elasmobranchs

Elasmobranchs are cartilaginous fish, including sharks and skates. There are over 30 species of elasmobranchs known to occur in Scottish waters, the most abundant being the small spotted catshark (*Scyliorhinus Anguilla)* and nursehound (*Scyliorhinus stellaris*), spurdog, tope shark, thornback ray and cuckoo ray (*Leucoraja naevus*) (BEIS, 2022; Baxter *et al.*, 2011). It should be noted that basking sharks (*Cetorhinus maximus*) are not included within this chapter and are instead considered within chapter 12: Marine mammals and megafauna.

The Shark Trust sightings database and the results of the Great Eggcase Hunt have been reviewed to understand the key elasmobranch species potentially present in the fish and shellfish ecology offshore study area (Shark Trust, 2022a; 2022b). Species sighted within the vicinity of the fish and shellfish ecology offshore study area, either though visual sightings in the water or strandings on beaches, include blue shark (*Prionace glauca*), thresher sharks (*Alopias* spp*.)*, blue skate, porbeagle (*Lamna nasus*) and small-spotted catshark (Shark Trust, 2022a). The egg cases of the following species have been recorded in the vicinity of the fish and shellfish ecology offshore study area (ordered from most to least common): Small spotted catshark, flapper skate, spotted ray, thornback ray, blonde ray (*Raja brachyura*), cuckoo ray, starry ray (*Amblyraja radiata*), blue skate, nursehound, undulate ray (*Raja undulata*), and small-eyed ray (*Raja microocellata*) (Shark Trust, 2022b).

As noted in section 11.4.4.2.1, the potential importance of the offshore Project area for flapper skate was highlighted in the Scottish Ministers (via MS-LOT) Scoping Opinion and during consultations with NatureScot (MS-LOT, 2022). Flapper skate typically occupy waters at depths between 20 and 225 m and recent research on the west coast of Scotland indicates a migration to shallower waters (25 – 75 m) in winter months and a higher occupancy of deep waters (100 – 150 m) over summer (Thorburn *et al.*, 2021). A recent distribution model by McGeady *et al.* (2022) (shown in Figure 11-9) indicates that the OAA has a relatively low potential for flapper skate presence, with a higher probability within the offshore ECC. Importantly, this in the context of areas of much higher probability of presence for inshore areas to the west coast of Scotland. Flapper skate are categorised as critically endangered by the IUCN and are now extinct across large extents of their natural range after years of overexploitation (NatureScot, 2022a). The west coast of Scotland and the waters around Orkney and Shetland support important populations of this species.

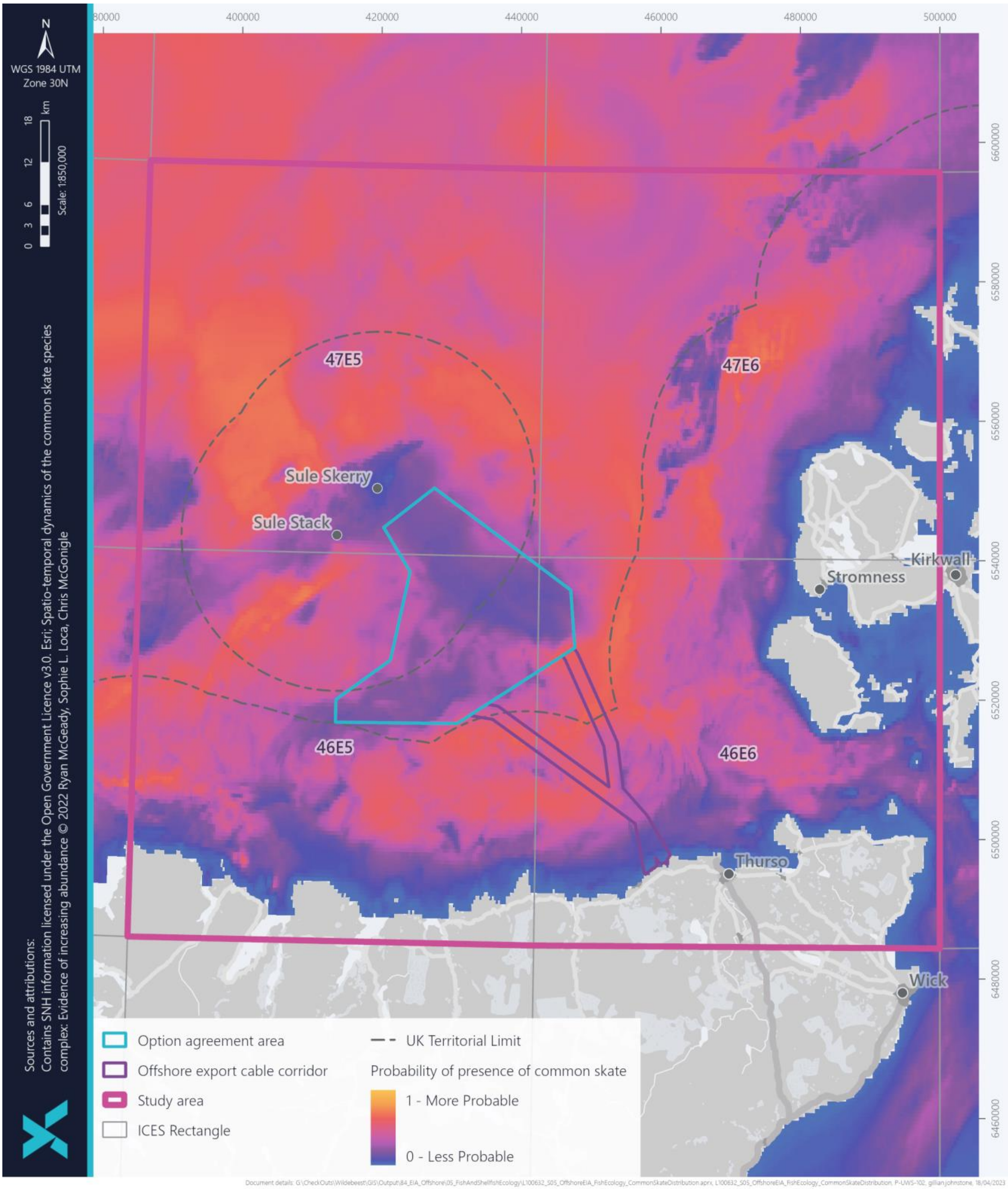

Figure 11-9 Probability of common skate presence (2018 – 2020) (McGeady et al., 2022)

11.4.4.6 Diadromous fish

Diadromous fish are fish that migrate between freshwater and marine environments to fulfil their lifecycle. Diadromy takes several forms, and this chapter focusses on anadromy – where a species migrates from marine waters to freshwater to spawn (salmonids, lamprey), and catadromy – where a species migrates from freshwater to spawn in seas and oceans (European eel (*Anguilla anguilla*)).

The project-specific eDNA surveys did not identify any diadromous fish as being present. However, this does not mean that diadromous fish are absent from the offshore Project area, as the design of the eDNA survey provides a snapshot of the species present at the time of the survey only.

A number of diadromous fish potentially use or migrate through the offshore Project area during various points of their life cycle, including Atlantic salmon, sea trout (*Salmo trutta*), sea lamprey, river lamprey and European eel. Although adult FWPM inhabit freshwater environments only, there is a direct relationship between salmonids and FWPM, described below.

A detailed description of the ecology, conservation and potential presence of diadromous fish within the offshore Project area is provided in SS7: Fish and shellfish ecology baseline report and a summary is provided below.

Atlantic salmon

Atlantic salmon is an Annex II species under the Habitat Directive, on the OSPAR list of threatened and/or declining species and habitats, a Scottish PMF species, and is of cultural, recreational and commercial importance in Scotland. Atlantic salmon spawn in riverine environments, and after maturing to become parr at approximately 10 cm, the salmon goes through a transformation to enable survival in saline conditions (smoltification) and once in the marine environment, Atlantic salmon become post-smolts.

The outward post-smolt migration to offshore feeding grounds occurs in April to June, with individuals spending either a single winter (One Sea-Winter (1SW) or grilse) or Multiple Winters at Sea (MSW). The offshore post-smolt migratory routes, patterns and behaviours is an area of growing research (e.g. Atlantic Salmon Trust West Coast[7] and Moray Firth[8] Tracking Projects and Newton *et al.*, 2021). Current evidence from the west coast of Scotland shows that smolts use a range of migratory routes in the initial stages of their migration. Acoustic receivers as part of the West Coast Tracking Project have been placed in the vicinity of the offshore Project this year (2023). However, the results from this deployment were not available to inform this chapter. Other studies indicate a more concentrated aggregation of post-smolts. For example, post-smolt tracking at the River Dee on the east coast of Scotland indicate that post-smolts travel in an easterly direction in their initial stage of migration, and the interim results of epi-pelagic trawling on the north and east coasts of Scotland conducted by MSS also indicate that post-smolts are widely distributed across offshore areas, with higher Catch Per Unit Effort (CPUE) on the east coast and lower catch rates in the outer Moray Firth (Main, 2021; Newton, 2023, *personal communication*). It is expected that both passive drifting

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[7] https://atlanticsalmontrust.org/our-work/the-west-coast-tracking-project/

[8] https://atlanticsalmontrust.org/our-work/morayfirthtrackingproject/

and active directing swimming is likely to be utilised on these post-smolt migrations (Ounsley *et al.*, 2020; Newton *et al.*, 2017; McIlvenny *et al.*, 2021).

There is currently no equivalent data on migratory patterns or aggregations of post-smolts on the north coast of Scotland and in the vicinity of the offshore Project, and therefore, the abundance or importance of the area for post-smolts is unknown. However, it is expected that post-smolts entering the sea from North Sea rivers could pass through the Pentland Firth and could occur within the offshore Project area.

Atlantic salmon homeward migrations back to freshwater is dictated by hormones and can occur during any month of the year. Tagging studies suggest a west-to-east migration of returning Atlantic salmon across the Pentland Firth and it is likely that adults in the area originate not only from local rivers but also from rivers hundreds of kilometres (km) away (Malcom *et al.*, 2010; Downie *et al.*, 2018; Armstrong *et al.*, 2018). The majority of adults die when after spawning, however, a small number return to sea to become repeat spawners (NatureScot, 2022b; Atlantic Salmon Trust, 2016; Malcom *et al.*, 2010).

The potential abundance and origin / destination of homing migrating salmon passing through the offshore Project area remains unknown. It may be possible for adult salmon returning to Scottish rivers from the northern Atlantic Ocean and for smolts of salmon leaving Scottish rivers and entering the ocean to interact with the offshore Project. Of particular relevance to the offshore Project is Forss Water, which has its river mouth at Crosskirk, one of the landfall options. The freshwater ecology surveys undertaken to inform the Onshore EIA (see section 11.4.3.3) identified that Forss Water is accessible to migratory salmonids such as Atlantic salmon. Forss Water is not designated as an SAC for Atlantic salmon.

The Caithness District Salmon Fishery Board publish yearly electrofishing reports surveying juvenile salmonids (2013-2021) (Youngson, 2022). Recent electrofishing data from the Forss Water (2020 and 2021) suggest a major decline in the production of juvenile Atlantic salmon in the river (Youngson, 2022). This has been caused by low spawning effort, potentially driven by adult mortality during migration or within early stages of freshwater return.

Anadromous brown trout (sea trout)

Sea trout is a Scottish PMF species and is also of cultural, recreational and commercial importance in Scotland. Sea trout have a similar life cycle to Atlantic salmon, conducting outward marine migrations as smolts and returning to native rivers to spawn as adults, following a period at sea (NatureScot, 2022c). Smolts typically migrate out to the marine environment between April and June (Ferguson *et al.*, 2019). For adult homeward migrations, there is considerable variation in timing and duration. Some individuals, known as 'finnock', return to their native rivers in July and September of the same year as their seaward migration, whereas larger fish known as 'maidens' may return after a migration duration of over 12 months (NatureScot, 2022c).

Sea trout migrations are generally more localised than Atlantic salmon, however, migratory routes of hundreds of km have been observed from rivers on the East coast of Scotland (Malcom *et al.*, 2010). Sea trout utilise areas closer to the coast for their outward migration relative to Atlantic salmon (River Dee Trust and Marine Scotland Science, 2019).

As noted above, Forss Water is adjacent to the Crosskirk landfall option and is considered accessible to migratory salmonids, including sea trout.

Lamprey species

There are three species of lamprey, including river, sea, and brook lamprey (*Lampetra planeri*). Lamprey species are listed as Annex II species on the Habitats Directive, a Scottish PMF species, and sea lamprey are listed on the OSPAR list of threatened and/or declining habitats and species. River and sea lamprey are diadromous, spawning in freshwater environments and migrating out to sea as juveniles. Most adults are parasitic on other fish or marine megafauna (NatureScot, 2022d).

River lamprey typically inhabit coastal and estuarine habitats for approximately one to two years following their migration to sea. Spawning typically occurs in autumn and spring, and migration out to sea occurs from late autumn onwards (Maitland, 2003). Sea lamprey migrate further offshore than river lamprey for approximately 18 to 24 months before returning to rivers in spring / early summer to spawn (NatureScot, 2022d). Unlike salmon and sea trout, sea lamprey do not display a homing behaviour (Waldman *et al.*, 2008).

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

The freshwater ecology surveys identified potential lamprey habitat in the lower reaches of the Forss Water catchment, adjacent to the Crosskirk landfall option.

European eel

European eel are critically endangered according to IUCN red list of threatened species, on the OSPAR list of threatened and/or declining species and habitats, and a Scottish PMF species.

European eel spend most of their lives in freshwater, migrating to the Sargasso Sea to spawn and die, over a distance of 5,000 to 10,000 km (Aarestrup *et al.*, 2009). A proportion of the total European eel population, at the adult (silver eel) migratory stage, may pass through Scottish coastal waters.

Migratory patterns of eels in Scottish waters remains poorly understood and the distribution or abundance of European eel within the offshore Project area is unclear. The freshwater ecology surveys identified that habitats are available for European eel in the Forss Water.

Freshwater pearl mussel (FWPM)

FWPM are reliant on salmonids during the glochidial stage (microscopic larval stage) of their life cycle, when they live on the gills of Atlantic salmon or sea trout as parasites (NatureScot, 2022e). As a result, the offshore Project only has the potential to impact FWPM indirectly through effects on Atlantic salmon or sea trout.

The results of the freshwater surveys indicated that impacts to FWPM in the Forss Water catchment could be scoped out (further details available in the Onshore EIA Report).

11.4.4.7 Designated sites

The North-West Orkney NCMPA is approximately 11 km north-east of the OAA. The North-West Orkney NCMPA was designated in July 2014 for lesser sandeels (*Ammodytes marinus*). High densities of sandeel have been recorded within the NCMPA and the area contains suitable habitat for sandeels. Newly hatched larvae within the NCMPA drift in currents to sandeel grounds (e.g. within the Moray Firth), and therefore, the site supports wider sandeel populations in Scotland (JNCC, 2014). As NCMPAs are not assessed through the HRA process, this chapter assesses the potential effects of the offshore Project on sandeel within this NCMPA.

The designated sites protecting Atlantic salmon and FWPM that have potential connectivity with the offshore Project are included in Table 11-9 and Figure 11-10, and this was informed by the HRA screening process. The Offshore EIA Report assesses the effects of the offshore Project on the protected features of these designated sites in EIA terms. Typically, an assessment of the potential effects of the offshore Project on the designated sites themselves would form part of the HRA process. However, as outlined in section 11.3 and in the Offshore RIAA, feedback from NatureScot stipulated that impacts on Atlantic salmon and FWPM should be considered within the EIA only and not as part of the HRA. Potential connectivity with designated sites with sea lamprey and river lamprey as qualifying features were screened out through the HRA screening process.

Table 11-9 SACs designated for diadromous fish interests with potential connectivity with the offshore Project

SAC	QUALIFYING FEATURES
River Thurso SAC	• Atlantic salmon
River Borgie SAC	• Atlantic salmon; and • FWPM.
River Naver SAC	• Atlantic salmon; and • FWPM.
Berriedale and Langwell Waters SAC	• Atlantic salmon
Langavat SAC	• Atlantic salmon
North Harris SAC	• Atlantic salmon; and • FWPM.
River Oykel SAC	• Atlantic salmon; and • FWPM.
Little Gruinard River SAC	• Atlantic salmon
River Spey SAC	• Atlantic salmon; • FWPM; and • Sea lamprey.
River Moriston SAC	• Atlantic salmon; and • FWPM.
River Dee SAC	• Atlantic salmon; and • FWPM.
River South Esk SAC	• Atlantic salmon; and • FWPM.
River Tay SAC	• Atlantic salmon; • Brook lamprey; • River lamprey; and

SAC	QUALIFYING FEATURES
	• Sea lamprey.
River Teith SAC	• Atlantic salmon; • Brook lamprey; • River lamprey; and • Sea lamprey.
Endrick Water SAC	• Atlantic salmon; • Brook lamprey; and • River lamprey.
River Tweed SAC	• Atlantic salmon; • Brook lamprey; • River lamprey; and • Sea lamprey.
River Bladnoch SAC	• Atlantic salmon
Foinaven SAC	• FWPM
River Evelix SAC	• FWPM
Abhainn Clais an Eas and Allt A'mhuilinn SAC	• FWPM
Ardnamurchan Burns SAC	• FWPM
Mingarry Burn SAC	• FWPM
River Kerry SAC	• FWPM
River Moidart SAC	• FWPM
Ardvar and Loch a' Mhuilinn Woodlands SAC	• FWPM
Glen Beasdale SAC	• FWPM
Inverpolly SAC	• FWPM
Rannoch Moor SAC	• FWPM

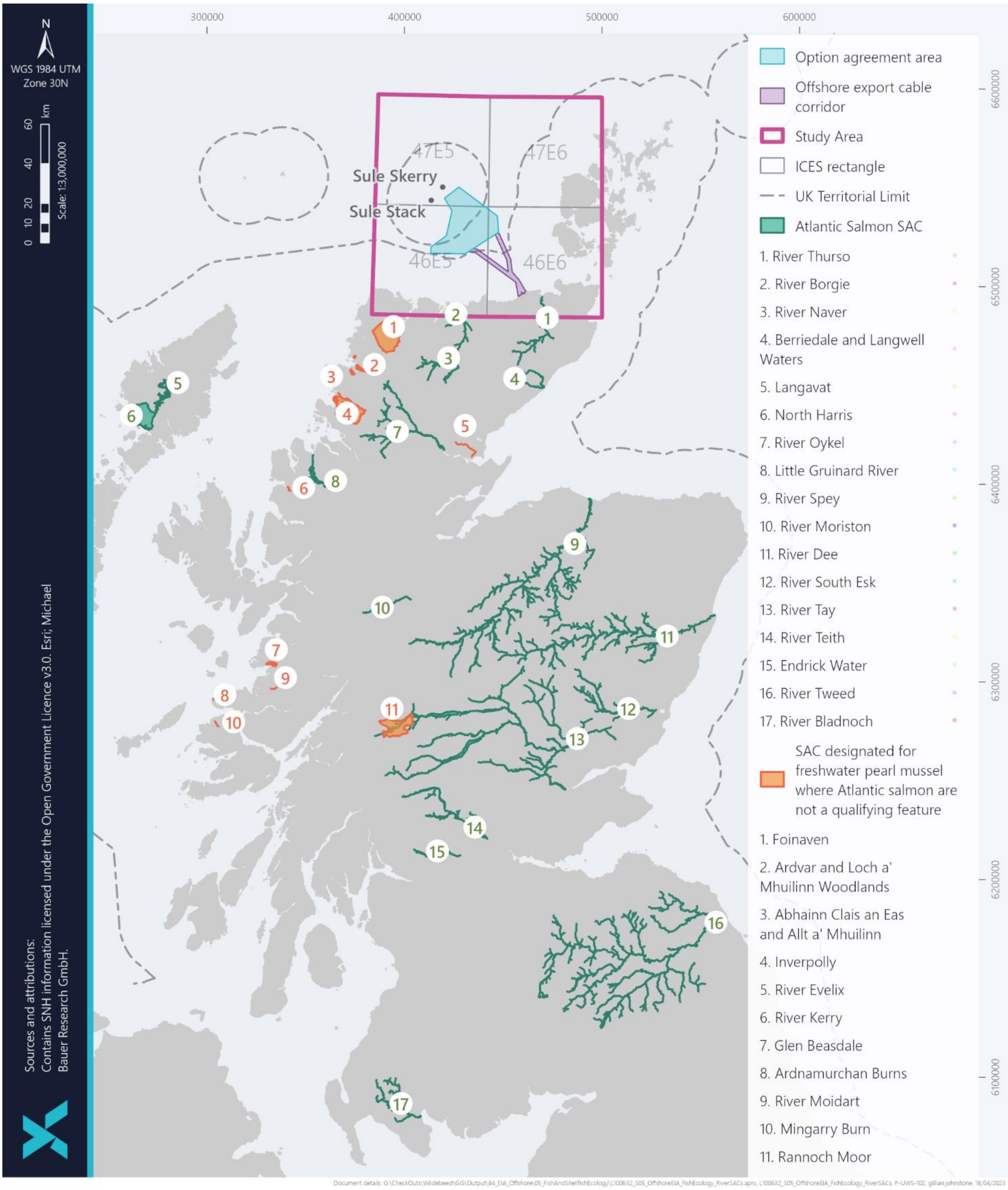

Figure 11-10 SACs designated for Atlantic salmon and FWPM

11.4.4.8 Key prey linkages

Fish and shellfish operate at various levels of the food chain, acting as both predators and prey and playing an important role in the transfer of energy across trophic levels within the ecosystem (BEIS, 2022).

The key prey interactions within the North Sea ecosystem are shown in Figure 11-11. Key predatory species include diadromous fish, elasmobranchs, haddock and cod. Key prey species include sandeel, mackerel and clupeids that are present in high biomass, as well as mackerel. These species play an important role in the food web, acting at intermediate trophic levels to transfer energy from zooplankton to top predators such as elasmobranchs, marine mammals and seabirds (BEIS, 2022).

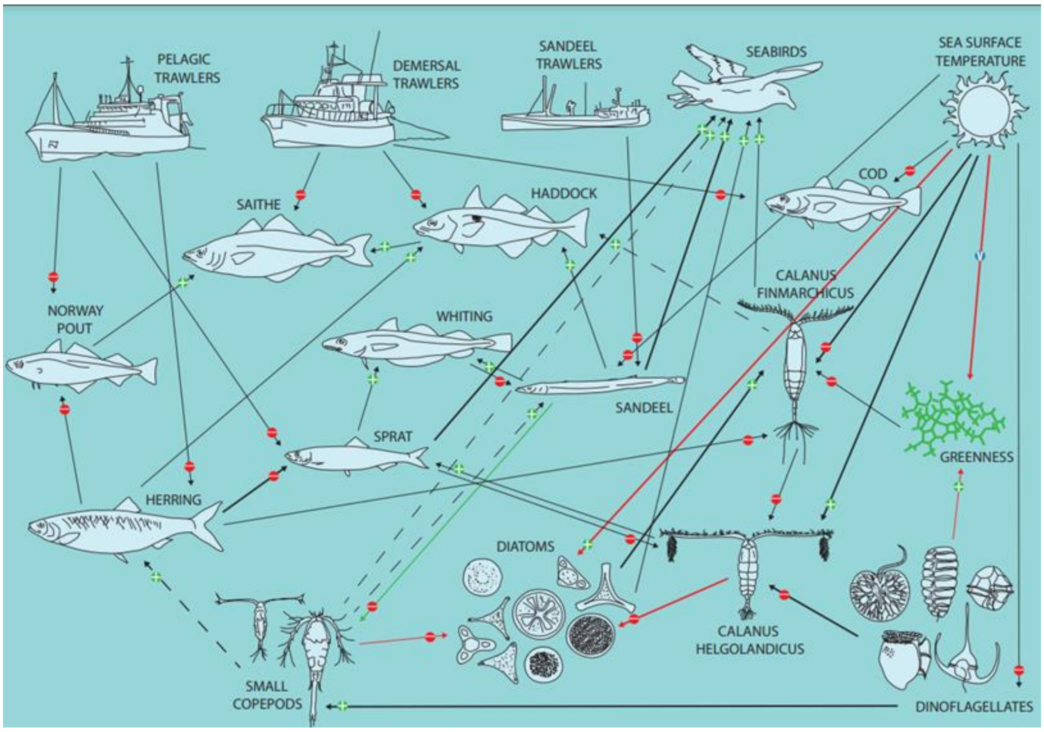

Figure 11-11 Key interactions within the North Sea ecosystem (Bayliss-Brown and Lynam, 2013)

11.4.5 Future baseline

The fish and shellfish baseline will continue to evolve over time as a result of a number of factors. Key drivers of change include climate change, predator-prey interactions, and fishing activities. Evidence of changes in the fish and shellfish distribution as a result of increased warming has already been observed, including northward shifts of population boundaries for a number of species (Perry *et al.*, 2005; Wright *et al.*, 2020). For instance, analysis of trawl survey data over a 45 year period has demonstrated that the number of Lusitanian (i.e. warmer-water) species has increased in the North Sea, Baltic Sea and Celtic Seas, whereas the number of Boreal (i.e. colder-water) species has decreased (EEA, 2022).

Increasing sea surface temperatures may result in a regional shift of 'colder-water' fish species into deeper and colder waters, with an increased abundance of 'warmer water' species within the Orkney region. Declines in recruitment may result if these environments do not contain the specific habitat requirements of some species (e.g. sandeel spawning grounds). Furthermore, a mismatch in the timing of fish spawning periods and algal blooms may have consequential effects on recruitment success for species with fish larvae that upon plankton (Wright *et al.*, 2020). Shifts in other life history stages (e.g. migratory timings), that are influenced by environmental cues such as temperature, may also occur (BEIS, 2022; Wright *et al.*, 2020).

As a result of natural variation, there is limited confidence in attributing climate change to observed changes in fish and shellfish communities (Wright *et al.*, 2020). It is also extremely difficult to predict climate change impacts on fish and shellfish populations, and therefore, an accurate future baseline for the fish and shellfish ecology offshore study area cannot be provided.

Changes in fishing patterns may also alter the fish and shellfish populations within the fish and shellfish ecology offshore study area. Elasmobranchs that have a slow growth rate and low fecundity are particularly sensitive to overfishing. It should be noted that there have been some improvements in some stocks in recent years which may continue (BEIS, 2022).

11.4.6 Summary and key issues

Table 11-10 Summary and key issues for fish and shellfish ecology

SUMMARY AND KEY ISSUES	OFFSHORE PROJECT AREA
	• Potential for diadromous fish to migrate through the offshore Project, including Atlantic salmon, sea trout, lamprey species and European eel, and for indirect effects on FWPM; • Crosskirk offshore ECC adjacent to the mouth of Forss Water, which may support Atlantic salmon, sea trout, lamprey species and European eel; • North-West Orkney NCMPA (designated for sandeel), located approximately 11 km from the offshore Project area; • Presence of preferred sandeel spawning habitat; • Presence of preferred herring spawning habitat (predominantly in the OAA); • Potential flapper skate egg laying habitat; • Potential interaction with species of commercial or conservation importance (e.g. PMF species) that have spawning and/or nursery grounds that overlap the offshore Project area (e.g. mackerel, brown crab, cod and haddock); and • Potential presence of key prey species such as sandeel, herring, sprat and mackerel.

11.4.7 Data limitations and uncertainties

The key data gaps and limitations for the fish and shellfish ecology baseline characterisation are described in Table 11-11. This has been informed by the ScotMER publication on "Fish and fisheries research to inform ScotMER evidence gaps and future strategic research in the UK: review" (Xoubanova and Lawrence, 2022).

The data sources listed in section 11.4.2 represent the most up-to-date desk-based data to characterise the fish and shellfish ecology baseline. These desk-based data were augmented by site-specific surveys, including eDNA, which help to address any data gaps for the majority of species. Therefore, for most species, a robust baseline is available for the impact assessment.

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

Table 11-11 Data gaps and limitations

SPECIES / FUNCTIONAL GROUP	DATA GAPS AND/OR LIMITATIONS
Spawning and nursery grounds	The Coull *et al.* (1998) and Ellis *et al.* (2012) spawning and nursery grounds are indicative and the data used to delineate these areas requires updating. The spawning areas and timing also represent the maximum spatial extents and durations, and in reality, these may be smaller and shorter, respectively. Information from a number of sources, including Aires *et al.* (2014), González-Irusta and Wright (2016a; 2016b; 2017), and IHLS survey and site-specific data (PSA data) have been used in conjunction with Coull *et al.* (1998) and Ellis *et al.* (2012) data to further understand the potential for spawning / nursery grounds at the offshore Project area at a finer scale. It should be noted that the site-specific PSA data indicates the potential presence of suitable sandeel and herring spawning habitat, rather than actual locations of sandeel and herring spawning, which may depend on other biotic and abiotic factors.
Marine finfish	There is a good understanding of the key marine finfish species in the regional area. Landings data, ICES surveys reports and the eDNA surveys have been used to improve the understanding of the marine finfish assemblage within the fish and shellfish ecology offshore study area. However, there are limitations to this data, relating to the specificity of the survey methods employed for ICES surveys and the fishing gears used. For instance, non-commercial species will be underrepresented in commercial landings data and the species targeted by specific fishing gears may be overrepresented. Landings data are also skewed towards commercial species (with non-commercial species being discarded at sea) and will also be influenced by fisheries legislation and controls. The eDNA surveys represent a 'snapshot' of the marine finfish assemblage at the time of the survey and do not reflect the seasonal and annual variation in marine finfish communities. The identification of taxa to species level is also dependent on the completeness of the reference databases.
Elasmobranchs	As above for marine finfish, there is relatively good understanding of the elasmobranch species present in the wider region. eDNA surveys and sightings data available through Shark Trust have been used to understand the presence of elasmobranchs at a more local scale. These data cannot be used to determine density / distribution within the offshore Project area itself but greatly improve the understanding of the key species relevant to the offshore Project. The sightings data is also subject to survey effort, and therefore cannot be used to provide a quantitative assessment of the distribution of species.

SPECIES / FUNCTIONAL GROUP	DATA GAPS AND/OR LIMITATIONS
	As mentioned for marine finfish, the eDNA surveys also represent a 'snapshot' of the elasmobranch assemblage at the time of the survey and do not reflect the seasonal and annual variation in elasmobranch communities.
Shellfish	There is a good understanding of the key shellfish species in the regional area. The brown crab tagging studies around Orkney improve the understanding of the migratory patterns of crab in the region. However, these data now require updating, and the relative importance of the offshore Project area for migrating crab remains unknown. Knowledge gaps remain around brown crab migratory behaviour, and there has also been little consideration of mapping shellfish habitat areas when compared with marine finfish. Landings data are skewed towards commercial species and will be influenced by fisheries legislation and controls, and the eDNA surveys provide a 'snapshot' of the shellfish assemblage at the time of the survey.
Diadromous fish	There is no empirical data for the offshore Project area itself with the exception of the eDNA surveys which did not detect diadromous fish DNA at the time of the survey. Tagging studies are available for Atlantic salmon on the north coast of Scotland, including those for adults and smolts. However, the majority of studies have been conducted in coastal environments, providing an indication of smolt behaviour / movement from freshwater to coastal environments or providing an indication of the origins / destinations of adult migrating salmon at the coast. There is limited information on sea trout, European eel and sea lamprey migration. Key uncertainties for diadromous fish include: • Migratory routes for Atlantic salmon, sea trout, European eel and sea lamprey juveniles and adults; • Specific timing of migrations; • The abundance / proximity of migratory fish to the offshore Project; • Post-smolt migratory behaviour (beyond the coastal environment) and migratory routes; and • Genetic origin of diadromous fish within the offshore Project area.

11.5 Impact assessment methodology

11.5.1 Impacts requiring assessment

The impacts identified as requiring consideration for fish and shellfish ecology are listed in Table 11-12. Information on the nature of impact (i.e. direct or indirect) is also provided. A holistic approach has been undertaken in the identification of impacts to consider any potential impacts that may occur at an ecosystem scale and particularly across trophic levels (e.g. impacts on prey species affecting their availability for predators).

Table 11-12 Impacts requiring assessment for fish and shellfish ecology

POTENTIAL IMPACT	NATURE OF IMPACT
Construction (including pre-construction) and decommissioning*	
Temporary habitat disturbance or loss	Direct
Underwater noise	Direct
Indirect effects related to changes in availability or distribution of prey species	Indirect
Operation and maintenance	
Long-term habitat loss and disturbance	Direct
EMF effects	Direct
Potential fish or predator aggregation	Direct
Barrier effects to diadromous fish	Indirect
Indirect effects related to changes in availability or distribution of prey species	Indirect
** In the absence of detailed information regarding decommissioning works, and unless otherwise stated, the impacts during the decommissioning of the offshore Project considered analogous with, or likely less than, those of the construction stage. Where this is not the case, decommissioning impacts have been listed separately and have been assessed in section 11.6.3.*	

11.5.2 Impacts scoped out of the assessment

The impacts scoped out of the assessment during EIA scoping, and the justification for this, are listed in Table 11-13. Furthermore, since the production of the Scoping Report, the Project Design Envelope no longer considers floating technology, and therefore, some of the impacts scoped into the Offshore EIA Report within the Scoping Report are no longer relevant, as detailed in Table 11-13.

Table 11-13 Impacts scoped out for fish and shellfish ecology

IMPACT SCOPED OUT	JUSTIFICATION
Construction (including pre-construction) and decommissioning	
Temporary increases in suspended sediment concentrations and associated sediment deposition	Increases in suspended sediment concentrations will be temporary and localised to the installation works, and sediments are expected to be rapidly dispersed by the strong tidal currents present in the Pentland Firth. Fish and shellfish are expected to be tolerant to temporary increases in suspended sediment concentrations as a result of the strong currents in the region. Hence the impact has been scoped out of the EIA.
Accidental release of pollutants	The risk and impact of accidental releases of hazardous substances will be reduced through the implementation of the Environmental Management Plan, including measures for compliance with the International Convention for the Prevention of Pollution from Ships (MARPOL) convention, as well as best practice for works in the marine environment (e.g. preparation of Shipboard Oil Pollution Emergency Plans (SOPEP)). In this manner, accidental release of potential contaminants from construction vessels will be strictly controlled and procedures will be in place to minimise the impact of any accidental release if it occurs, and hence the impact has been scoped out of the EIA.
Operation and maintenance	
Ghost fishing due to lost fishing gear becoming entangled in installed infrastructure*	Floating technology no longer forms part of the Project Design Envelope. The potential for fishing gear to become entangled with offshore Project infrastructure is considered to be lower for fixed-bottom Wind Turbine Generators (WTGs) as there are no mooring lines or suspended cables within the water column. As a result, the potential for ghost fishing from the offshore Project is low, and this impact has been scoped out of the EIA.
Underwater noise*	The evidence base suggests that the level of operational noise is significantly less than construction noise and detectable only at short ranges from each WTG. Given an individual would need to approach the WTG to experience operational noise, this is not considered a pathway for injury or significant disturbance impacts due to underwater noise. Therefore, noise impacts during operation are expected to be negligible, and hence the impact has been scoped out of the EIA. Please note that the potential for underwater noise to result in a barrier effect for diadromous fish is assessed in the assessment of "barrier effects to diadromous fish" in section 11.6.
Accidental release of pollutants	As described for construction and decommissioning, accidental release of potential contaminants from construction vessels will be strictly controlled and procedures will be in place to minimum the impact of any accidental release if it occurs.

**** These impacts were originally scoped in. However, since the submission of the Scoping report, floating infrastructure has been removed from the offshore Project design and therefore these impacts have now been scoped out.***

11.5.3 Assessment methodology

An assessment of potential impacts is provided separately for the construction, operation and maintenance, and decommissioning stages.

The assessment for fish and shellfish ecology is undertaken following the principles set out in chapter 7: EIA methodology. The sensitivity of the receptor is combined with the magnitude to determine the impact significance. Topic-specific sensitivity and magnitude criteria are assigned based on professional judgement, as described in Table 11-14 and Table 11-15.

Table 11-14 Sensitivity criteria for fish and shellfish ecology

SENSITIVITY OF RECEPTOR	DEFINITION
High	• Receptor with no capacity to accommodate a particular effect and no ability to recover or adapt (i.e. high vulnerability); and • Receptor of conservation value to an extent that is internationally or nationally important (e.g. species on the OSPAR list of threatened and declining species and habitats, IUCN Red List of Threatened Species ('Red List') (near threatened, vulnerable, endangered or critically endangered), PMF species, species listed on Annex II of the Habitats Directive and / or a qualifying interest of a SAC or NCMPA).
Medium	• Receptor with low capacity to accommodate a particular effect with low ability to recover or adapt (i.e. medium vulnerability); and/or • Receptor of conservation or commercial value to an extent that is regionally important.
Low	• Receptor has some tolerance to accommodate a particular effect or will be able to recover or adapt (i.e. low vulnerability); and/or • Receptor of conservation / commercial value to an extent that is locally important.
Negligible	• Receptor is generally tolerant and can accommodate a particular effect without the need to recover or adapt (i.e. not vulnerable); and/or • Receptor is widespread / common and is of low conservation / commercial value.

Table 11-15 Magnitude criteria for fish and shellfish ecology

MAGNITUDE CRITERIA	DEFINITION
High	• Total change or major alteration to key elements / features of the baseline conditions;

MAGNITUDE CRITERIA	DEFINITION
	• Impact occurs over a large scale or spatial geographical extent and/or is long-term or permanent in nature; and/or • High frequency (occurring repeatedly or continuously for a long period of time) and/or at high intensity.
Medium	• Partial change or alteration to one or more key elements / features of the baseline conditions; • Impact occurs over a medium scale/spatial extent and/or has a medium-term duration; and/or • Medium to high frequency (occurring repeatedly or continuously for a moderate length of time) and/or at moderate intensity or occurring occasionally/intermittently for short periods of time but at a moderate to high intensity.
Low	• Minor shift away from the baseline conditions; • Impact occurs over a local to medium scale/spatial extent and/or has a short to medium-term duration; and/or • Impact is unlikely to occur or at a low frequency (occurring occasionally / intermittently for short periods of time at a low intensity).
Negligible	• Very slight change from baseline conditions; • Impact is highly localised and short term with full rapid recovery expected to result in very slight or imperceptible changes to baseline conditions or receptor population; and/or • The impact is very unlikely to occur and if it does will occur at very low frequency or intensity.

The consequence and significance of effect is then determined using the matrix provided in chapter 7: EIA methodology.

11.5.4 Embedded mitigation

As described in chapter 7: EIA methodology, certain measures have been adopted as part of the Project development process in order to reduce the potential for impacts to the environment, as presented in Table 11-16. These have been accounted for in the assessment presented below. The requirement for additional mitigation measures (secondary mitigation) will be dependent on the significance of the effects on fish and shellfish ecology receptors.

Table 11-16 Embedded mitigation measures relevant to fish and shellfish ecology

MITIGATION MEASURE	FORM (PRIMARY OR TERTIARY)	DESCRIPTION	HOW MITIGATION WILL BE SECURED
Cable protection	Primary	Suitable implementation and monitoring of cable protection (via burial or external protection). Cables will be buried as the first choice of protection. External cable protection will be used where adequate burial cannot be achieved and this will be minimised as far as is practicable. This will be informed by a Cable Burial Risk Assessment (CBRA), undertaken post-consent following results of the geotechnical survey. Burial or protection of cables increases the distances between cables and fish and shellfish ecology receptors, reducing EMF effects.	Final cable design will be informed by the CBRA and detailed within the Cable Plan (CaP), required under Section 36 Consent and/or Marine Licence conditions.
Landfall installation methodology	Primary	Landfall installation methodology (HDD) will avoid directly impacting the tidal reaches of the River Forss Water (i.e. between MHWS and MLWS) to protect salmonid river entry.	Landfall installation methodology will be detailed within the Construction Method Statement (CMS), required under Section 36 Consent and/or Marine Licence conditions.
Presence of Environmental Clerk of Works (ECoW) during Horizontal Directional Drilling (HDD) works at the landfall	Tertiary	Ensure appropriately qualified ECoW presence during HDD works at the landfall.	The production and approval of an Environmental Management Plan (EMP), which will include the roles and responsibilities of the ECoW, will be required under Section 36 Consent and/or Marine Licence conditions. An outline EMP is provided as part of the offshore application in OP1: Outline Environmental Management Plan.

MITIGATION MEASURE	FORM (PRIMARY OR TERTIARY)	DESCRIPTION	HOW MITIGATION WILL BE SECURED
Piling Strategy (PS)	Tertiary	Development and adherence to a PS which delineates the requirement for and nature of noise mitigation measures (documented in the MMMP[9]) that will be implemented during piling activities (e.g. soft-start and ramp-up procedures) to reduce potential underwater noise effects during construction.	The production and approval of the PS and MMMP will be required under Section 36 Consent and/or Marine Licence conditions. An outline MMMP is provided as part of the offshore application in OP2: Outline Marine Mammal Mitigation Protocol.
Detonation of Unexploded Ordnance (UXO) using low order techniques	Primary	Low order techniques for UXO detonation will be utilised wherever practicable to reduce underwater noise effects.	The production and approval of the PS and MMMP will be required under Section 36 Consent and/or Marine Licence conditions. An outline MMMP is provided as part of the offshore application in OP2: Outline Marine Mammal Mitigation Protocol.
Environmental Management Plan (EMP)	Tertiary	The development of, and adherence to, an EMP covering pollution prevention, biosecurity and waste management. A Marine Pollution Contingency Plan (MPCP) and Invasive Non Native Species (INNS) management plan will be included within the EMP.	The production and approval of an EMP, including the MPCP and INNS management plan, will be required under Section 36 Consent and/or Marine Licence conditions. An outline EMP is provided as part of the offshore application in OP1: Outline Environmental Management Plan.

[9] *Although the Marine Mammal Mitigation Protocol (MMMP) is primarily aimed at mitigating noise impacts on marine mammals the same mitigations are also relevant for fish and shellfish ecology.*

MITIGATION MEASURE	FORM (PRIMARY OR TERTIARY)	DESCRIPTION	HOW MITIGATION WILL BE SECURED
Decommissioning Programme	Tertiary	The development of, and adherence to, a Decommissioning Programme approved by Scottish Ministers prior to construction and updated throughout the Project lifespan.	The production and approval of a Decommissioning Programme will be required under Section 105 of the Energy Act 2004 (as amended).

11.5.5 Worst case scenario

As detailed in chapter 7: EIA methodology, this assessment considers the worst case scenario for the offshore Project parameters which are predicted to result in the greatest environmental impact, known as the 'worst case scenario'. The worst case scenario represents, for any given receptor and potential impact, the design option (or combination of options) that would result in the greatest potential for change.

Given that the worst case scenario is based on the design option (or combination of options) that represents the greatest potential for change, the development of any alternative options within the design parameters will give rise to no worse effects than those assessed in this impact assessment. Table 11-17 presents the worst case scenario for potential impacts on fish and shellfish ecology during construction, operation and maintenance, and decommissioning.

Table 11-17 Worst case scenario specific to fish and shellfish ecology receptor impact assessment

POTENTIAL IMPACT	WORST CASE SCENARIO	JUSTIFICATION
Construction		
Temporary habitat disturbance or loss	Up to 69.1 km^2 of temporary habitat disturbance and loss associated with: • Seabed preparation: – UXO clearance requiring detonation of up to 22 targets over 22 days; – Disturbance over 30.4 km^2 from boulder clearance across the offshore Project, including for the WTG and Offshore Substation Platforms (OSPs), and along the full length of all cables (at a width of 30 m per cable) (this area will also encompass the disturbance from pre-lay grapnel run along the entire length of all cables at a width of 2 m per cable); and – Maximum bedform clearance[10] along the inter-array and interconnector cables at a width of 150 m (inter-array cables = 3.4 km^2, interconnector cables = 2.9 km^2), and bedform clearance along the offshore export cables at a width of 1,000 m (area = 19.2 km^2); and – Maximum bedform clearance required for WTG and OSP suction bucket foundation installation over 0.22 km^2. • Offshore export cables: – Seabed disturbance associated with installation of up to five offshore export cable circuits with a total length of 320 km and a worst case seabed disturbance width of 50 m = 16 km^2;	Largest spatial area and duration of habitat disturbance and loss during construction. The total area of habitat disturbance or loss for the cables has been calculated based on the 50 m widths of seabed disturbance associated with cable burial / installation in addition to areas of bedform clearance. Any seabed disturbance associated with the boulder clearance and pre-lay grapnel run would be located within these areas. It has been assumed that up to two jack-up events will be required per WTG and per OSP. Anchoring vessel disturbance assumes a six-point mooring system with 3 m^2 anchors deployed every 500 m of cable.

[10] *Bedforms include sandwave bedforms, bedform fields comprising of sand and gravel, megaripples and rippled scour depressions which are present in different areas across the offshore Project area (see chapter 8: Marine physical and coastal processes for further information).*

POTENTIAL IMPACT	WORST CASE SCENARIO	JUSTIFICATION
	• Inter-array cables: – Seabed disturbance associated with installation of a total length of 500 km and a worst case seabed disturbance width of 50 m = 25 km^2; • Interconnector cables: – Seabed disturbance associated with installation of up to six interconnector cables with a total length of 150 km and a worst case seabed disturbance width of 50 m = 7.5 km^2; • Landfall: – Maximum of six HDD exit pits (five plus one spare) each of an area of 300 m^2 (totalling 1,800 m^2), at a water depth of approximately 10 - 40 m below Lowest Astronomical Tide (LAT) (approximately at a minimum of 100 m offshore from 0 mLAT). • Jack-up vessels on site at for 125 WTGs and five OSPs, each with a seabed footprint of 270 m^2 x 6 jack-up legs = 0.42 km^2; • Anchoring vessel seabed disturbance = 0.03 km^2; • Maximum seabed footprint for ancillary equipment, including mooring systems for Heavy Lift Vessels (HLVs) = 0.00003 km^2; and • Intermittent disturbance over the four year construction period, (with an additional year of seabed preparation activities such as UXO clearance and boulder clearance), lasting approximately 40 months.	
Underwater noise	• WTG impact piling: – Spatial worst case scenario: piling of up to 125 WTGs with monopiles foundations at a maximum of one pile per day and up to 16 hours of piling per day (125 piling days), at 5,000 kJ hammer energy); – Temporal worst case scenario: piling of up to 125 WTGs with piled jacket foundations (500 piles) at a maximum of two piles per day and up to 8 hours of piling per day (250 piling days), at 3,000 kJ hammer energy;	Monopile WTG foundations will require the maximum hammer energy of 5,000 kJ and this represents the worst case in terms of the spatial extent of any underwater noise. The installation of jacket foundations may involve more piles being installed over a longer time, however, the maximum hammer energy is lower than what is required for monopile WTG foundations.

POTENTIAL IMPACT	WORST CASE SCENARIO	JUSTIFICATION
	– Intermittent piling over a six-month piling window each year in a three year period (83.5 piling days per year); • OSP impact piling: – Spatial worst case scenario: piling of up to five OSP pin-pile jacket foundations (total of 80 piles) with a maximum of four piles per day and up to 16 hours of piling per day (20 piling days), at 3,000 kJ hammer energy); and – Temporal worst case scenario: piling of up to five OSP pin-pile jacket foundations (total of 80 piles) with a maximum of two piles per day and up to 8 hours of piling per day (40 piling days), at 3,000 kJ hammer energy); – Intermittent piling over a six-month piling window each year in a three year period (13.5 piling days per year); • Concurrent piling: – Two concurrent piling locations with up to two piles installed in a 24-hour period at each location. • UXO clearance: – Detonation of up to 22 UXO; – High-order clearance of a maximum charge of 247 kg + 5 kg donor charge; and – 1 detonation per day using high-order clearance over 22 days. • HDD landfall installation works.	Therefore, the installation of jacket foundations at two piles per day represents the longest duration of piling activities (i.e. the temporal worst case scenario). In terms of injury ranges, the spatial worst case scenario for OSP foundations is a maximum hammer energy of 3,000 kJ and a maximum of four piles per day. The temporal worst case scenario is up to two piles installed per day.
Indirect effects related to changes in availability or distribution of prey species	The worst case scenarios for fish and shellfish ecology are considered to represent the worst case scenario for prey related impacts associated with changes in availability or distribution of other prey species. The worst case scenario for benthic and intertidal habitats is presented in chapter 10: Benthic subtidal and intertidal ecology.	

POTENTIAL IMPACT	WORST CASE SCENARIO	JUSTIFICATION
Operation and maintenance		
Long-term habitat loss and disturbance	Up to 7.34 km^2 of long-term habitat loss associated with: • WTGs: – Up to 125 WTGs using suction-bucket foundations = 1.25 km^2; • OSPs: – Up to five OSPs with suction-bucket foundations = 0.107 km^2; • Inter-array cables: – Up to 140 inter-array cables, with a maximum cable protection footprint of 2 km^2; • Interconnector cables: – Up to six interconnector cables with a maximum cable protection footprint of 1.98 km^2; • Offshore export cables: – Up to five offshore export cable circuits with a maximum cable protection footprint of 1.87 km^2. • Up to 10 total cable crossings across the offshore Project area with five within the offshore ECC (including with the consented Scottish Hydro Electric Transmission Limited (SHET-L) Caithness to Orkney High Voltage Alternating Current (HVAC) Link) and an additional five with the inter-array and interconnector cables. A total area of 0.125 km^2, protected by concrete mattresses, rock placement, grout / cement bags or a Cable Protection System (CPS). • Maximum seabed footprint for ancillary equipment, including mooring systems and monitoring equipment (e.g. wave buoy) = 0.00037 km^2; • Temporary disturbance associated with replacement or repair of major components or cable replacement and reburial; and	Largest spatial area and duration of habitat disturbance and loss during construction. Conservative assumptions have been made to estimate the scour protection and cable protection requirements for the offshore Project, as detailed in chapter 5: Project description.

POTENTIAL IMPACT	WORST CASE SCENARIO	JUSTIFICATION
	• Operational life of 30 years.	
EMF effects	• Inter-array cables: – HVAC cables (up to 145 kV) with a maximum length of 500 km; – Minimum target burial depth of 1 m; and – Up to 20% (100 km) of the inter-array cables will require cable protection at a height of 3 m (2 km^2). • Interconnector cables: – Up to six interconnector HVAC cables (up to 420 kV) with a maximum length of 150 km; – Minimum target burial depth of 1 m; and – Up to 66% (99 km) of the interconnector cables will require cable protection at a height of 3 m (1.98 km^2). • Offshore export cables: – Up to five offshore export HVAC cables (up to 420 kV) with a maximum length of 320 km; – Minimum target burial depth of 1 m; and – Up to 29% (96 km) of the offshore export cable routes to require cable protection with a height of 3 m (1.87 km^2). • Up to 10 total cable crossings across the offshore Project area with five within the offshore ECC (including with the consented SHET-L Caithness to Orkney HVAC Link) and an additional five with the inter-array and interconnector cables. Cable protection at a height of 4 m, with a total area of 0.125 km^2; and • Operational life of 30 years.	The maximum length of inter-array, interconnector cables and offshore export cables will result in the greatest potential for EMF effects. The minimum target burial depth represents the worst case scenario as EMF exposure will be minimised by greater burial depths.
Potential fish or predator aggregation	Up to 7.34 km^2 of long-term habitat creation associated with: • WTGS:	The maximum area of scour protection and cable protection has the greatest potential to

POTENTIAL IMPACT	WORST CASE SCENARIO	JUSTIFICATION
	– Up to 125 WTGs using suction-bucket foundations (including scour protection) = 1.25 km^2; • OSPs: – Up to five OSPs with suction-bucket foundations (including scour protection) = 0.107 km^2; • Inter-array cables: – A maximum cable protection footprint of 2 km^2; • Interconnector cables: – Up to six interconnector cables with a maximum cable protection footprint of 1.98 km^2; • Offshore export cables: – Up to five offshore export cable circuits with a maximum cable protection footprint of 1.87 km^2; and • Maximum seabed footprint for ancillary equipment, including mooring systems and monitoring equipment (e.g. wave buoy) = 0.00037 km^2; and • Up to 10 total cable crossings across the offshore Project area with five within the offshore ECC (including with the consented SHET-L Caithness to Orkney HVAC Link) and an additional five with the inter-array and interconnector cables, with a total area of 0.125 km^2.	result in artificial reef or fish / predator aggregation.
Barrier effects to diadromous fish	• Up to 125 WTGs built out across the OAA; • Up to five OSPs built out across the OAA; • Minimum spacing of 944 m; and • Worst case scenario for EMF (as described above).	The maximum number of WTGs and OSPs built out across the OAA is considered to represent the greatest spatial extent of any barrier effect to diadromous fish during the operation and maintenance stage. The justification for the worst case scenario for EMF is described above for EMF effects.

POTENTIAL IMPACT	WORST CASE SCENARIO	JUSTIFICATION
Indirect effects related to changes in availability or distribution of prey species	The worst case scenarios for fish and shellfish ecology are considered to represent the worst case scenario for prey related impacts associated with changes in availability or distribution of other prey species. The worst case scenario for benthic and intertidal habitats is presented in chapter 10: Benthic subtidal and intertidal ecology.	
Decommissioning		
In the absence of detailed information regarding decommissioning works, the implications for fish and shellfish ecology are considered analogous to or likely less than those of the construction stage. Therefore, the worst case parameters defined for the construction stage also apply to decommissioning. The decommissioning approach is set out in chapter 5: Project description.		

11.6 Assessment of potential effects

11.6.1 Potential effects during construction (including pre-construction)

11.6.1.1 Temporary habitat disturbance or loss

During the construction stage, temporary habitat loss or disturbance may occur as a result of seabed preparation activities (e.g. bedform clearance, boulder clearance and pre-lay grapnel runs), foundation installation (e.g. jack-up vessel placement) and cable installation activities (e.g. trenching, laying, burial and protection). Temporary habitat disturbance or loss may affect individuals directly through injury or physical harm and also indirectly through the disturbance or loss of nursery and spawning habitats.

As described in section 11.5.5, up to 69.1 km^2 of temporary habitat loss and disturbance may occur during the construction stage, intermittently over a period of four years (with an additional one year of pre-construction activities e.g., UXO and boulder clearance). As the construction activities will occur intermittently, only a small area of seabed is expected to be disturbed at any one time.

11.6.1.1.1 Marine finfish

The marine finfish most vulnerable to any temporary habitat loss or disturbance include those that spawn on or near the seabed with a demersal egg phase, including sandeel and herring. Adult and juvenile sandeel are also potentially vulnerable to this impact, as they remain relatively immobile in burrows for the majority of their lives, including during a winter hibernation period. Given their increased vulnerability compared to other marine finfish species, the effects of temporary habitat loss and disturbance during construction on sandeel and herring have been assessed separately below.

Sandeel

The offshore Project area overlaps with low intensity spawning grounds for sandeel, and analysis of the PSA data indicates that there are likely to be areas of preferred sandeel spawning habitat within the OAA and offshore ECC, with 20 of the 66 grab samples assigned as prime spawning habitat.

The Scottish Government Feature Activity Sensitivity Tool (FeAST) tool categorises sandeel as having a high sensitivity to sub-surface abrasion or penetration and a medium sensitivity to surface abrasion (Scottish Government, 2023a). Sandeel spawning habitats are spatially limited, and this in combination with their demersal egg phase, make sandeel vulnerable to temporary disturbance or loss of spawning habitat. Adult and juvenile sandeel are also potentially vulnerable to habitat loss or disturbance that could reduce the availability of sandeel burrowing habitat or directly impact immobile sandeel in burrows during their over-wintering period. As individuals show a high degree of site fidelity once settled, populations are susceptible to local impacts (Jensen *et al.*, 2011). However, pre- and post-construction monitoring of sandeel at the Beatrice Offshore Wind Farm and Horns Rev indicate that sandeel populations are able to recover following cessation of construction activities (BOWL, 2021; Jensen *et al.*, 2004).

Sandeel are deemed to have a high vulnerability to habitat loss and disturbance and are a nationally important receptor, on account of this species being a PMF and protected within the North-West Orkney NCMPA. Therefore, sandeel are assessed to have a high sensitivity.

Sandeel preferred habitats and spawning grounds are widely distributed across Scottish and English waters and therefore temporary habitat loss and disturbance will only affect a small proportion of the habitat available for this species. The temporary habitat loss and disturbance will be highly localised and intermittent for a period of 40 months throughout the four-year construction stage (and additional one year for pre-construction activities). Furthermore, only a small proportion of habitat would be disturbed at any one time (69.1 km^2, which represents 8.8% of the offshore Project area). A degree of recovery would be expected following any disturbance, with sandeel recolonising the area (e.g. larvae settling from adjacent spawning grounds). No direct impacts on the sandeel present in the North-West Orkney NCMPA is expected as this NCMPA is approximately 11 km from the offshore Project area. It is possible that adults or juveniles disturbed during construction could recolonise areas in this NCMPA. However, it would be expected that a degree of spatial mixing between these two areas would already occur, as this has been recorded out to 28 km (Jensen *et al.*, 2011). Overall, the impact is considered to be of a local spatial extent, temporary and of a low frequency (intermittent over the four-year construction period and additional one year of pre-construction activities), and the impact is defined as being of low magnitude.

Evaluation of significance

Taking the high sensitivity of sandeel and the low magnitude of impact, the overall effect of temporary habitat loss and disturbance during construction is considered to be minor and not significant in EIA terms.

Sensitivity	Magnitude of impact	Consequence
High	Low	Minor

Impact significance - NOT SIGNIFICANT

Herring

The offshore Project area also overlaps with low intensity spawning areas for herring. However, analysis of the PSA data indicates that only a small portion of the offshore Project area represents preferred herring spawning habitat with only 12 of the 66 grab samples being assigned as prime herring spawning habitat.

Similar to sandeel, herring have specific sediment requirements for spawning and a demersal egg phase, making this species potentially vulnerable to habitat loss and disturbance. As adults, herring are more mobile than sandeel and are able to avoid direct disturbance impacts.

As a PMF species, herring are considered to be a nationally important receptor and are considered to have a medium vulnerability to habitat loss and disturbance. Therefore, herring are assessed as having a medium sensitivity.

Based on the available evidence outlined in section 11.4, spawning by herring in the offshore Project area is expected to occur at low levels, with more important areas located elsewhere in Scottish waters and the wider North Sea. Therefore, any temporary (40 months), localised (69.1 km^2) and intermittent habitat loss and disturbance from the offshore Project during the four-year construction stage (and additional one year of pre-construction activities) is unlikely to affect the long term functioning of spawning herring populations. This is in the context of the relatively low importance of the offshore Project area for spawning by this species. Overall, the impact is considered to be of a local spatial extent, temporary and of a low frequency, and the impact is defined as being of low magnitude.

Evaluation of significance

Taking the medium sensitivity of herring and low magnitude of impact, the overall effect of temporary habitat loss and disturbance during construction is considered to be minor and not significant in EIA terms.

Sensitivity	Magnitude of impact	Consequence
Medium	Low	Minor
Impact significance - NOT SIGNIFICANT		

All other marine finfish

Many other fish are predicted to utilise the fish and shellfish ecology offshore study area, including demersal marine finfish that are in close contact with the seabed. However, any temporary habitat disturbance or loss is unlikely to affect the long term functioning of these species, as the majority of other marine finfish are mobile species and able to avoid injury or physical harm associated with temporary habitat disturbance or loss. These species also spawn into the pelagic environment with a wide availability of spawning grounds.

Other marine finfish (excluding sandeel and herring) are considered to be of regional to national importance and their vulnerability is deemed to be low. Therefore, other marine finfish species (excluding sandeel and herring) are assessed to have a low sensitivity. Any temporary habitat loss and disturbance will occur across 69.1 km^2 over a total of 40 months intermittently throughout the four-year construction period (and additional one year of pre-construction activities). Based on the local spatial extent, temporary, and low frequency nature of this impact, it is defined as being of low magnitude.

Evaluation of significance

Taking the low sensitivity of all other marine fish and low magnitude of impact, the overall effect of temporary habitat loss and disturbance during construction is considered to be negligible and not significant in EIA terms.

Sensitivity	Magnitude of impact	Consequence
Low	Low	Negligible
Impact significance – NOT SIGNIFICANT		

11.6.1.1.2 Shellfish

There are no boundaries for shellfish spawning and nursery grounds in the data from Coull *et al.* (1998) and Ellis *et al*. (2012), with the exception of *Nephrops norvegicus* (which do not overlap with the offshore Project area). However, shellfish have a more limited mobility when compared with fish and are potentially vulnerable to habitat loss and disturbance during the construction stage. As described in section 11.4, according to the landing statistics for the fish and shellfish ecology offshore study area, the key species for the offshore Project are brown crab and scallops, and to a lesser extent whelks and lobsters.

Depending on the life-cycle stage, some shellfish show a degree of mobility (e.g. scallop jet propulsion), whereas others are predominantly immobile (e.g. 'berried' female crabs and lobsters). Immobile shellfish may be vulnerable to physical abrasion of the seabed. 'Berried' female crabs and lobsters carry their eggs under their abdomen and are often found buried under sediment. During this time when they are relatively immobile, any disturbance could result in the damage to these females and/or their egg masses (Neal and Wilson, 2008). Furthermore, female brown crab undertake extensive migrations westwards from Orkney, potentially to breeding grounds on north-west Scotland (Coleman and Rodrigues, 2017). Any habitat loss or disturbance that is slow to recover could affect these migrations. However, a degree of recovery would be expected over time following the cessation of construction activities.

Shellfish are judged to be regionally important, as they are not protected but are of commercial importance in the region, and of moderate vulnerability, due to their low mobility. Therefore, shellfish are assessed as being of medium sensitivity.

Any habitat loss or disturbance during the construction stage will be short-term (40 months) and localised in nature (69.1 km^2), representing a small proportion of the available habitat in the area. Moreover, individuals are expected to recolonise the area as the seabed recovers and only a small proportion of available habitat would be disturbed at any one time. For instance, evidence from the Westermost Rough offshore wind farm showed that temporary fishing restrictions during construction provided respite for European lobster and resulted in increased abundance and size of lobster (Roach *et al*., 2018). Overall, it is expected that some disturbance to individuals may occur, but this is unlikely to affect the long term functioning of the shellfish populations, including for migrating brown crab. Therefore, the impact is considered to be of a local spatial extent, temporary and of a low frequency, and the impact is defined as being of low magnitude.

Evaluation of significance

Taking the medium sensitivity of shellfish and low magnitude of impact, the overall effect of temporary habitat loss and disturbance during construction is considered to be minor and not significant in EIA terms.

Sensitivity	Magnitude of impact	Consequence
Medium	Low	Minor

Impact significance – NOT SIGNIFICANT

11.6.1.1.3 Elasmobranchs

Spawning grounds for elasmobranchs were not established by Coull *et al.* (1998) and Ellis *et al.* (2012) due to a lack of data on egg laying grounds. However, nursery grounds for common skate, spotted ray, thornback ray, spurdog and tope shark overlap with the offshore Project area and a comparison of flapper skate egg laying preferences and the site-specific survey data indicate that there are localised areas of potential egg laying habitat for this species in the OAA and offshore ECC.

Flapper skate, blue skate, spotted ray, thornback ray and spurdog all lay egg cases that are deposited on the seabed and are therefore vulnerable to seabed disturbance as a result of seabed abrasion. The Scottish Government FeAST tool categorises common skate (prior to the recognition of flapper skate and blue skate as two separate species) as having a medium sensitivity to surface abrasion due to the potential disturbance to egg cases (Scottish Government, 2023a).

Flapper skate are critically endangered and extinct over large extents of their natural range. Therefore, this species is of conservation value to an extent that is internationally important. This species has a medium vulnerability to habitat loss and disturbance. Considering this, combined with the fact that the offshore Project area is considered to be an important area for flapper skate egg laying and this species is slow to mature (Régnier *et al.*, 2021), flapper skate are assessed to have a high sensitivity. Spotted ray, thornback ray and spurdog are nationally to internationally important receptors with a medium vulnerability, but are considered to be relatively widespread in Scottish waters. Blue skate are only expected to be present at the offshore Project area at low numbers as this species is predominantly distributed in the south of England. Therefore, these species are assessed as having a medium sensitivity. All other elasmobranchs are assessed to have a negligible sensitivity.

Any disturbance will be temporary, intermittent and highly localised, and once the construction activities occur, a degree of recovery would be expected. There is a preference for flapper skate egg laying habitat in areas with boulders or rocky substrates (11.4.4.2.1). It is possible that boulder clearance could result in the temporary loss or disturbance of flapper skate egg laying habitat over a localised area. However, the intention is to avoid boulders wherever possible through micro-siting, reducing any potential impact on flapper skate egg laying habitat. Where it is not possible to avoid boulders, boulders will likely only be moved a short distance and a recovery of the habitat would be expected, meaning that there would be no long-term habitat loss. Furthermore, only localised areas of the OAA and offshore Project area are expected to represent flapper skate egg laying habitat, and therefore only a small proportion of egg laying habitat would be disturbed at any one time. Temporary disturbance and habitat loss may occur over an area of 69.1 km^2, over 40 months of the four-year construction period (and additional one year of pre-construction activities). Overall, the impact is considered to be of a local spatial extent, temporary and of a low frequency, and the impact is defined as being of low magnitude.

Evaluation of significance

Taking the high sensitivity of flapper skate and the low magnitude of impact, the overall effect of temporary habitat loss and disturbance during construction is considered to be minor and not significant in EIA terms.

Taking the medium sensitivity of spotted ray, thornback ray, spurdog and blue skate, and the low magnitude of impact, the overall effect of temporary habitat loss and disturbance during construction is considered to be minor and not significant in EIA terms.

Taking the negligible sensitivity of all other elasmobranchs and the low magnitude of impact, the overall effect of temporary habitat loss and disturbance during construction is considered to be negligible and not significant in EIA terms.

Species	Sensitivity	Magnitude of impact	Consequence
Flapper skate	High	Low	Minor
Spotted ray, thornback ray, spurdog and blue skate	Medium	Low	Minor
All other elasmobranchs	Negligible	Low	Negligible
Impact significance - NOT SIGNIFICANT			

11.6.1.1.4 Diadromous fish

There is the potential for diadromous fish to utilise the habitats that could be disturbed during the construction stage of the offshore Project for feeding or to pass through the offshore Project area during migrations to and from Scottish rivers, including the Forss Water which is adjacent to Crosskirk landfall option. However, as diadromous fish do not rely on specific seabed habitats and are highly mobile, temporary habitat disturbance is not likely to affect this species.

Diadromous fish are a highly protected species and are considered to be internationally important. However, the vulnerability of diadromous fish to habitat loss and disturbance in the marine environment is negligible, and overall, diadromous fish are assessed to have a low sensitivity.

Any disturbance during the construction stage will be temporary, over 40 months of the four-year construction period (and additional one year of pre-construction activities), and highly localised (69.1 km^2) and is therefore unlikely to result in any adverse effects on diadromous fish populations. Overall, the impact is considered to be of a local spatial extent, temporary and of a low frequency, and the impact is defined as being of low magnitude. Please note that any indirect effects of habitat loss and disturbance on the prey species of diadromous fish is assessed in section 11.6.1.3.

Evaluation of significance

Taking the low sensitivity of diadromous fish and the low magnitude of impact, the overall effect of temporary habitat loss and disturbance during construction is considered to be **negligible** and **not significant** in EIA terms.

Sensitivity	Magnitude of impact	Consequence
Low	Low	Negligible
Impact significance - NOT SIGNIFICANT		

11.6.1.2 Underwater noise

An increase in noise can have mortality, physical injury or behavioural effects on fish and shellfish receptors. Behavioural effects (e.g. displacement or avoidance) may impact acoustic communication in fish, reproductive success, foraging, predator avoidance and navigation (Radford *et al.*, 2014; De Jong *et al.*, 2020; Hawkins and Myrberg, 1983).

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

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

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

- Group 1: Flatfish, shark, skates and rays lack swim bladders that are sensitive to particle motion and therefore only show sensitivity to a narrow band of frequencies;
- Group 2: Fishes with swim bladders that do not appear to play a role in hearing. Therefore, they are only sensitive to particle motion and only show sensitivity to a narrow band of frequencies;
- Group 3: Fishes with swim bladders that are connected to the ear but not intimately connected. These species are sensitive to both particle motion and sound pressure extending up to around 500 Hertz (Hz); and

- Group 4: Herring species have structures mechanically linking the swim bladder to their ear. Therefore, they are sensitive primarily to sound pressure, but they can also detect particle motion. Their frequency range is much wider, extending to several kHz and they generally show higher sensitivity to sound pressure than the other groups.

No threshold criteria are available for shellfish.

Popper *et al.* (2014) provide sound pressure-based threshold assessment criteria for mortal injury, recoverable injury and Temporary Threshold Shift[11] (TTS), masking and behavioural effects from impact piling and explosions, and these criteria are provided in the underwater noise assessment (see SS11: Underwater noise modelling report). Where insufficient data exist to determine a quantitative guideline value, the risk is categorised in relative terms as "high", "moderate" or "low" at three distances from the source: "near" (i.e. in the tens of metres), "intermediate" (i.e. in the hundreds of metres) or "far" (i.e. in the thousands of metres). It should be noted that these qualitative criteria cannot differentiate between exposures to different levels of sound and therefore all sources of sound, independent of source level, would theoretically elicit the same assessment result. No criteria currently exist for assessing impact ranges associated with changes in particle motion. Therefore, the criteria set out by Popper *et al.* (2014) remain the best available for use in assessing underwater noise impacts on fish.

11.6.1.2.1 Impact piling

Underwater noise modelling has been undertaken to determine the extent of underwater sound propagation from impact piling of the WTGs and OSPs from three representative locations at the north-west (NW), south-east (SE) and south-west (SW) extremities of the OAA (see SS11: Underwater noise modelling report).

The INSPIRE underwater noise model (version 5.1) was used for all impact piling modelling (i.e. impulsive noise source), which uses numerical modelling and measured source-level data to calculate noise propagation in shallow (less than 100 m), mixed water (typical of that around the offshore Project, and the UK in general). This model has been developed using over 80 data sources of underwater noise propagation from piling activities. To ensure results are specific to the offshore Project, other project-specific inputs such as hammer energy, piling duration and swim-speeds of the assessed receptors, have been included (as detailed in SS10: Underwater noise modelling report). Both unweighted Sound Pressure Level peak criteria (SPLpeak) and cumulative Sound Exposure Level (SELcum) criteria have been used to determine the distances at which receptors are likely to experience sound levels above the thresholds for auditory injury. The SPLpeak criteria is a measure of sound energy from a single pulse, whereas SELcum is a metric of the cumulative sound energy an animal is exposed to over a standard time period, with 24-hours being used in these assessments (Popper *et al.*, 2014). Both fleeing animal models (at 1.5 m/s) and stationary animal models have been used to assess the SELcum criteria for fish.

An assessment of the potential injury and behavioural underwater noise effects based on the underwater noise modelling is provided below. As no assessment criteria are available for shellfish, the assessment of potential

[11] *TTS refers to a temporary reduction in hearing sensitivity after a noise exposure (Popper et al., 2014).*

underwater noise effects on shellfish has been based on available literature at the time of writing and is presented in section 11.6.1.2.4.

Injury effects

For the purpose of this assessment, there are three classes of potential injury to individual fish: mortality and potential mortal injury, recoverable injury and TTS. Mortal injuries are severe injuries resulting from a sound source that result in death to an individual. A recoverable injury is a survivable injury where the fish or shellfish receptor will fully recover after the exposure to noise has ended (e.g. hair cell damage). TTS refers to a temporary reduction in hearing sensitivity. Recoverable injury and TTS may result in a temporary decrease in fitness and increase the individual's susceptibility to predation.

The injury ranges based on the Popper *et al*. (2014) criteria and the worst case scenario for the offshore Project are presented in Table 11-18 and Table 11-19. The injury ranges for the spatial worst case scenario have been presented here, representing the design parameters that will result in the greatest injury or disturbance ranges:

- WTG piling: piling of up to 125 WTGs with monopile foundations at a maximum of one pile per day and up to 16 hours of piling per day (125 piling days), at 5,000 kJ hammer energy); and
- OSP piling: piling of up to five OSP pin-pile jacket foundations (total of 80 piles) with a maximum of four piles per day and up to 16 hours of piling per day (20 piling days), at 3,000 kJ hammer energy).

However, consideration should also be made for the temporal worst case scenario that would represent the installation scenarios of the greatest duration (albeit with smaller impact ranges). The temporal worst case scenario is up to 290 piling days for both WTGs and OSPs.

For all groups of fish, piling activities have the potential to cause mortality or potential mortal injury, recoverable injury, and TTS under the spatial worst case scenario. The injury ranges are highest for Group 3 (e.g. cod and whiting) and Group 4 (e.g. herring and sprat) fish for WTG monopile foundations at the SE location in hard sediment, and therefore, only the modelling outputs for this location have been presented in this chapter (see SS11: Underwater noise modelling report for modelling outputs for the other two representative locations). Mortality or potential mortality may occur at a mean range up to 330 m for this group based on SPLpeak. For SELcum, assuming a stationary individual, mortality or potential mortality may occur at a mean range of up to 16 km (760 km^2) for Group 3 and 4 fish, recoverable injury may occur at a mean range of 22 km (1,600 km^2) and TTS may occur at a mean range of 52 km (9,000 km^2). The SELcum mean ranges are substantially reduced assuming fleeing behaviour and are in the range of less than 100 m (0.1 km^2) for mortal and potential mortality injury, less than 3.2 km (32 km^2) for recoverable injury and less than 33 km (3,600 km^2) for TTS. The majority of fish species are likely to move away from sounds that are loud enough to potentially cause harm (Dahl *et al*., 2015; Popper *et al*., 2014). Those that may not move awaY from loud sounds are likely to be benthic dependant species (e.g. sandeel) or species without swim bladders, which are less sensitive to sound compared to those with swim bladders (Goertner *et al*., 1994; Stephenson *et al*., 2010; Halvorsen *et al*., 2012; Popper *et al*., 2014). SS10: Underwater noise modelling outlines the precautionary nature of the underwater noise modelling.

Table 11-18 Popper et al. (2014) mortality and potential mortal injury thresholds and results for impact piling at the SE location (Subacoustech, 2023; SS11: Underwater noise modelling report)

TYPE OF ANIMAL	MORTALITY AND POTENTIAL MORTAL INJURY				
	THRESHOLD	WTG MONOPILES		WTG / OSP PILED JACKET	
		MEAN RANGE (M)	AREA (KM²)	MEAN RANGE (M)	AREA (KM²)
Group 1: Fish with no swim bladder (particle motion detection)	>219 dB SELcum	Fleeing: <100 Stationary: 3,600	Fleeing: <0.1 Stationary: 41	Fleeing: <100 Stationary: 1,700	Fleeing: <0.1 Stationary: 9
	>213 dB SPLpeak	130	0.05	100	0.03
Group 2: Fish with swim bladder not involved in hearing (particle motion detection)	>210 dB SELcum	Fleeing: <100 Stationary: 11,000	Fleeing: <0.1 Stationary: 400	Fleeing: <100 Stationary: 6,100	Fleeing: <0.1 Stationary: 120
	>207 dB SPLpeak	330	0.3	270	0.2
Group 3 and 4: Fish with swim bladder involved in hearing (primarily sound pressure detection)	>207 dB SELcum	Fleeing: <100 Stationary: 16,000	Fleeing: <0.1 Stationary: 760	Fleeing: <100 Stationary: 8,800	Fleeing: <0.1 Stationary: 240
	>207 dB SPLpeak	330	0.3	270	0.2
Eggs and larvae	>210 dB SELcum	Fleeing: <100 Stationary: 11,000	Fleeing: <0.1 Stationary: 400	Fleeing: <100 Stationary: 6,100	Fleeing: <0.1 Stationary: 120
	>207 dB SPLpeak	330	0.3	270	0.2

Table 11-19 Popper et al. (2014) recoverable injury and TTS thresholds and results for impact piling at the SE location (Subacoustech, 2023; SS11: Underwater noise modelling report) (N = near field, I = intermediate field and F = far-field)

TYPE OF ANIMAL	IMPAIRMENT									
	RECOVERABLE INJURY					TTS				
	THRESHOLD	WTG MONOPILES		OSP PILED JACKET		THRESHOLD	WTG MONOPILES		WTG / OSP PILED JACKET	
		MEAN RANGE (M)	AREA (KM^2)	MEAN RANGE (m)	AREA (KM^2)		MEAN RANGE (m)	AREA (KM^2)	MEAN RANGE (M)	AREA (KM^2)
Group 1: Fish with no swim bladder (particle motion detection)	>216 dB SELcum	Fleeing: < 100 m Stationary: 5,400	Fleeing: <0.1 Stationary: 93	Fleeing: <100 Stationary: 2,600	Fleeing: <0.1 Stationary: 22	186 dB SELcum	Fleeing: 33,000 Stationary: 52,000	Fleeing: 3,600 Stationary: 9,000	Fleeing: 29,000 Stationary: 44,000	Fleeing: 2,800 Stationary: 6,100
	>213 dB SPLpeak	130	0.05	100	0.03					
Group 2: Fish with swim bladder not involved in hearing (particle motion detection)	>203 dB SELcum	Fleeing: 3,200 Stationary: 22,000	Fleeing: 32 Stationary: 1,600	Fleeing: 1300 Stationary: 14,000	Fleeing: 5.8 Stationary: 600		Fleeing: 33,000 Stationary: 52,000	Fleeing: 3,600 Stationary: 9,000	Fleeing: 29,000 Stationary: 44,000	Fleeing: 2,800 Stationary: 6,100
	>207 dB SPLpeak	320	0.3	270	0.2					
Group 3 and 4: Fish with swim bladder involved in hearing (primarily sound pressure detection)	>203 dB SELcum	Fleeing: 3200 Stationary: 22,000	Fleeing: 32 Stationary: 1,600	Fleeing: 1,300 Stationary: 14,000	Fleeing: 5.8 Stationary: 600		Fleeing: 33,000 Stationary: 52,000	Fleeing: 3,600 Stationary: 9,000	Fleeing: 29,000 Stationary: 44,000	Fleeing: 2,800 Stationary: 6,100
	>207 dB SPLpeak	320	0.3	270	0.2					
Eggs and larvae			(N) Moderate (I) Low (F) Low					(N) Moderate (I) Low (F) Low		

Sound propagation modelling has also been carried out to understand the potential impacts of concurrent piling of jacket foundations (WTG or OSP) at the SE and SW locations. As described in the underwater noise modelling report (Subacoustech, 2023), concurrent piling operations may increase the SELcum impact ranges. A summary of the mortality and potential mortality, recoverable injury and TTS ranges for piling activities at two locations are shown in Table 11-20. Mortality and potential mortality ranges for fleeing animals remain unchanged as a result of concurrent piling activities for all fish groups. However, when a stationary animal is concerned, the mortality and potential mortality impact area increases to up to 970 km^2 for Group 3 fish, the recoverable injury range to increase up to 2,300 km^2 for Group 2 and Group 3 fish and for the TTS range to increase up to 11,000 km^2 for all groups. These impact areas are reduced by over 50% when a fleeing animal is assumed.

Table 11-20 Popper et al. (2014) recoverable injury and TTS thresholds and results for concurrent impact piling at the SE and SW location (Subacoustech, 2023; SS11: Underwater noise modelling report)

TYPE OF ANIMAL	MORTALITY AND POTENTIAL MORTALITY		RECOVERABLE INJURY		TTS	
	THRESHOLD	AREA (KM^2)	THRESHOLD	AREA (KM^2)	THRESHOLD	AREA (KM^2)
Group 1: Fish with no swim bladder (particle motion detection)	>219 dB SELcum	Fleeing: n/a* Stationary: 44	>216 dB SELcum	Fleeing: n/a* Stationary: 100		Fleeing: 5,400 Stationary: 11,000
Group 2: Fish with swim bladder not involved in hearing (particle motion detection)	>210 dB SELcum	Fleeing: n/a* Stationary: 480	>203 dB SELcum	Fleeing: 430 Stationary: 2,300	186 dB SELcum	Fleeing: 5,400 Stationary: 11,000
Group 3 and 4: Fish with swim bladder involved in hearing (primarily sound pressure detection)	>207 dB SELcum	Fleeing: n/a* Stationary: 970	>203 dB SELcum	Fleeing: 430 Stationary: 2,300		Fleeing: 5,400 Stationary: 11,000
Eggs and larvae	>210 dB SELcum	Fleeing: n/a* Stationary: 480	(N) Moderate (I) Low (F) Low		(N) Moderate (I) Low (F) Low	

* No in-combination effect when piling occurs simultaneously.

Behavioural effects

Fish and shellfish species will have varying reactions and sensitivities to piling noise. This is dependent on how these species perceive sound in the environment. There is potential for these responses to lead to significant effects at an individual level (e.g. reduced fitness, susceptibility to predation) or potentially at a population level (e.g. avoidance or delayed migration to key spawning grounds), depending on the duration and strength of the impact.

As noted above, no quantitative guideline values are available for behavioural effects, and thus, the risk is categorised in relative terms as "high", "moderate" or "low" at three distances from the source: "near" (i.e. in the tens of metres), "intermediate" (i.e. in the hundreds of metres) or "far" (i.e. in the thousands of metres) which are independent of source level. The qualitative guideline values are presented in Table 11-21 and apply to both WTG and OSP impact piling.

As Group 3 and 4 fish are able to detect sound pressure, they are most sensitive to behavioural effects associated with underwater noise and there is a high risk of masking or behavioural effects within hundreds of metres of the sound source.

Table 11-21 Risk of qualitative effects on fish from impact piling (Popper et al., 2014) (N = near-field (i.e. tens of metres), I = Intermediate-field (i.e. hundreds of metres) and F = Far-field (i.e. thousands of metres)

TYPE OF ANIMAL	MASKING	BEHAVIOUR
Group 1: Fish with no swim bladder (particle motion detection)	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low
Group 2: Fish with swim bladder not involved in hearing (particle motion detection)	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low
Group 3 and 4: Fish with swim bladder involved in hearing (primarily sound pressure detection)	(N) High (I) High (F) Moderate	(N) High (I) High (F) Moderate
Eggs and larvae	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low

11.6.1.2.2 UXO clearance

UXO clearance has been identified as a possible noise source with the potential to impact fish and shellfish ecology receptors through the generation of high levels of underwater sound. The detonation of UXOs would result in a short term (seconds) increase in underwater noise (i.e. sound pressure levels and particle motion). Underwater sound levels will be temporarily elevated, and this may result in injury or behavioural effects on fish and shellfish species.

UXO will be avoided wherever possible. However, for the purpose of this assessment of potential worst case impacts, an assessment of noise-related impacts from UXO clearance has been undertaken. Underwater noise modelling was carried out for various UXO clearance methods and charge weights, including the following:

- The worst case scenario of high-order clearance of a 247 kg charge with an additional donor weight of 5.0 kg; and
- Low-order clearance of any charge using a 0.05 kg donor charge to vaporise the explosive material in the UXO.

Injury effects

For all groups of fish species, mortality and potential mortal injury from explosions is expected to occur between 229 – 234 dB, according to the thresholds in Popper *et al.* (2014). This is due to methodologies and data on fish species in relation to explosions being highly varied, and as such, the guidelines provided by Popper *et al.* (2014) for explosions use the lowest amplitude in the literature available that have caused consistent mortality. Due to this, for all groups there is the potential that UXO clearance could result in mortality and potential mortal injury impacts at a radius of between <50 m and 630 m from the source, where high order clearance of a 247 kg + donor charge results in the largest injury range. Therefore, as a cautious worst case for this impact assessment, the 630 m radius has been assumed for all fish species. No SELcum metric is used for UXO clearance as this noise source represents a single pulse.

Table 11-22 Popper et al. (2014) thresholds and results for mortality and potential mortal injury from UXO clearance (see SS11: Underwater noise modelling report)

UXO CLEARANCE METHOD	PARAMETER	IMPACT RANGE (m)
Low order	234 dB SPL peak	< 50
	229 dB SPL peak	< 50
High order (247 kg + donor charge)	234 dB SPL peak	380
	229 dB SPL peak	630

The Popper *et al.* (2014) qualitative guidelines values for risk of recoverable injury and TTS associated with explosions is provided in Table 11-23. There is a high risk of recoverable injury and TTS within near distances from the source (i.e. tens of metres). The risk of recoverable injury reduces to low within intermediate distances from the source (i.e. hundreds of metres) and the risk of TTS reduces to low within far distances from the source (i.e. thousands of metres).

Table 11-23 Risk of recoverable injury and TTS from UXO clearance (see SS11: Underwater noise modelling report) (N = near-field (i.e. tens of metres), I = Intermediate-field (i.e. hundreds of metres) and F = Far-field (i.e. thousands of metres) (Popper et al., 2014)

TYPE OF ANIMAL	RECOVERABLE INJURY	TTS
Group 1: Fish with no swim bladder (particle motion detection)	(N) High (I) Low (F) Low	(N) High (I) Moderate (F) Low
Group 2: Fish with swim bladder not involved in hearing (particle motion detection)	(N) High (I) High (F) Low	(N) High (I) High (F) Low
Group 3 and 4: Fish with swim bladder involved in hearing (primarily sound pressure detection)	(N) High (I) High (F) Low	(N) High (I) High (F) Low
Eggs and larvae	(N) High (I) Low (F) Low	(N) High (I) Low (F) Low

Behavioural effects

The Popper *et al.* (2014) qualitative guidelines values for risk of masking and behaviour associated with explosions is provided in Table 11-24. There is a high risk of masking within near distances from the source for all groups and a high risk of behavioural effects for Group 3 and 4 fish in this range. The risk of masking remains high within intermediate distances and is reduced to moderate within far distances for all groups except eggs and larvae which are less sensitive according to the Popper *et al.* (2014) criteria. The risk of behavioural effects remains as moderate for all groups within intermediate distances from the source and is reduced to low within far distances from the source.

Table 11-24 Risk of masking and behaviour from UXO clearance (Popper et al., 2014) (see SS11: Underwater noise modelling report)

TYPE OF ANIMAL	MASKING	BEHAVIOUR
Group 1: Fish with no swim bladder (particle motion detection)	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Group 2: Fish with swim bladder not involved in hearing (particle motion detection)	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Group 3 and 4: Fish with swim bladder involved in hearing (primarily sound pressure detection)	(N) High (I) High (F) Moderate	(N) High (I) Moderate (F) Low
Eggs and larvae	(N) High (I) Moderate (F) Low	(N) Moderate (I) Moderate (F) Low

11.6.1.2.3 Other noise generating activities

This section focuses on the underwater noise impacts from piling activities of up to 125 WTGs and up to five OSPs, and UXO clearance of up to 22 targets on sensitive fish and shellfish species. If utilised, these activities represent the greatest sound sources during the construction stage. Other installation activities such as cable laying, dredging, trenching, rock placement and vessels also result in underwater sound emissions. Underwater noise modelling, undertaken by Subacoustech, predicted the potential effects of underwater sound produced from these sources (excluding piling and UXO clearance) will be negligible and that sound emissions from these sources fall below the appropriate injury or disturbance criteria for fish and shellfish species within 50 m of the sound source (Subacoustech, 2023).

Underwater sound generated from the HDD works at the landfall could affect diadromous fish migrating to and from the Forss Water, adjacent to the Crosskirk landfall option. As noted in section 11.4.4, the populations of Atlantic salmon in the Forss Water have been in a poor condition over recent years, potentially as a result of mortality during migration. The period of smolt migration is particularly sensitive for salmonids, which occurs between April and May in the Forss Water.

The Subacoustech modelling report predicts the impact ranges from dredging and drilling activities, both of which may be required for the HDD works at the landfall. The Popper *et al.* (2014) thresholds for continuous sound for recoverable injury and TTS are 170 dB and 158 dB, respectively and the modelling predicts impact ranges for HDD drilling works to be less than 50 m for both recoverable injury and TTS. It is important to also note that smolts perform a rapid initial coastal migration (Newton *et al.*, 2021) and would therefore only be within the impact ranges of the HDD works for a very short length of time.

11.6.1.2.4 Assessment of significance

The key fish and shellfish receptors for the offshore Project, as outlined in section 11.4.4, have been grouped based on their hearing capabilities and in accordance with Popper *et al.* (2014) to aid this assessment, as presented in Table 11-25.

An assessment of the potential impact of underwater noise associated with impact piling and UXO clearance is provided below for fish and shellfish ecology receptors. The assessment for fish receptors draws on the underwater noise modelling results presented above. For shellfish, as no threshold criteria exist, the assessment is based on available literature at the time of the assessment.

Table 11-25 Fish ecology hearing capability for the key species relevant to the offshore Project

GROUP	KEY MARINE FINFISH RECEPTORS RELEVANT TO THE OFFSHORE PROJECT
Group 1	• Sandeels, mackerel, flatfish (e.g. lemon sole), elasmobranchs including flapper skate, thornback ray, spotted ray, tope shark, and spurdog, and sea lamprey and river lamprey.
Group 2	• Salmonids including Atlantic salmon and sea trout.
Group 3	• Gadoids such as Norway pout, cod, whiting, saithe, and haddock and European eel.
Group 4	• Herring and sprat.
Eggs and larvae	• All fish species potentially spawning in the area (see section 11.4.4.2).

Marine finfish

Group 1 marine finfish

As shown in Table 11-25, the majority of marine finfish receptors relevant to the offshore Project area are categorised as Group 1 fish and are less vulnerable to underwater noise effects (including injury or behavioural effects). The majority of these species have a wide availability of spawning and nursery habitats, spawn into the pelagic environment, and are able to vacate the area during piling activities and UXO clearance. The exception to this is sandeel that are in close association to the seabed and remain in burrows for the majority of their life cycle. As a result, sandeel are less able to vacate the area during piling activities and UXO clearance and are potentially more sensitive to particle motion that is transmitted through vibrations in the seabed.

Some of the Group 1 fish are highly protected and are considered to be nationally important. Sandeel are considered to have a medium vulnerability to underwater noise effects due to their limited mobility and all other Group 1 fish are assessed to have a low vulnerability. Therefore, sandeel are assessed as having a medium sensitivity and all other Group 1 fish are assessed to have a low sensitivity.

The impact ranges for mortality and potential mortal injury are described in sections 11.6.1.2.1 and 11.6.1.2.2. For Group 1 fish, the ranges remain within 130 m for unweighted SPLpeak and within 3.6 km based on SELcum and when stationary individuals are assumed. When a fleeing individual is assumed, mortal or potential mortal injury is only expected be within 100 m of either WTG piling and OSP piling and within 630 m for UXO clearance. Recoverable injury and TTS from piling is expected to remain within 5.4 km and 52 km, respectively. These ranges increase when concurrent piling occurs and where there is an overlap of impact areas. The Popper *et al*. (2014) qualitative guidelines values for Group 1 fish for risk of recoverable injury and TTS associated with explosions (such as UXO clearance) suggests that high risk of recoverable injury and TTS is only expected to occur within tens of metres from the source, reducing to low at far distances from the source (i.e. thousands of metres). The same Popper *et al.* (2014) criteria indicates that masking or behavioural effects are only highly likely to occur within hundreds of metres from the source for both piling activities and UXO clearance.

The piling activities and UXO clearance will be short-term (up to 290 days under the temporal worst case scenario for impact piling) and not continuous (i.e. there would be periods of quiet between piling and UXO clearance events). As outlined in section 11.5.4, impacts will be reduced through the implementation of piling soft start and ramp up measures that will allow individuals to vacate the area before noise levels increase to injurious levels. The main exception to this would be sandeel that have a lower mobility than other marine finfish species. However, it is important to note that evidence from the Beatrice Offshore Wind Farm shows that sandeel populations are able to recover following piling activities (BOWL, 2021). Overall, the impact is considered to be temporary, of medium spatial extent, and of a low frequency. Therefore, the impact is defined as being of low magnitude.

Evaluation of significance

Taking the low sensitivity of Group 1 marine finfish (except sandeel) and the low magnitude of impact, the overall effect of underwater noise during construction is considered to be negligible and not significant in EIA terms.

Taking the medium sensitivity of sandeel and the low magnitude of impact, the overall effect of underwater noise during construction is considered to be minor and not significant in EIA terms.

Receptor	Sensitivity	Magnitude of impact	Consequence
Group 1 fish (except sandeel)	Low	Low	Negligible
Sandeel	Medium	Low	Minor

Impact significance – NOT SIGNIFICANT

Group 3 and 4 marine finfish

Group 3 and 4 species, including cod, whiting, haddock, Norway pout, herring and sprat are more sensitive to underwater noise impacts. The offshore Project area overlaps with spawning grounds and/or nursery grounds for these species. However, the majority of species have no known specific habitat requirements. The main exception to this is herring that have more spatially limited spawning grounds and are also considered to be 'hearing specialists' due to the mechanical linkage between the swim bladder and the inner ear. It should also be highlighted that several gadoid species produce vocalisations for communication and are therefore potentially sensitive to masking by underwater noise (Hawkins and Picciulin, 2019). It should be noted, however, that Group 3 and 4 marine finfish are able to vacate the area and reduce their potential susceptibility to injury and behavioural effects.

Group 3 and 4 fish species are either highly protected and/or of commercial importance for the offshore Project area and are considered to be regionally to nationally important. The vulnerability of Group 3 and 4 fish species is considered to be medium. Therefore, they are assessed to have a medium sensitivity.

Mortal and potential mortal injury effects to Group 3 and 4 marine finfish will largely be within close proximity of any impact piling or UXO clearance (<100 m for fleeing individuals for impact piling and up to 630 m for UXO clearance). Recoverable injury, TTS, masking and behavioural effects may occur over larger ranges as outlined in section 11.6.1.2.1 and 11.6.1.2.2. A degree of recovery would be expected following these sub-lethal effects. However, it is acknowledged that they could indirectly result in reduced fitness (e.g. increased predation) or result in effects at a population level if avoidance of spawning grounds or delays in spawning occur. Based on the results of the underwater noise modelling, the spatial extent of underwater noise impacts on Group 3 and 4 marine finfish is medium. The piling activities and UXO clearance will be short-term (up to 290 days under the temporal worst case scenario for impact piling) and not continuous (i.e. there would be periods of quiet between piling and UXO clearance events). As outlined in section 11.5.4, impacts will be reduced through the implementation of piling soft start and ramp up measures that will allow individuals to vacate the area before noise levels increase to injurious levels. Overall, the impact is considered to be temporary, of medium spatial extent, and of a low frequency. Therefore, the impact is defined as being of low magnitude.

Evaluation of significance

Taking the medium sensitivity of Group 3 and 4 fish and the low magnitude of impact, the overall effect underwater noise during construction is considered to be minor and not significant in EIA terms.

Sensitivity	Magnitude of impact	Consequence
Medium	Low	Minor

Impact significance - NOT SIGNIFICANT

Eggs and larvae

Herring, sandeel, cod, whiting, haddock, lemon sole, Norway pout and sprat have spawning grounds that overlap with the offshore Project area. There is a paucity of data on the response of eggs and larvae to underwater noise effects. However, it is expected that demersal eggs may be vulnerable to vibrations from impact piling and explosions (Popper *et al.*, 2014).

Eggs and larvae of species that spawn within the offshore Project area are highly protected and/or are of commercial importance and are considered to be a regionally to nationally important receptor. Considering their limited mobility eggs and larvae are considered to have a medium vulnerability. Therefore, eggs and larvae are assessed as having a **medium sensitivity.**

Mortal and potential mortal injury may occur out to 11,000 km from impact piling and the risk of recoverable injury, TTS masking or behavioural effects is moderate within tens of metres and low within hundreds of metres. For UXO clearance, no particle motion modelling for mortality and potential mortal injury has been modelled for eggs and larvae at this stage. Popper *et al*. (2014) states that risk of mortality and potential mortality could occur at a peak particle motion velocity greater than 13 mm/s in a spawning bed during the period of egg incubation. The risk of recoverable injury, TTS, are expected to reduce to low within hundreds of metres and masking and behavioural effects will reduce to low within thousands of metres.

Based on the underwater noise modelling results and the criteria set by Popper *et al.* (2014), the spatial extent of any underwater noise effects on eggs and larvae is assessed as low. Combined with the temporary (up to 290 days under the temporal worst case scenario for impact piling) and low frequency nature of impact piling and UXO clearance, the impact is defined as being of **low magnitude.**

Evaluation of significance

Taking the medium sensitivity of eggs and larvae and the low magnitude of impact, the overall effect of underwater noise during construction is considered to be **minor** and **not significant** in EIA terms.

Sensitivity	Magnitude of impact	Consequence
Medium	Low	Minor

Impact significance - NOT SIGNIFICANT

Shellfish

There is a paucity of data on the effects of underwater noise on invertebrates. However, several shellfish species have been recorded as being able to detect particle motion, such as blue mussel (*Mytilus edulis*), hermit crab (*Pagurus bernhardus*), American lobster (*Homarus americanus*) and longfin squid (*Doryteuthis pealeii*) (Roberts *et al.*, 2015; Roberts *et al.*, 2016; Miller *et al.*, 2016; Jones *et al.*, 2021). Therefore, it is assumed that the shellfish present in the fish and shellfish ecology, including crabs, lobster and scallops could potentially detect particle motion. Shellfish are not as mobile as fish, and are therefore, less able to avoid underwater noise impacts.

There are no specific threshold criteria available to assess the effects of underwater sound on shellfish. However, available literature show mixed results for physiological or behavioural responses to underwater noise, depending on the experimental design and species. Miller *et al*. (2016) modelled the effects of exposure to underwater noise from pile driving on American lobster from 1.2 m piles in up to 30 m of water and concluded that particle motion could be detected out to 400 m from the pile. Scott *et al.* (2020) also provide an overview of the potential effects of underwater noise on crustaceans. Generally, Scott *et al.* (2020) conclude that the understanding of potential physiological or behavioural effects from underwater noise on shellfish is limited and there is insufficient evidence to understand whether any underwater noise effects could result in detrimental effects at any sufficient scale or not. Shellfish are assessed as having a medium vulnerability, and combined with the regional importance of this receptor, shellfish are assessed as being of medium sensitivity.

The piling activities and UXO clearance will be short-term up to 290 days under the temporal worst case scenario for impact piling) and not continuous (i.e. there would be periods of quiet between piling and UXO clearance events). Considering the impact will be of medium spatial extent, temporary and of low frequency, it is defined as being of low magnitude.

Evaluation of significance

Taking the medium sensitivity of shellfish and the low magnitude of impact, the overall effect of underwater noise during construction is considered to be minor and not significant in EIA terms.

Sensitivity	Magnitude of impact	Consequence
Medium	Low	Minor

Impact significance - NOT SIGNIFICANT

Elasmobranchs

Elasmobranchs lack a swim bladder and are classified as Group 1 fish according to the Popper *et al.* (2014) criteria. Therefore, elasmobranchs can detect particle motion only. The offshore Project area overlaps with spawning / nursery grounds for tope shark, thornback ray, spotted ray, spurdog and common skate (aka flapper skate and blue skate) and site-specific survey data indicates there may be areas within the offshore Project area suitable for flapper skate egg laying. Skates and rays are in close association with the seabed, and therefore, may be more sensitive to particle motion transmitted through the seabed associated with impact piling vibrations and UXO clearance, when compared with species in the water column (e.g. tope shark). However, as elasmobranchs are mobile, they should be able to vacate the area during piling activities to reduce their susceptibility to injury.

Elasmobranchs potentially present at the offshore Project area are considered to be of national to international importance. Considering their limited hearing capabilities, elasmobranchs are assessed to have a low vulnerability to underwater noise, and overall, are assessed to have a low sensitivity.

As a Group 1 species according to Popper *et al.* (2014), the impact ranges for elasmobranchs are the same as those described for Group 1 marine fish. As outlined in section 11.5.4, impacts will be reduced through the implementation of piling soft start and ramp up measures that will allow individuals to vacate the area before noise levels increase to injurious levels. Therefore, any injurious or behavioural effects are expected to be localised to a medium spatial extent when compared with the available habitat for these species. It is possible that individuals could be displaced for a short period of time. However, considering the temporary up to 290 days (under the temporal worst case scenario for impact piling) and low frequency nature of the underwater noise associated with impact piling and UXO clearance, the impact is defined as being of low magnitude.

Evaluation of significance

Taking the low sensitivity of elasmobranchs and the low magnitude of impact, the overall effect of underwater noise during construction is considered to be negligible and not significant in EIA terms.

Sensitivity	Magnitude of impact	Consequence
Low	Low	Negligible
Impact significance - NOT SIGNIFICANT		

Diadromous fish

Lamprey species lack swim bladders and are classified as Group 1 fish according to Popper *et al.* (2014). Salmonids have a swim bladder that is not connected to, or in close proximity to, the inner ear and are classified as a Group 2 fish. European eel are classified as Group 3 fish and are most likely able to detect particle motion, but may detect sound pressure if it is converted to particle motion by the swim bladder (Piper *et al.*, 2019; Jerkø *et al.*, 1989). As diadromous fish are mobile, they are able to vacate the area and reduce their susceptibility to injury effects. However, this avoidance or displacement from the piling activities and/or UXO clearance could result in a barrier effect to migration.

Empirical studies investigating the effect of underwater noise on diadromous fish are lacking. Harding *et al.* (2016) exposed Atlantic salmon post-smolts and adults to piling noise and showed no significant behavioural or physiological response. However, this study was conducted in a laboratory environment and the relevance to wild salmon is not clear (Harding *et al.*, 2016). Available evidence for caged sea trout exposed to pile driving at a range of distances in Southampton water indicated that fish with a received sound pressure level of 134 dB re 1µPa at 400 m from the pile did not respond (Nedwell *et al.*, 2003).

It is possible that diadromous fish may be displaced for a short period of time during construction. For Atlantic salmon and sea trout, this impact may be greatest during the post-smolt migratory period which occurs during late spring to June and in hours of darkness when post-smolt migrations are most likely to occur (Moore *et al.*, 1995). However, considering the distance from the OAA to the coast and the temporary nature of this impact, it is considered unlikely that substantial barrier effects will occur from impact piling or UXO clearance. In relation to underwater noise at the landfall, the modelling predicts highly localised impact ranges (<50 m). Combined with the rapid coastal migration of post-smolts in the coastal environment, adverse effects on post-smolts are considered highly unlikely, including those migrating from the Forss Water, as well as other Scottish rivers.

All diadromous fish are highly protected and are considered to be of national to international importance. Overall, European eel, Atlantic salmon and sea trout are considered to have a medium vulnerability and lamprey species are assessed to have a low vulnerability. Therefore European eel, Atlantic salmon and sea trout are assessed to have a medium sensitivity and lamprey species are assessed to have a low sensitivity.

The underwater noise modelling results indicate that mortality and mortal injury effects from impact piling and UXO clearance would remain within 100 m if a fleeing animal is assumed and recoverable injury would remain within 3.2 km. TTS effects may extend to within tens of km and the risk of behavioural and masking effects are both reduced to low and moderate, respectively, within the intermediate-field (i.e. hundreds of km). As outlined in section 11.5.4, impacts will be reduced through the implementation of piling soft start and ramp up measures that will allow individuals to vacate the area before noise levels increase to injurious levels. Piling activities, UXO clearance and other noise generating activities (e.g. HDD works) will be temporary in nature and intermittent, reducing the temporal overlap of these underwater noise sources and the migration of diadromous fish. Considering this, the impact is considered to be temporary (up to 290 days under the temporal worst case scenario for impact piling), of medium spatial extent, and of a low frequency, and is defined to be of low magnitude. The assessment for salmonids is also relevant to FWPM who may be indirectly affected by effects on these species.

Evaluation of significance

Taking the medium sensitivity of salmonids and European eel and the low magnitude of impact, the overall effect of underwater noise during construction is considered to be minor and not significant in EIA terms.

Taking the low sensitivity of lamprey species and the low magnitude of impact, the overall effect of underwater noise during construction is considered to be negligible and not significant in EIA terms.

Receptor	Sensitivity	Magnitude of impact	Consequence
Salmonids (Atlantic salmon and sea trout), and European eel	Medium	Low	Minor
Lamprey species	Low	Low	Negligible

Impact significance – NOT SIGNIFICANT

11.6.1.3 Indirect effects related to changes in availability or distribution of prey species

As outlined in section 11.4.4.8, sandeels, clupeids (e.g. herring and sprat) and fish present in high biomass (e.g. mackerel and Norway pout) play an important role in the food web. Changes in the availability or distribution of these species may indirectly affect those species that feed on them (including piscivorous fish, marine mammals and birds). The effect of changes on fish prey for marine mammals and birds is assessed in chapter 12: Marine mammals and megafauna and chapter 13: Offshore and intertidal ornithology, respectively. Benthic species can also act as prey species for fish and shellfish receptors. Therefore the impacts discussed in chapter 10: Benthic subtidal and intertidal ecology may indirectly affect fish and shellfish ecology receptors.

Most fish and shellfish ecology receptors are mobile and able to tolerate a degree of change in prey availability and distribution. Atlantic salmon, sea trout, European eel and flapper skate have undergone significant population reductions in recent years and are considered to be more vulnerable to potential reductions or changes in prey. These species are also highly protected and are therefore of national to international importance. Considering this, and the medium vulnerability of Atlantic salmon, sea trout, European eel and flapper skate to changes in prey availability and distribution, they are assessed to be of medium sensitivity. All other fish and shellfish ecology receptors are considered to have a low vulnerability and are assessed to be of a low sensitivity.

As described in sections 11.6.1.1 and 11.6.1.2, no significant (above minor consequence) effects are expected to arise during the construction stage as a result of temporary habitat loss and disturbance or underwater noise. Any effects on feeding habitat and prey items are expected to affect only a small proportion of the available habitat in the area and are, therefore, not anticipated to have a widespread impact on feeding opportunities. Furthermore, the assessment of effects on benthic species (including potential prey) in chapter 10: Benthic subtidal and intertidal ecology also did not identify any significant effects, with all impacts being highly localised and predominantly temporary, affecting a small area of available foraging habitat. These effects are predicted to be of a local spatial extent, temporary, of a low frequency, and recovery would be expected after the construction stage. Therefore, impact has been defined as being of a low magnitude. The assessment for salmonids is also relevant to FWPM who may be indirectly affected by effects on these species.

Evaluation of significance

Taking the medium sensitivity of Atlantic salmon, sea trout, European eel and flapper skate and the low magnitude of impact, the overall effect of indirect effects related to changes in prey availability and distribution during construction is considered to be minor and not significant in EIA terms.

Taking the low sensitivity of all other fish and shellfish ecology receptors and the low magnitude of impact, the overall effect of indirect effects related to changes in prey availability and distribution during construction is considered to be negligible and not significant in EIA terms.

Receptor	Sensitivity	Magnitude of impact	Consequence
Atlantic salmon, sea trout, European eel and flapper skate	Medium	Low	Negligible
All other fish and shellfish ecology receptors	Low	Low	Negligible

Impact significance – NOT SIGNIFICANT

11.6.2 Potential effects during operation and maintenance

11.6.2.1 Long-term habitat loss and disturbance

Long-term habitat loss may occur in the areas where foundation structures (WTG and OSP), scour protection and cable protection are located. Inter-array cables, interconnector cables and offshore export cables will be buried where possible to reduce any potential long-term habitat loss. However, where the target burial depth is not achieved, or in areas with cable crossings, cable protection may be required. As described in section 11.5.5, the long-term seabed footprint within of the offshore Project is up to 7.34 km^2. This represents 0.9% of the overall offshore Project area. It should be noted that this habitat loss will initially occur during the construction stage when the infrastructure is installed. However, the effects will continue to be realised through to the operation and maintenance stage.

Temporary habitat loss and disturbance will also occur during the operation and maintenance stage as a result of seabed disturbance associated with the requirement for jack-up vessel placement during major replacement activities and cable repair or replacement activities. This temporary disturbance would occur intermittently over the 30 year operation and maintenance stage. However, the spatial extent would be highly localised and is not expected to exceed the effects assessed for the construction stage. Therefore, the sensitivity and magnitude ratings for temporary habitat loss and disturbance during the construction stage is also considered applicable to the operation and maintenance stage.

11.6.2.1.1 Marine finfish

As described for construction, the majority of marine finfish species have a low vulnerability to habitat loss and disturbance as they are not dependent on the seabed during their life cycle. The main exceptions to this are sandeel and herring that have specific habitat requirements for spawning. Adult and juvenile sandeel may also be affected by long-term habitat loss and disturbance if this reduces the availability of their burrowing habitat.

Sandeel

As described for construction, the offshore Project area overlaps with low intensity spawning grounds for sandeel and analysis of PSA data indicates that preferred sandeel spawning habitat may be present in localised areas both in the OAA and the offshore ECC. As a result of the specific habitat requirements required for the demersal spawning and adult and juvenile burrows of this species, the Scottish Government FeAST tool categorises sandeel as having a high sensitivity to a physical change in seabed type, and therefore sandeel are considered to have a high vulnerability to this impact (Scottish Government, 2023a). Combined with the national importance of this species, sandeel are assessed to have a high sensitivity.

The introduction of long-term infrastructure on the seabed, including foundations structures, scour protection and cable protection represent a physical change in the seabed type over a maximum area of 7.34 km^2 for the duration of the operation and maintenance stage (30 years). This physical change in the seabed would result in the loss of sandeel spawning and burrowing habitat. However, the seabed footprint associated with the offshore Project represents a small proportion of the available habitat in the area, and it is important to re-iterate that habitats suitable for sandeel are only expected to be present in parts of the OAA, as described in section 11.4. Overall, the impact is considered to be of a local spatial extent, long-term and continuous. Therefore, the impact is defined as being of low magnitude. Furthermore, considering the localised nature of this impact, the effects on the North-West Orkney NCMPA are also expected to be limited.

Evaluation of significance

Taking the high sensitivity of sandeel and the low magnitude of impact, the overall effect of temporary habitat loss and disturbance during operation and maintenance is considered to be minor and not significant in EIA terms.

Sensitivity	Magnitude of impact	Consequence
High	Low	Minor

Impact significance - NOT SIGNIFICANT

Herring

The offshore Project area overlaps with spawning grounds for herring. However, analysis of the PSA data indicates that the majority of survey locations were classified as being unsuitable for herring spawning. Herring are a nationally important receptor with a medium vulnerability to habitat loss as a result of the specific habitat requirements required for the demersal spawning of this species. Therefore, herring are assessed as having a medium sensitivity.

The long-term loss of spawning habitat will be localised in an area (7.34 km^2) where only low levels of herring spawning are expected to occur for a period of 30 years. Overall, the impact is considered to be of a local spatial extent, long-term and continuous. Therefore, the impact is defined as being of low magnitude.

Evaluation of significance

Taking the medium sensitivity of herring and the low magnitude of impact, the overall effect of temporary habitat loss and disturbance during operation and maintenance is considered to be minor and not significant in EIA terms.

Sensitivity	Magnitude of impact	Consequence
Medium	Low	Minor

Impact significance - NOT SIGNIFICANT

All other marine finfish

As described for construction, all other marine finfish species (excluding sandeel and herring) are considered to have a low vulnerability to habitat loss and disturbance as they are not seabed dependent during their life cycle. Some of the other marine finfish species are nationally or internationally important. Overall, all other marine fish (excluding sandeel and herring) are assessed as having a low sensitivity.

Based on the localised spatial extent of the long-term habitat loss and disturbance during the operation and maintenance stage (7.34 km^2) when compared with the wider availability of habitat for marine finfish species other than sandeel and herring, long-term habitat loss will only affect a small proportion of the available habitat for these species. Overall, the impact is considered to be of a local spatial extent, long-term (30 years) and continuous. Therefore, the impact is defined as being of low magnitude.

Evaluation of significance

Taking the low sensitivity of all other marine fish and low magnitude of impact, the overall effect of temporary habitat loss and disturbance during operation and maintenance is considered to be negligible and not significant in EIA terms.

Sensitivity	Magnitude of impact	Consequence
Low	Low	Negligible
Impact significance – NOT SIGNIFICANT		

11.6.2.1.2 Shellfish

Some shellfish receptors are potentially vulnerable to long-term habitat loss and disturbance, including brown crab, lobster, and scallops due to their limited mobility. Considering the regional importance of shellfish and their medium vulnerability, shellfish are assessed as having a medium sensitivity.

The long-term habitat loss and disturbance during the operation and maintenance stage is highly localised (7.34 km^2) when compared with the wider region of habitat available to shellfish. Therefore, only a small proportion of the habitat available for this receptor would be affected. Furthermore, any long-term habitat loss associated with the introduction of hard substrate may act as an area of refuge and a potential source of food for shellfish, as discussed in section 11.6.2.3. Overall, the impact is considered to be of a local spatial extent, long-term (30 years) and continuous. Therefore, the impact is defined as being of low magnitude.

Evaluation of significance

Taking the medium sensitivity of shellfish and low magnitude of impact, the overall effect of habitat loss and disturbance during operation and maintenance is considered to be minor and not significant in EIA terms.

Sensitivity	Magnitude of impact	Consequence
Medium	Low	Minor
Impact significance – NOT SIGNIFICANT		

11.6.2.1.3 Elasmobranchs

The offshore Project area is predicted to overlap with nursery grounds for tope shark, spurdog, thornback ray, spotted ray and common skate (aka flapper skate and blue skate). The main impact associated with long-term habitat loss and disturbance during the operation and maintenance stage would be the loss of suitable egg laying grounds for oviparous elasmobranchs, including spurdog, thornback ray, spotted ray, flapper skate and blue skate. The Scottish Government FeAST tool categorises common skate (prior to the identification of flapper skate and blue skate as two separate species) as having a low sensitivity to physical change to another seabed type (Scottish Government, 2023a).

All species except flapper skate are assessed as being of national to international importance and of a medium vulnerability to long-term habitat loss. Considering the potential importance of the areas around Orkney for egg laying by this species, flapper skate are assessed to have a **high sensitivity.** Spotted ray, thornback ray and spurdog are nationally to internationally important receptors with a medium vulnerability but are considered to be relatively widespread in Scottish waters. Blue skate are only expected to be present at the offshore Project area at low numbers as this species is predominantly distributed in the south of England. Therefore, these species are assessed as having a **medium sensitivity.** All other elasmobranchs are assessed to have a **negligible sensitivity.**

Egg laying habitat may be lost under the footprint of the long-term infrastructure associated with the offshore Project, including foundation structures, scour protection and cable protection. However, this would represent a highly localised area (7.34 km^2), with alternative egg laying grounds present in the wider region, including areas of the OAA where no infrastructure is present on the seabed. Furthermore, if fishing activity within the OAA is reduced, this could reduce seabed abrasion and damage to egg cases associated with demersal fishing gear (e.g. scallop dredges and demersal trawls). Overall, the impact is considered to be of a local spatial extent, long-term (30 years) and continuous. Therefore, the impact is defined as being of **low magnitude.**

Evaluation of significance

Taking the high sensitivity of flapper skate and the low magnitude of impact, the overall effect of temporary habitat loss and disturbance during operation and maintenance is considered to be **minor** and **not significant** in EIA terms.

Taking the medium sensitivity of spotted ray, thornback ray, spurdog and blue skate, and the low magnitude of impact, the overall effect of temporary habitat loss and disturbance during operation and maintenance is considered to be **minor** and **not significant** in EIA terms.

Taking the negligible sensitivity of all other elasmobranchs and the low magnitude of impact, the overall effect of temporary habitat loss and disturbance during operation and maintenance is considered to be **negligible** and **not significant** in EIA terms.

Species	Sensitivity	Magnitude of impact	Consequence
Flapper skate	High	Low	Minor
Spotted ray, thornback ray, spurdog and blue skate	Medium	Low	Minor
All other elasmobranchs	Negligible	Low	Negligible
Impact significance - NOT SIGNIFICANT			

11.6.2.1.4 Diadromous fish

Diadromous fish are national to internationally important receptors but have a negligible vulnerability to disturbance in the marine environment, owing to the fact that diadromous fish do not rely on specific seabed habitats and are highly mobile. Therefore, diadromous fish are assessed being of a low sensitivity.

Considering the localised extent of any habitat disturbance and the wide availability of habitat available to diadromous fish, the impact is not anticipated to result in adverse effects on diadromous fish migrating through the offshore Project area. Overall, the impact is considered to be of a local spatial extent (7.34 km^2), long-term (30 years) and continuous. Therefore, the impact is defined as being of low magnitude. The assessment for salmonids is also relevant to FWPM who may be indirectly affected by effects on these species.

Evaluation of significance

Taking the low sensitivity of diadromous fish and the low magnitude of impact, the overall effect of temporary habitat loss and disturbance during operation and maintenance is considered to be negligible and not significant in EIA terms.

Sensitivity	Magnitude of impact	Consequence
Low	Low	Negligible

Impact significance - NOT SIGNIFICANT

11.6.2.2 EMF effects

EMFs have the potential to alter the behaviour of marine organisms that are able to detect electric (E-fields, measured in volts per metre (V/m)) or magnetic (B-field, measured in micro Tesla (μT)) components of the fields. The B-field penetrates most materials, and therefore, is emitted into the marine environment, thus resulting in an associated induced electric (iE)-field. The direct E-fields are blocked by the use of conductive sheathing within the cable, and hence are not considered further. When relative motion is present between B-fields and a conductive medium (e.g. sea water), iE-fields are produced. Earth has its own natural Geomagnetic Field (GMF) with associated B and iE-fields which species rely on for navigation (Gill and Desender, 2020; Winklhofer, 2009). The natural iE-fields result from sea water interacting with the natural GMF, due to relative motion caused by the Earth's rotation, and tidal currents (Gill and Desender, 2020).

A number of fish and shellfish species are able to detect EMFs and use them for various different reasons. Particular focus has been placed on assessing the response of crustaceans, elasmobranchs and salmonids to EMF (Hutchison *et al.*, 2020; Copping *et al.*, 2020; 2021). Generally, electrosensitive species are mainly responsive to both Direct Currents (DC) and Alternating Currents (AC), low intensity electric fields between 0.02 microvolts (μV) cm^{-1} and 100 μV cm^{-1} and frequencies of 0–15 Hz (Tricas and Sisneros, 2004; Stoddard and Markham, 2010; Hutchison *et al.*, 2020). NatureScot has created a feature activity sensitivity tool to determine the sensitivity of marine receptors to various human-induced pressures, including EMFs. Pressure benchmarks are set for EMFs, which the sensitivity of the marine receptor is assessed against. The benchmark has been set as a change in the local E-field of 1 V/m or local B-field of 10 μT, due to anthropogenic means (NatureScot, 2021b).

The introduction of anthropogenic EMF into the marine environment has the potential to alter the behaviour of some fish and shellfish species and the migratory behaviours of salmonids (e.g. Atlantic salmon and sea trout) and European eels, potentially resulting in increased energy expenditure.

Up to 140 145 kV inter-array HVAC cables (500 km), six 420 kV interconnector HVAC cables (150 km) and five 420 kV offshore export cables (320 km) will be installed as part of the offshore Project. All cables will either be buried to a target depth of 1-3 m or covered by cable protection to a height of 3 m and the HDD would be at a depth greater than this (approximately 20 m in the intertidal area), with an exit point between 10 to 40 m below LAT. Although the burial of cables and other protective measures such as cable protection are not considered to be effective ways to mitigate the extent of magnetic fields in the marine environment, it does separate the most sensitive species from the source of the emissions, therefore reducing the maximum field strength likely to be encountered (e.g. at the seabed) (Copping *et al.*, 2020). In addition, design parameters and installation methods are expected to conform to industry standard specifications which includes shielding technology to reduce the direct emission of EMFs.

A Project specific modelling study was undertaken by a cable manufacturer to inform the assessment of EMF effects, focussing on B-fields from the inter-array cables and offshore export cables. 66 kV inter-array cables at 691 A and 275 kV offshore export cables at 972 A were modelled. It is acknowledged that these voltages are less than those being proposed for the offshore Project. However, it is important to note that potential B-fields are proportional to cable current, and a higher voltage results in a smaller current. Therefore, modelling B-fields for these lower currents represents the worst case.

The results of the modelling study are shown in Table 11-26, representing the B-fields at the seabed surface at 0, 1, 2 and 3 m burial depths (where cable protection of up to 3 m can be treated the same as burial depth). The B-fields rapidly dissipate when assuming 1 -3 m burial or cable protection. Furthermore, the approximate natural GMF at the offshore Project area is 50 μT, and in all cases, the B-fields are less than this at 1 m burial or protection depth.

Table 11-26 Magnetic (B) fields at various burial depths for the inter-array and offshore export cables from the Project specific modelling study

COMPONENT	BURIAL DEPTH (M)			
	0	1	2	3
Inter-array cable B-fields	348 μT	9.3 μT	2.8 μT	1.3 μT
Offshore export cables	507 μT	18 μT	5.7 μT	2.7 μT

The results above are also similar to the modelling conducted by Normandeau *et al.* (2011) on a range of subsea cable designs, including HVAC cables ranging from 35 – 132 kV with 1 – 600 Megawatt (MW). Normandeau showed that the average B-fields for the modelled HVAC cables (when assuming 1 m cable burial), were 7.85 μT at the seabed directly above the cable (i.e. horizontal distance from the cable = 0).

11.6.2.2.1 Marine finfish

Pelagic marine finfish (e.g. mackerel, herring and sprat) are unlikely to come into contact with the EMF associated with the offshore Project, given that they are not on or in close association with the seabed. Furthermore, as these species are highly mobile, they are unlikely to be in the vicinity of any increased EMF associated with the offshore Project for any significant length of time. Demersal marine finfish, eggs and larvae that are on or above the seabed are more likely to overlap with the zone of increased EMF associated with the offshore Project, and are therefore, the most vulnerable marine finfish receptors (Nyqvist *et al.*, 2020). There are several demersal marine finfish species that have nursery grounds that overlap with the offshore Project area, as outlined in section 11.4.4. Herring and sandeel spawning may also occur at the offshore Project area and these species have a demersal egg phase.

Some recent primary literature by Cresci *et al*. (2020; 2022a; 2022b) has investigated the effects of EMF exposure on haddock, herring and lesser sandeel larvae. Haddock larvae are magneto-sensitive (see Cresci *et al.*, 2019). Exposure to B-fields of 50 to 150 μT in a laboratory setting resulted no significant changes in spatial distribution (i.e. there was no attraction effect), but did result in slower swimming speeds, with potential consequences on the dispersal ecology of this species (Cresci *et al.*, 2022). Atlantic herring larvae exposed to B-fields of 48.8 – 50 μT *in situ* and in laboratory settings did not show any changes in orientation as result of EMF exposure, indicating that this species does not use magnetic compass orientation, at least at this life history stage (Cresci *et al.*, 2020). Similarly, lesser sandeel exposed to B-fields of 50 – 150 μT in a laboratory setting showed no change in spatial distribution or alteration to swimming speed, acceleration or distanced moved (Cresci *et al.*, 2022b). It should also be noted that B-fields of these strengths would only be expected in very close proximity to the cables for the offshore Project, as outlined above in the summary of the EMF modelling.

Gill and Desender (2020) and Copping *et al.* (2021) provide an overview of the current knowledge on EMF effects on marine finfish. Generally, field studies on the response of marine finfish to EMF are lacking and laboratory studies that indicate potential developmental, genetic, and physiological implications of exposure to B-fields in the range of several milli Tesla (mT), rather than μT (1 mT = 1,000 μT), and therefore, are much higher than would be expected for the offshore Project. Overall, Gill and Desender (2020) and Copping *et al.* (2021) conclude that EMF emissions associated with offshore renewable developments are unlikely to result in substantial ecological impacts, although this is based on a small evidence base.

Marine finfish receptors are considered to be regionally to nationally important receptors of a low vulnerability to EMF effects. Therefore, marine finfish are assessed to have a low sensitivity. EMF will be continuous and emitted throughout the life-cycle of the offshore Project (i.e. long term). However, based on the local spatial extent of this impact, it is defined as being of low magnitude.

Evaluation of significance

Taking the low sensitivity of marine finfish and the low magnitude of impact, the overall effect of EMF during operation and maintenance is considered to be **negligible** and **not significant** in EIA terms.

Receptor	Sensitivity	Magnitude of impact	Consequence
Marine finfish	Low	Low	Negligible
Impact significance - NOT SIGNIFICANT			

11.6.2.2.2 Shellfish

The response of invertebrates to EMF emissions remains relatively unknown. However, several recent studies have shown that crustaceans may be capable of detecting B-fields. A specific study on lobsters demonstrated statistically significant responses to EMF when exposed to static EMFs within enclosures above a High Voltage Directional Current (HVDC) power cable. However, there was no indication that the parameters were associated with zones of high or low EMF, but was an overall response (Hutchison *et al.*, 2020). It is also important to note that whilst this study does show a response to EMF on lobster, the study considered HVDC cables at 300 kV and 500 kV, where the magnetic fields exhibited were much greater than that of earth's GMF, and as such these results are not comparable to the proposed HVAC cables for the offshore Project. A recent study on lobsters and brown crabs found EMF did not alter embryonic development time, larval release time, or vertical swimming speed for either species. However, when exposed throughout embryonic development, an increase in larval deformities was observed and reduced swimming test success rate amongst lobster larvae (Harsanyi *et al.*, 2022). Again this study looked at exposure to 2.8 Millitesla (mT) of EMF, which is significantly higher, and thus not comparable, to the proposed cables for the offshore Project. A recent laboratory study on brown crab (Scott *et al.*, 2021), found that there were no adverse physiological or behavioural impacts at magnetic fields of 250 μT. Adverse behavioural (i.e. attraction and reduced time spent roaming) and physiological impacts, however, were observed at 500 μT and above. Although responses are observed at these elevated levels, the proposed cables for the offshore Project would not emit magnetic fields within these magnitudes, as discussed above. Overall, research since 2016 concerning invertebrates generally supports previous studies that demonstrated no or minor effects of encounters with EMFs (Albert *et al.*, 2020). Considering this, no substantial physiological or behavioural effects are expected, including for migrating brown crab.

Shellfish are considered to have a low vulnerability to EMF effects and combined with the commercial value of this group that is assessed as regionally important, shellfish are assessed to have a **low sensitivity.**

EMF will be continuous and emitted throughout the life-cycle of the offshore Project. However, based on the localised spatial change, the impact is defined as being of **low magnitude.**

Evaluation of significance

Taking the low sensitivity of shellfish and the low magnitude of impact, the overall effect of EMF during operation and maintenance is considered to be **negligible** and **not significant** in EIA terms.

Sensitivity	Magnitude of impact	Consequence
Low	Low	Negligible
Impact significance - NOT SIGNIFICANT		

11.6.2.2.3 Elasmobranchs

Elasmobranchs detect magnetic fields directly, rather than via induction of E-fields (Anderson *et al.* 2017) and are more responsive to magnetic fields in comparison to other species (Hutchison *et al.*, 2020; Porsmoguer *et al.*, 2015). Depending on the species and experimental design, elasmobranchs have been shown to be responsive at varying degrees. Gill *et al*. (2009) showed that lesser spurdog and thornback ray responded to EMF (B-fields of 8 μT and iE-fields of 2.2 μV/m), but that this response was species-specific and unpredictable. Hutchison *et al*. (2020) also demonstrated that little skate (*Leucoraja erinacea*) showed an increased exploratory / foraging behaviour in response to EMF exposure (HVDC cable with B-fields up to 65.3 μT) (Hutchison *et al.*, 2020). For a population level effect to occur, this would have to result in reduced health, survival or reproductive success (Gill and Desender, 2020).

Some species of skate and ray are species of conservation importance, with the flapper skate and blue skate being listed as Critically Endangered on the IUCN Red List. As described previously, areas of the offshore Project area may be used as egg laying habitat for flapper skate. Overall, elasmobranchs are considered to be of medium vulnerability and international importance, resulting in an assessment of **medium sensitivity**.

EMF will be emitted continuously throughout the life-cycle of the offshore Project (i.e. long-term). EMF emissions from the offshore Project will be reduced through cable burial and/or cable protection measures, delivered through management plans, including the CaP. Considering this, the impact is considered to occur over a local spatial extent, and overall, the impact is defined to be of **low magnitude.**

Evaluation of significance

Taking the medium sensitivity of elasmobranchs and the low magnitude of impact, the overall effect of EMF during operation and maintenance is considered to be **minor** and **not significant** in EIA terms.

Sensitivity	Magnitude of impact	Consequence
Medium	Low	Minor
Impact significance - NOT SIGNIFICANT		

11.6.2.2.4 Diadromous fish

Unlike elasmobranch species, diadromous species do not possess specialist magnetic receptor cells. Instead, within their skeletal structure they contain magnetically sensitive material and use EMFs as a navigational tool for migration. Therefore, if a diadromous species migratory route crosses the offshore Project cable routes, there is a potential for cable EMFs to affect the behaviour of the individuals, especially in shallow waters of 20 m or less (Gill, *et al*. 2012). Such an effect could result in avoidance behaviour, delaying the migration of salmonids and European eels. However, studies have shown widely variable results, and therefore the extent of the effect of EMFs on migratory fish is currently unclear (Gill & Bartlett, 2010).

Adult and juvenile Atlantic salmon primarily swim within the top 5 m of the water (Godfrey *et al.*, 2014; Newton *et al.*, 2021). Therefore, these fish would not be affected by EMF emitted from the cables on the seabed, including any post-smolts migrating from Scottish rivers, such as from Forss Water adjacent to the Crosskirk landfall option. The HDD depth will be to approximately 20 m in the intertidal area, and therefore, EMF would be undetectable to any post-smolts migrating from Forss Water. Eels migrate at various depths throughout the water column and therefore are more likely to encounter the EMF from the dynamic cables. Sea trout are also sensitive to magnetic fields and commonly found in water depths between 0-190 m (MarLIN, 2023). A laboratory study carried out by Marine Scotland (Orpwood *et al.*, 2015) indicated that there was no evidence of a difference in the movement of eels as a result of EMF and there were no observations of changes in behaviour of the eels. Armstrong *et al.* (2015) also concluded that there was no identifiable physiological or behavioural response of Atlantic salmon to magnetic fields at intensities of 95 μT and below. No field studies are available on the response of Atlantic salmon to EMF. However, Wyman *et al*. (2018) investigated the effect of EMF from a 200 kV subsea cable on the migratory success of Chinook salmon in San Francisco Bay, California. It was observed that the activation of EMF resulted in a slight deviation from normal migratory routes but this did not reduce the overall success of migration (Wyman *et al.*, 2018).

The diadromous fish species identified to potentially utilise the offshore Project are of conservation importance, either as Annex II species (lamprey species and Atlantic salmon) or as critically endangered under the IUCN red list (European eel). High levels of EMF may have the potential to impact the migration of diadromous fish, but they are considered to have low vulnerability to the levels being emitted. Overall, the diadromous fish are assessed to have a medium sensitivity.

EMF will be continuously emitted throughout the life-cycle of the offshore Project (i.e. long-term). Exposure to EMF emissions from the offshore Project will be reduced through cable burial and/or cable protection measures, delivered through management plans, including the CaP. Considering this, the impact is considered to occur over a local spatial extent, and overall, the impact is defined to be of low magnitude. The assessment for salmonids is also relevant to FWPM who may be indirectly affected by effects on these species.

Evaluation of significance

Taking the medium sensitivity of diadromous fish and the low magnitude of impact, the overall effect of EMF during operation and maintenance is considered to be minor and not significant in EIA terms.

Sensitivity	Magnitude of impact	Consequence
Medium	Low	Minor
Impact significance - NOT SIGNIFICANT		

11.6.2.3 Potential fish or predator aggregation

Subsea infrastructure from offshore wind farms can provide new habitats for fish and shellfish species as they can act as artificial reefs. The introduction of hard infrastructure alters previously soft sediment habitat areas, which can attract new species and increase the habitat complexity and biodiversity of the area (Degraer *et al.*, 2020). Offshore wind farms may also act as a Fish Aggregation Device (FAD) if any artificial reefs or newly fouled structures attract fish. It is thought that FADs concentrate fish stock in a particular area, rather than increasing productivity (Inger *et al.*, 2009). There is evidence, however, to suggest that hard structures acting as artificial reefs provide food and refuge, and therefore may increase the productivity of an area (Langhamer and Wilhelmsson, 2009; Wilhelmsson *et al.*, 2006; Linley *et al.*, 2007). The reef or aggregation effect is expected to be greatest where WTGs are installed in homogeneous sandy areas. In areas of more heterogeneous substrate, less aggregation is expected to occur as a result of the installation of WTGs (Xoubanova and Lawrence, 2022).

MSS also highlighted that reef effects or fish aggregation may change the abundance of predators (e.g. piscivorous fish, marine mammals and seabirds) at offshore wind farms once operational, and this could adversely affect diadromous fish migrating through the area. At the time of writing, the results of the Predators and Prey Around Renewable Developments (PrePARED) project (a five year programme that began in April 2022) are not available. However, the results of this project will aid in the understanding of predator-prey relationships at operational offshore wind farms.

Xoubanova and Lawrence (2022) outline the current knowledge on the reef/fish aggregation effects associated with offshore renewable developments. Generally, no clear conclusions on the potential for reef or aggregation effects can be drawn from the post-construction monitoring at operational UK offshore wind farms. However, longer-term monitoring at European windfarms indicates that there are changes in fish communities at operational wind farms (Xoubanova and Lawrence, 2022). For instance, monitoring at Horns Rev 1 offshore windfarm in the Danish waters (where fishing activity is prohibited at operational windfarms) found no adverse effects on fish communities, higher abundance of fish within the wind farm, increased diversity close to the WTGs, and no reduction in the abundance of sandeels (a species that prefers sandy sediments) (Stenberg *et al.*, 2011; 2015).

As per section 11.5.5, the long-term footprint of the offshore Project is 7.34 km^2, present for the duration of the operation and maintenance stage (30 years). In addition, the presence of up to 125 WTG and five OSP foundation structures may introduce new structures for habitat creation, with the potential for fish and predator aggregation.

To reduce the footprint of the cable protection, the cables associated with the offshore Project will be buried where possible and cable protection will only be required where sufficient burial depth is not achieved. The surfaces provided by the offshore Project will provide minimal surface area for colonisation, when compared with the larger offshore Project area. Furthermore, it is important to note that the sediments across the offshore Project area are relatively heterogeneous. As outlined in chapter 8: Marine physical and coastal processes and chapter 10: subtidal and intertidal ecology, there is a mixture of sandy, coarse and mixed sediments with large patches of rocky substrate, much of which is classified as potential reef (50% of offshore Project area)[12]. Therefore, a substantial change in the fish and shellfish community is not expected.

11.6.2.3.1 Marine finfish

Fish aggregation and the introduction of hard substrate may result in the provision of shelter and increased food availability, especially for higher trophic level species (Degraer *et al*., 2020). Displacement of marine finfish that prefer sandy substrates (e.g. sandeel) may also occur. However, this impact is assessed in relation to long-term habitat loss in section 11.6.2.1.

Generally, monitoring studies show that the potential reef and aggregation effects associated with offshore wind farms are unlikely to result in adverse effects for marine finfish species (Methratta and Dardick, 2019). Marine finfish are considered to have a low vulnerability to this impact and combined with the local to national importance of marine finfish in the offshore Project area, they are assessed to have a low sensitivity.

Considering the heterogenous seabed across the offshore Project area, the introduction of hard substrate is considered unlikely to result in any substantial reef or aggregation effects. If reef or aggregation effects do occur, these will be in discrete areas only (< 50 m) (Methratta, 2021). Overall, the impact is considered to be continuous, long-term (30 years) and of a local spatial extent. Considering this, the impact is defined as being of low magnitude.

Evaluation of significance

Taking the low sensitivity of marine finfish and the low magnitude of impact, the overall effect of potential fish or predator aggregation during operation and maintenance is considered to be negligible and not significant in EIA terms.

Sensitivity	Magnitude of impact	Consequence
Low	Low	Negligible

Impact significance – NOT SIGNIFICANT

[12] *As noted in chapter 10: Benthic subtidal and intertidal ecology, the classification of 'low to medium' potential stony reef are expected to represent an overestimate based on the analysis using a Rugosity model. Therefore, it is expected that less than 50% of the offshore Project area is an Annex I reef in reality.*

11.6.2.3.2 Shellfish

Some shellfish species may benefit from an increase in hard substrate through the provision of refuge areas. For instance, Krone *et al*. (2017) demonstrated that monopile foundations with scour protection were associated with approximately 5,000 brown crabs per foundation (twice as much as foundation with no scour protection) in the German Bight, North Sea. The wind farm also acted as nursery ground for brown crab (Krone *et al*., 2017). One exception to this may be scallops that are typically present in clean sand, fine or sandy gravel. Shellfish within the offshore Project area are of commercial importance at a regional scale and are of a low vulnerability to this impact. Therefore, shellfish are assessed as having a low sensitivity.

Overall, the impact is considered to be continuous, long-term (30 years) and of a local spatial extent. Considering this, the impact is defined as being of low magnitude.

Evaluation of significance

Taking the low sensitivity of shellfish and the low magnitude of impact, the overall effect of EMF during operation and maintenance is considered to be minor and not significant in EIA terms.

Sensitivity	Magnitude of impact	Consequence
Low	Low	Negligible

Impact significance – NOT SIGNIFICANT

11.6.2.3.3 Elasmobranchs

Several elasmobranchs are carnivorous, feeding on benthic invertebrates and fishes, and may benefit from the provision of shelter and increased food availability. However, as described for marine finfish, monitoring studies show that the potential reef and aggregation effects (including predators) associated with offshore wind farms are unlikely to result in adverse effects (Methratta and Dardick, 2019).

Elasmobranchs are of national to international importance and are considered to have a low vulnerability to this impact. Therefore, elasmobranchs are assessed to have a low sensitivity.

Overall, the impact is considered to be continuous, long-term (30 years) and of a local spatial extent. Considering this, the impact is defined as being of low magnitude.

Evaluation of significance

Taking the low sensitivity of elasmobranchs and the low magnitude of impact, the overall effect of potential fish or predator aggregation during operation and maintenance is considered to be negligible and not significant in EIA terms.

Sensitivity	Magnitude of impact	Consequence
Low	Low	Negligible
Impact significance – NOT SIGNIFICANT		

11.6.2.3.4 Diadromous fish

Several diadromous fish species may migrate through the offshore Project area, either as juveniles (e.g. post-smolts) or adults. As described in the sections above, it is likely that higher trophic levels will benefit most from any potential reef or aggregation effects associated with the offshore Project. For example, Reubens *et al.* (2013a; 2013b) demonstrated that cod (a piscivorous fish that preys on Atlantic salmon post-smolts) catches at an operational wind farm site in the Belgium part of the North Sea were higher than adjacent areas, as cod aggregated around WTG foundations and over areas of hard substrate. Studies on seals also indicate that operational wind farms may act as a foraging habitat (Russell *et al.*, 2014). Therefore, an increase in piscivorous fish and other predators (e.g. seals) may occur at the offshore Project and could increase predation of diadromous fish as they migrate through the offshore Project area.

As highlighted by MSS, a change in predation has been cited as a key driver of the reduced Atlantic salmon and sea trout post-smolt survival in the Baltic Sea (Friedland *et al.*, 2017). Both Scottish Atlantic salmon and sea trout populations are in decline, and predation as post-smolts during the early stages of migration could result in a substantial degree of mortality and impact adult returns (Gillson *et al.*, 2022). The aggregation of post-smolts at the offshore Project area, and therefore the potential importance of the area for Atlantic salmon and sea trout remains uncertain, and therefore, the relative impact of any increased predation at the offshore Project is unclear. However, current evidence indicates that Atlantic salmon post-smolts from rivers on the East coast of Scotland are likely to migrate in an easterly direction, and therefore, are unlikely to pass through the Pentland Firth (as described in section 11.4.4). Furthermore, although uncertain, it is considered unlikely that a substantial portion of post-smolts from other Scottish rivers will migrate through the offshore Project area, given the wider availability of habitat along the north coast of Scotland. There is limited information available on European eel and sea lamprey use of the marine environment.

Overall, diadromous fish are nationally to internationally important receptors and are considered to have a high vulnerability to this impact, due to the potential for increased predation on juveniles which can have wider impacts on adult returns. Therefore, diadromous fish are assessed to be of a high sensitivity.

It is acknowledged that the number and distribution of diadromous fish at the offshore Project remains relatively uncertain, given the lack of empirical data on the abundance and distribution of diadromous fish in Scottish waters.

However, the area affected represents a relatively small portion of the habitat available to diadromous fish and areas of increased predation are expected to be highly localised. Overall, the impact is considered to be continuous, long-term (30 years) and of a local spatial extent. Considering this, the impact is defined as being of low magnitude. The assessment for salmonids is also relevant to FWPM who may be indirectly affected by effects on these species.

Evaluation of significance

Taking the high sensitivity of diadromous fish and the low magnitude of impact, the overall effect of potential .fish or predator aggregation during operation and maintenance is considered to be minor and not significant in EIA terms.

Sensitivity	Magnitude of impact	Consequence
High	Low	Minor

Impact significance – NOT SIGNIFICANT

11.6.2.4 Barrier effects to diadromous fish

The presence, origin and distribution of diadromous fish within the offshore Project area remains relatively unknown, given the lack of empirical data on diadromous fish migratory routes in Scottish waters. However, the Pentland Firth is expected to be an important migratory corridor for Atlantic salmon as described in section 11.4.4 and in SS7: Fish and shellfish ecology baseline report. Post-smolt migrations may also occur through the Pentland Firth and in the vicinity of the offshore Project area, including from Forss Water which is adjacent to the Crosskirk landfall option. Recent evidence indicates that post-smolts from East coasts may migrate in an easterly direction (i.e. not through the Pentland Firth) as described in section 11.4.4.6 above. There is currently no data on distribution and presence of Atlantic salmon adults or post-smolts along the north coast of Scotland and in the vicinity of the offshore Project, and therefore, the abundance or importance of the area for Atlantic salmon is unknown. Sea trout, European eel and lamprey species may also migrate through the offshore Project area, including to / from Forss Water. However, empirical data for these species is also lacking. In the absence of this data, it has been assumed that these diadromous fish species have the potential to migrate through the offshore Project.

There is the potential for any impact that could result in avoidance behaviours by diadromous fish to act as a barrier effect to migration. The key impacts on diadromous fish during the operation and maintenance with the potential to result in avoidance behaviours are considered to be EMF effects, underwater noise (e.g. the combined sound associated with the operational noise of multiple WTGs) and visual effects. However, it should be noted that there is currently no available evidence of an offshore wind farm posing a barrier to diadromous fish, from any plausible impact pathway.

The potential effect of EMF on diadromous fish is described in section 11.6.2.2.4 and it was concluded that displacement or avoidance of EMF to a level that would act as a barrier to migration was unlikely to occur.

Continuous low frequency underwater noise may result from the operation of up to 125 WTGs at the offshore Project and act as a barrier to migration. Unless in close proximity to a WTG, underwater noise from a single WTG is unlikely to be detectable below ambient noise levels. Tougaard *et al.* (2020) reviewed the reported underwater noise levels from 17 operational wind farms. Using a formula derived by Tougaard *et al.* (2020), Subacoustech (2023) have modelled the predicted recoverable injury and TTS ranges using Popper *et al.* (2014) criteria for continuous noise sources. The results of the modelling indicate that individuals would have to remain within 50 m for over 48 hours for recoverable injury and for over 12 hours for TTS. Tougaard *et al.* (2020) highlighted the importance of considering the potential cumulative sound source from an offshore wind farm array of multiple WTGs, as the noise level could be elevated out to several km from the source. This in turn, could act as a barrier to movement, especially in areas with low levels of ambient noise. It is important to note that a number of vessels were recorded within the offshore Project area during the vessel traffic surveys, and based on Automatic Identification System (AIS) data, up to 12 commercial shipping routes (with up to 4 vessel trips per week) traverse the offshore Project area and the surrounding area (see chapter 15: Shipping and navigation and SS14: Navigational risk assessment). As such, any additional continuous noise emitted from operation of the WTGs is likely to be largely indistinguishable from background vessel noise. It is acknowledged that WTGs are static noise sources, unlike vessels which represent a transient noise source. Nonetheless, the potential for the operational WTGs to act as a barrier to movement for diadromous fish is considered to be low.

The majority of research on the responses of diadromous to visual effects focus on artificial light. For instance, exposure to street lights during downstream migration of Atlantic salmon smolts at the River Itchen, England, resulted in a more random timing of migration compared with non-lit years when migration was correlated to sunset (Riley *et al.*, 2012). Similarly, downstream migrating European eel were less likely to migrate down an artificially lit route option than an unlit route option (Vowles and Kemp, 2021). Furthermore, at fish farms, exposure to submerged artificial light has been observed to increase swimming depths by Atlantic salmon (Juell *et al.*, 2003). Dodd and Briers (2021) conclude that there is no published information regarding the biological or behavioural responses of Atlantic salmon to light patterns associated with shadow flicker. Atlantic salmon and sea trout are commonly found near the sea surface, and therefore, may be receptive to visual stimuli associated with the offshore Project. However, considering the distance of the blades of the offshore Project above the sea surface and in the context of other visual stimuli, such as cloud cover and distortions of the water surface, it is considered unlikely that shadow flicker or any other visual stimuli associated with the offshore Project will have any adverse effects on diadromous fish. Furthermore, the offshore Project area is located far from the coast where visual or olfactory stimuli for returning to natal rivers are expected to play a more important role in navigation for Atlantic salmon (Keefer and Caudill, 2014). Considering the above, visual effects are considered unlikely to result in a barrier effect to diadromous fish.

It should also be noted that there would be no continuous noise or visual effects in the nearshore area. Furthermore, as described in section 11.6.2.2, and summarised in this section, EMF from the offshore Project would be highly localised and undetectable in the intertidal area. Therefore, no barrier to movement in the nearshore area would be present for fish migrating to / from the Forss Water (or any other Scottish rivers).

Diadromous fish are national to internationally important receptors. Diadromous fish have some capacity to tolerate barrier effects and diversions if a successful migration can still be made. Therefore, diadromous fish are considered to have a medium vulnerability to barrier effects and are assessed as being of a medium sensitivity. Considering the information presented above on the potential for EMF effects, underwater noise and visual effects to act as a potential barrier to migration, this impact is considered to be continuous, of a local spatial extent, long-term, and is unlikely to substantially reduce the successful migrations of diadromous fish. Therefore, the impact is defined to be of a low magnitude. The assessment for salmonids is also relevant to FWPM who may be indirectly affected by effects on these species.

Evaluation of significance

Taking the medium sensitivity of diadromous fish and the low magnitude of impact, the overall effect of the barrier effects to diadromous fish during operation and maintenance is considered to be minor and not significant in EIA terms.

Sensitivity	Magnitude of impact	Consequence
Medium	Low	Minor
Impact significance - NOT SIGNIFICANT		

11.6.2.5 Indirect effects related to changes in availability or distribution of prey species

As outlined in section 11.4.4.8, sandeels, clupeids (e.g. herring and sprat) and fish present in high biomass (e.g. mackerel and Norway pout) play an important role in the food web. Changes in the availability or distribution of these species may indirectly affect those species that feed on them (including piscivorous fish, marine mammals and birds). The effect of changes on fish prey for marine mammals and birds is assessed in chapter 12: Marine mammals and megafauna and chapter 13: Offshore and intertidal ornithology, respectively. Benthic species can also act as prey species for fish and shellfish receptors. Therefore the impacts discussed in chapter 10: Benthic subtidal and intertidal ecology may indirectly affect fish and shellfish ecology receptors.

Most fish and shellfish ecology receptors are mobile and able to tolerate a degree of change in prey availability and distribution. Atlantic salmon, sea trout, European eel (that prey on small fish, molluscs and crustaceans) and flapper skate (that prey on benthic invertebrates) have undergone significant population reductions in recent years and are considered to be more vulnerable to potential reductions or changes in prey. These species are also highly protected and are therefore of national to international importance. Considering this, and the medium vulnerability of Atlantic salmon, sea trout, European eel and flapper skate to changes in prey availability and distribution, they are assessed to be of medium sensitivity. All other fish and shellfish ecology receptors are considered to have a low vulnerability and are assessed to be of a low sensitivity.

As described in sections 11.6.2.1 to 11.6.2.4, no significant (above minor consequence) effects are expected to arise during the operation and maintenance stage as a result of habitat loss and disturbance, EMF effects, potential fish or predator aggregation, and barrier effects to diadromous fish. The assessment of potential fish or predator aggregation assesses the potential effect of increased predation, with a focus on diadromous fish. It is acknowledged that there may be changes in fish and shellfish communities as a result of the offshore Project but based on the assessment conducted, only a small proportion of the available habitat or prey in the area is anticipated to be affected. Furthermore, the assessment of effects on benthic species (including potential prey) in chapter 10: Benthic subtidal and intertidal ecology also did not identify any significant effects, with all impacts being highly localised, affecting a small area of available foraging habitat. Therefore, changes in prey availability and distribution are not anticipated to have a widespread impact on feeding opportunities. These effects are predicted to be continuous, of a local spatial extent, and long-term. Therefore, impact has been defined as being of a **low magnitude.** The assessment for salmonids is also relevant to FWPM who may be indirectly affected by effects on these species.

Evaluation of significance

Taking the medium sensitivity of Atlantic salmon, sea trout, European eel and flapper skate and the low magnitude of impact, the overall effect of indirect effects related to changes in prey availability and distribution during operation and maintenance is considered to be **minor** and **not significant** in EIA terms.

Taking the low sensitivity of all other fish and shellfish ecology receptors and the low magnitude of impact, the overall effect of indirect effects related to changes in prey availability and distribution during operation and maintenance is considered to be **negligible** and **not significant** in EIA terms.

Receptor	Sensitivity	Magnitude of impact	Consequence
Atlantic salmon, sea trout, European eel and flapper skate	Medium	Low	Minor
All other fish and shellfish ecology receptors	Low	Low	Negligible
Impact significance - NOT SIGNIFICANT			

11.6.3 Potential effects during decommissioning

In the absence of detailed information regarding decommissioning works, the impacts during the decommissioning of the offshore Project are considered analogous with, or likely less than, those of the construction stage.

The worst case scenario for decommissioning will be a clear seabed, where substructures and foundations that extend below the seabed will be cut approximately 1 m below the seabed to allow removal of the substructure. The same applies for the worst case scenario of the offshore export cables, inter-array cables and the interconnector cables; a clear seabed where some materials may be left *in situ*. The cable ends will be buried at an acceptable depth below the seabed and exposed sections of the cable will most likely be cut and removed or subjected to rock placement.

A Decommissioning Programme will be developed and approved pre-construction to address the principal decommissioning measures for the offshore Project, this will be written in accordance with applicable guidance and will detail the management, environmental management and schedule for decommissioning. Prior to the commencement of any decommissioning works, the Decommissioning Programme will be reviewed and revised as required in accordance with the industry practice at that time. The decommissioning activities are expected to take a similar duration as the construction programme.

Given the nature of the decommissioning activities, which will largely be a reversal of the installation process, the impacts during decommissioning are expected to be similar to or less than those assessed for the construction stage. Therefore, the magnitude of impacts assigned to fish and shellfish ecology receptors during the construction stage is also applicable to the decommissioning stage. It is also assumed that the receptor sensitivities will not materially change over the lifetime of the offshore Project. Therefore, the decommissioning effects are not expected to exceed those assessed for construction.

11.6.4 Summary of potential effects

A summary of the outcomes of the assessment of potential effects from the construction, operation and maintenance and decommissioning of the Project is provided in Table 11-27. No significant effects on fish and shellfish ecology receptors were identified. Therefore, mitigation measures in addition to the embedded mitigation measures listed in section 11.5.4 are not considered necessary.

As detailed in the assessment of potential construction, operation and maintenance and decommissioning effects, no significant effects on sandeel designated within the North-West Orkney NCMPA have been identified from the offshore Project alone. The conservation objectives of this site are to:

- "So far as already in favourable condition, remain in such condition; and
- So far as not already in favourable condition, be brought into such condition, remain in such condition."

In the latest conservation statement for this NCMPA (December 2020), sandeels were categorised as being in a favourable condition (JNCC, 2020). As no significant effects are anticipated on sandeels as a result of the offshore Project, including those designated within the North-West Orkney NCMPA, the offshore Project is not expected to hinder the achievement of the site objectives or affect the wider ecosystem benefits that the site supports.

Table 11-27 Summary of potential effects

POTENTIAL EFFECT	RECEPTOR	SENSITIVITY OF RECEPTOR	MAGNITUDE OF IMPACT	CONSEQUENCE (SIGNIFICANCE OF EFFECT)	SECONDARY MITIGATION REQUIREMENTS	RESIDUAL CONSEQUENCE (SIGNIFICANT OF EFFECT)
Construction and decommissioning						
Temporary habitat loss and disturbance	Sandeel	High	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	Herring	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	All other marine finfish	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
	Shellfish	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)

POTENTIAL EFFECT	RECEPTOR	SENSITIVITY OF RECEPTOR	MAGNITUDE OF IMPACT	CONSEQUENCE (SIGNIFICANCE OF EFFECT)	SECONDARY MITIGATION REQUIREMENTS	RESIDUAL CONSEQUENCE (SIGNIFICANT OF EFFECT)
	Flapper skate	High	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	Spotted ray, thornback ray, spurdog and blue skate	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	All other elasmobranchs	Negligible	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
	Diadromous fish	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
Underwater noise	Sandeel	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	All other Group 1 marine finfish	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)

POTENTIAL EFFECT	RECEPTOR	SENSITIVITY OF RECEPTOR	MAGNITUDE OF IMPACT	CONSEQUENCE (SIGNIFICANCE OF EFFECT)	SECONDARY MITIGATION REQUIREMENTS	RESIDUAL CONSEQUENCE (SIGNIFICANT OF EFFECT)
	Group 3 and 4 marine finfish	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	Eggs and larvae	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	Shellfish	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	Elasmobranchs	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
	Salmonids (Atlantic salmon and sea trout), and European eel	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	Lamprey species	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)

POTENTIAL EFFECT	RECEPTOR	SENSITIVITY OF RECEPTOR	MAGNITUDE OF IMPACT	CONSEQUENCE (SIGNIFICANCE OF EFFECT)	SECONDARY MITIGATION REQUIREMENTS	RESIDUAL CONSEQUENCE (SIGNIFICANT OF EFFECT)
Indirect effects related to changes in availability or distribution of prey species	Atlantic salmon, sea trout, European eel and flapper skate	Medium	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
	All other fish and shellfish ecology receptors	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
Operation and maintenance						
Long-term habitat loss and disturbance	Sandeel	High	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	Herring	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	All other marine finfish	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)

POTENTIAL EFFECT	RECEPTOR	SENSITIVITY OF RECEPTOR	MAGNITUDE OF IMPACT	CONSEQUENCE (SIGNIFICANCE OF EFFECT)	SECONDARY MITIGATION REQUIREMENTS	RESIDUAL CONSEQUENCE (SIGNIFICANT OF EFFECT)
	Shellfish	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	Flapper skate	High	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	Spotted ray, thornback ray, spurdog and blue skate	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	All other elasmobranchs	Negligible	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
	Diadromous fish	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
EMF	Marine finfish	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)

POTENTIAL EFFECT	RECEPTOR	SENSITIVITY OF RECEPTOR	MAGNITUDE OF IMPACT	CONSEQUENCE (SIGNIFICANCE OF EFFECT)	SECONDARY MITIGATION REQUIREMENTS	RESIDUAL CONSEQUENCE (SIGNIFICANT OF EFFECT)
	Shellfish	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
	Elasmobranchs	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	Diadromous fish	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
Potential fish or predator aggregation	Marine finfish	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
	Shellfish	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
	Elasmobranchs	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)

POTENTIAL EFFECT	RECEPTOR	SENSITIVITY OF RECEPTOR	MAGNITUDE OF IMPACT	CONSEQUENCE (SIGNIFICANCE OF EFFECT)	SECONDARY MITIGATION REQUIREMENTS	RESIDUAL CONSEQUENCE (SIGNIFICANT OF EFFECT)
	Diadromous fish	High	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
Barrier effects to diadromous fish	Diadromous fish	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
Indirect effects related to changes in availability or distribution of prey species	Atlantic salmon, sea trout, European eel and flapper skate	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	All other fish and shellfish ecology receptors	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)

11.7 Assessment of cumulative effects

11.7.1 Introduction

Potential impacts from the offshore Project have the potential to interact with those from other developments, plans and activities, resulting in cumulative impacts on fish and shellfish ecology receptors. The general approach to the cumulative effects assessment is described in chapter 7: EIA methodology and further detail is provided below.

The list of relevant developments for inclusion within the cumulative effects assessment is outlined in Table 11-28. This has been informed by a screening exercise, undertaken to identify relevant developments for consideration within the cumulative effects assessments for each EIA topic, based on defined Zones of Influence (ZoI). Impacts relating to habitat disturbance are expected to be localised to the offshore Project with a ZoI aligned with chapter 8: Marine physical processes and chapter 10: Benthic subtidal and intertidal ecology (20 km from the OAA and 30 km from the offshore ECC). A similar ZoI has been used for EMF effects, however, this is considered to be conservative due to the extremely localised extent of EMF emissions. However, it is recognised that underwater noise impacts may extend to a further distance and that a greater ZoI needs to be considered for potential impacts on migratory species (e.g. EMF impacts on migratory routes of salmon etc.). Therefore, a 100 km ZoI has been assumed based on the results of the underwater noise modelling. It should be noted that an overlap with the decommissioning activities at the Beatrice Field may overlap with the construction of the offshore Project and lie within the 100 km ZoI from the offshore Project (98 km from OAA and 65 km from offshore ECC). However, the Decommissioning Programmes for the assets state that the main pathway for underwater noise will be from vessels, and therefore, will be highly localised. For this reason, the decommissioning of this asset is not considered further within the cumulative effects assessment.

Table 11-28 List of developments considered for the fish and shellfish ecology cumulative impact assessment

LOCATION	DEVELOPMENT TYPE	DEVELOPMENT NAME	DISTANCE TO OAA (KM)	DISTANCE TO OFFSHORE ECC (KM)	STATUS	CONFIDENCE[13]
West of Orkney	Offshore wind farm (export cables)	West of Orkney Windfarm – transmission connection to the Flotta Hydrogen Hub	0	0	Pre-application	Low

[13] *Confidence ratings have been applied to each cumulative development where: 'Low' = pre-application or application, 'Medium' = consented and 'High' = under construction or operational.*

LOCATION	DEVELOPMENT TYPE	DEVELOPMENT NAME	DISTANCE TO OAA (KM)	DISTANCE TO OFFSHORE ECC (KM)	STATUS	CONFIDENCE[13]
Pentland Firth (Caithness to Mainland Orkney)	Power transmission cable	SHET-L Caithness to Orkney HVAC Link	22	0	Consented	Medium
Muckle Bay, Caithness to Rackwick Bay, Orkney	Power distribution cable	Pentland Firth East (3) Cable Replacement	26	11	Under construction	High
Bay of Deepdale, Scapa Flow	Port / harbour	Scapa Deep Water Quay	55	52	Pre-application	Low
Pentland Firth	Offshore wind farm	Pentland Floating Offshore Wind Farm (PFOWF)[14]	20	2	Consented	Medium
Moray Firth	Offshore wind farm	Caledonia Offshore Wind Farm	92	64	Pre-application	Low

The following impacts have been taken forward for the cumulative assessment:

- Construction and decommissioning;
  – Temporary habitat disturbance and loss;
  – Underwater noise; and
  – Indirect effects related to changes in availability or distribution of prey species;
- Operation and maintenance;
  – Habitat loss and disturbance;
  – EMF effects;
  – Potential fish or predator aggregation;
  – Barrier effects to diadromous fish; and
  – Indirect effects related to changes in availability or distribution of prey species.

[14] Pentland Floating Offshore Wind Farm (PFOWF) will incorporate the currently consented Pentland Floating Offshore Wind Demonstrator turbine, and hence PFOWF only has been considered. The PFOWF Section 36 Consent and Marine Licence was granted for 10 years. However, the cumulative effects assessment has been based on the Project Design Envelope, as specified within the EIA, and therefore, an operational life of up to 30 years for the PFOWF has been considered. Since consent was granted in June 2023, PFOWF have submitted a Screening Report to MD-LOT with the intention to request a variation to the Section 36 Consent. This variation will incorporate refinements to the Project Design Envelope and to extend the operational life to 25 years.

11.7.2 Cumulative construction effects

11.7.2.1 Temporary habitat disturbance and loss

As described above for the offshore Project alone, the most sensitive fish and shellfish receptors to habitat loss are sandeels, herring, oviparous elasmobranchs (including flapper skate) and shellfish. The sensitivities presented for the offshore Project alone are also relevant for the cumulative effects assessment.

The types of developments considered within the cumulative effects assessment are those within 20 km of the OAA and within 30 km of the offshore ECC and include: the West of Orkney Windfarm transmission connection to the Flotta Hydrogen Hub, the SHET-L Caithness to Orkney HVAC Link, the PFOWF and the Pentland Firth East (3) Cable Replacement. There will be temporary seabed disturbance during the construction of these three developments. The replacement works for the Pentland Firth East (3) Cable replacement are anticipated to be complete by August 2023, and therefore, these will not overlap with the offshore Project construction stage. The construction timelines for the West of Orkney Windfarm transmission connection to the Flotta Hydrogen Hub are unknown, however, an overlap with the construction of the offshore Project cannot be ruled out. It is also possible that the SHET-L Caithness to Orkney HVAC Link may be constructed at the same time as the offshore Project.

There is limited information available for the West of Orkney Windfarm transmission connection. However, it is anticipated that up to five offshore export cables may be installed, with a length of up to 340 km to Hoy. For the SHET-L Caithness to Orkney HVAC Link, it is anticipated that up to 1 km^2 of temporary habitat loss and disturbance may result from the seabed preparation and cable installation activities (SSE, 2019). It is expected that for both of these cable installation developments, any temporary disturbance will be highly localised with some recovery of the seabed once the installation activities are completed. Furthermore, it likely that the temporal overlap in the construction activities of these developments and the offshore Project will be limited.

The PFOWF will be in its operation and maintenance stage during the offshore Project construction. Therefore, any temporary habitat loss during the operation and maintenance stage is expected to be highly localised.

Overall, the temporary habitat loss of the cumulative developments will not substantially increase that which is associated with the offshore Project. Therefore, the impact remains as being at a low magnitude for all receptors. Therefore, the overall effect is assessed to be minor for sandeel, herring, spotted ray, thornback ray, spurdog, blue skate, flapper skate and shellfish, and negligible for all other receptors. All cumulative effects are not significant in EIA terms.

11.7.2.2 Underwater noise

The cumulative developments with the greatest potential to result in a cumulative effect is considered to be the Caledonia offshore wind farm and the Scapa Deep Water Quay which may be constructed at the same time as the offshore Project and will involve similar activities to the offshore Project such as impact piling and UXO clearance. Other anthropogenic underwater noise generating activities such as cable laying, trenching, remedial protection and installation vessels only have the potential to cause injury and behavioural effects at a more localised scale.

There are limited details available for the Caledonia offshore wind farm as it is currently at the scoping stage. Based on the information available within the Scoping Report, the construction period is expected to commence in 2028 and last for three years. Up to 150 WTGs and 6 OSPs may be installed and a range of foundations options may be utilised, potentially installed by impact piling. UXO clearance may also be required. No further details are provided within the Caledonia offshore wind scoping report (Ocean Winds, 2022).

Available information on the Orkney Harbours website[15] states that the Scapa Deep Water Quay may be constructed between 2024 and complete by early 2027, and therefore, there is the potential to overlap with some of the pre-construction activities (e.g. UXO clearance). Information available in the Scoping Report for this development states that impact piling may be required for the quay wall (Orkney Island Council Harbour Authority, 2021).

The Caledonia offshore wind farm is approximately 98 km from the OAA where piling activities and UXO clearance could occur and 65 km from the offshore ECC where UXO clearance could occur. The Scapa Deep Water Quay is located approximately 55 km from the OAA and 52 km from the offshore ECC. It is considered unlikely that piling activities at the Caledonia offshore wind farm and the Scapa Deep Water Quay will be concurrent with the offshore Project, and if this does occur, it is highly unlikely that this will occur for a substantial length of time. Furthermore, considering this distance exceeds the impact ranges for injury from the offshore Project, and the fact that piling and UXO clearance will be temporary and intermittent, the potential for the Caledonia offshore wind farm and the Scapa Deep Water Quay to increase the significant of the effects associated with the offshore Project is low. Therefore, the impact remains as being low magnitude for all fish and shellfish ecology receptors. The overall effect is assessed to be minor for all receptors, with the exception of Group 1 marine finfish (excluding sandeel), elasmobranchs and lamprey species, for which the overall effect is assessed to be negligible. All cumulative effects are not significant in EIA terms.

11.7.2.3 Indirect effects related to changes in availability or distribution of prey species

Other cumulative developments may result in changes in fish or invertebrate abundance and distribution which could affect the availability of prey for fish and shellfish ecology receptors during the construction stage. The sensitivities presented for the offshore Project alone are also relevant to the cumulative effects assessment.

As described in sections 11.7.2.1 and 11.7.2.2, the effects of the offshore Project alone are not expected to be substantially exacerbated by impacts associated with other cumulative developments. The impact remains as being at a low magnitude, and therefore the overall effect remains as being minor for Atlantic salmon, seatrout, European eel and flapper skate and negligible for all other fish and shellfish ecology receptors. All cumulative effects are not significant in EIA terms.

[15] *https://orkneyharboursmasterplan.com/faq*.

11.7.3 Cumulative operation and maintenance effects

11.7.3.1 Long-term habitat loss and disturbance

As described above for the offshore Project alone, the most sensitive fish and shellfish receptors to habitat loss are sandeels, herring, oviparous elasmobranchs (including flapper skate) and shellfish. The sensitivities presented for the offshore Project alone are also relevant for the cumulative effects assessment.

The types of developments considered within the cumulative impact assessment are those within 20 km of the OAA and within 30 km of the offshore ECC and include: the West of Orkney Windfarm transmission connection to the Flotta Hydrogen Hub, the SHET-L Caithness to Orkney HVAC Link, the PFOWF and the Pentland Firth East (3) Cable Replacement. There will be long-term habitat loss associated with the introduction of hard substrate associated with these cumulative developments. There is limited information available for the West of Orkney Windfarm transmission connection. However, it is anticipated that up to five offshore export cables may be installed, with a length of up to 340 km to Hoy. For the SHET-L Caithness to Orkney HVAC Link, it is anticipated that up to 1.03 km^2 of long-term habitat loss and disturbance may occur (SSE, 2019). The operation and maintenance of the PFOWF will overlap with the operation and maintenance of the offshore Project. The area of potential long-term habitat loss associated with this development was estimated at 0.22 km^2 plus an additional 2.205 km^2 associated with the continuous abrasion associated with the mooring lines for this development (Highland Wind Limited, 2022). Long-term habitat loss associated with the Pentland Firth East (3) Cable Replacement will occur in areas of cable protection, and this is anticipated to be highly localised.

Overall, the habitat loss of the cumulative developments will not substantially increase that which is associated with the offshore Project. Therefore, the impact remains as being at a low magnitude for all receptors. Therefore, the overall effect is assessed to be minor for sandeel, herring, spotted ray, thornback ray, spurdog, blue skate, flapper skate and shellfish and negligible for all other receptors. All cumulative effects are not significant in EIA terms.

11.7.3.2 EMF effects

As described above for the offshore Project alone, the most sensitive fish and shellfish receptors are elasmobranchs and diadromous fish, which have been identified as medium sensitivity receptors. All other fish and shellfish ecology receptors are assessed to have a low sensitivity to EMF effects.

The range of EMF from subsea cables is very localised, therefore, only the SHET-L Caithness to Orkney HVAC Link, the PFOWF, the West of Orkney Windfarm transmission connection to the Flotta Hydrogen Hub and the Pentland Firth East (3) Cable replacement have been considered as having the potential to act cumulatively with the offshore Project. The SHET-L Caithness to Orkney HVAC Link, the PFOWF and the Pentland Firth East (3) Cable replacement state commitments to burying cables to a sufficient depth where possible or, where burial is not possible, cable protection measures will be applied to reduce the effects of EMF (SSE, 2019; Highland Wind Limited, 2022; SSE, 2022). PFOWF will also consist of suspended cables in the water column. However, the EMF effects associated with these cables are also anticipated to be highly localised.

The offshore Project may have to cross the SHET-L Caithness to Orkney HVAC Link. The crossing will be in line with industry best practice to reduce any potential damage and in accordance with a crossing agreement, sought between

SHET-L and OWPL. Proximity agreements will also be developed, if required, and these will seek agreement on how close construction activities can occur to existing infrastructure. Any cumulative EMF levels are anticipated to be highly localised. Proximity agreements will be in place, and therefore, the cables will not be close enough to cause cumulative EMF effects, with the exception of the point of crossing, where the cables will be protected. Therefore, the impact is still considered to be low magnitude, making the overall effect minor for elasmobranchs and diadromous fish and negligible for all other fish and shellfish ecology receptors. Therefore, the cumulative effect is not significant in EIA terms.

11.7.3.3 Potential fish or predator aggregation

As described for the offshore Project alone, diadromous fish are considered to be most sensitive to potential predator aggregation and is assessed as having a high sensitivity. All other fish and shellfish receptors are assessed as having a low sensitivity.

The potential areas of artificial reef or fish aggregation will be localised to discrete areas around the WTGs, OSPs, scour protection and cable protection associated with the inter-array cables, interconnector cables and offshore export cables. Therefore, only the SHET-L Caithness to Orkney HVAC Link, the PFOWF and the West of Orkney Windfarm transmission connection to the Flotta Hydrogen Hub have been considered as having the potential to act cumulatively with the offshore Project.

As described for the cumulative assessment for long-term habitat loss and disturbance, the SHET-L Caithness to Orkney HVAC Link may result in up to 1.03 km^2 of habitat loss. Hard substrate will be introduced in areas of cable protection. However, as noted in the Marine Environmental Appraisal (MEA) for this development, the offshore areas of the cable installation corridor for the SHET-L Caithness to Orkney HVAC Link are located in areas with rocky substrates, and thus, any potential reef effect would be minimal (SSE, 2019). The long-term seabed footprint associated with the PFOWF extends to a total of 0.22 km^2. As the PFOWF will also include up to 7 WTGs, 63 mooring lines and 7 dynamic cables in the water column that may become fouled (although anti-fouling paint will be used to minimise this), there is the potential that this development would also act as a FAD (Highland Wind Limited, 2022). As described previously, details on the West of Orkney Windfarm transmission connection to the Flotta Hydrogen Hub are limited. However, it would be expected that some hard substrate may be required for cable protection, which could result in artificial reef effects.

Overall, the potential reef or FAD effects of the cumulative developments will be highly localised and are not expected to substantially increase that which is associated with the offshore Project. Therefore, the impact remains as being at a low magnitude for all receptors. Therefore, the overall effect is assessed to be minor for diadromous fish and negligible for all other fish and shellfish ecology receptors. All cumulative effects are not significant in EIA terms.

11.7.3.4 Barrier effects to diadromous fish

The impacts of the offshore Project that may present a barrier to migration for diadromous fish are highly localised (EMF effects, operational noise and visual effects). As described for the offshore Project, diadromous fish are assessed as having a medium sensitivity.

As outlined in section 11.7.3.2, it is expected the cables associated with the SHET-L Caithness to Orkney HVAC Link, the PFOWF, the West of Orkney Windfarm transmission connection to the Flotta Hydrogen Hub and the Pentland Firth East (3) Cable replacement will be buried or protected to minimise potential EMF effects. Overall, the EMF effects associated with these nearby developments will be highly localised, and therefore, the overall effect remains as being minor, as described above. The PFOWF is the only cumulative development that is considered to have the potential to act cumulatively with any operational noise or visual effects associated with the offshore Project that could result in a barrier effect to diadromous fish. However, the PFOWF will consist of up to seven WTGs only, and therefore, any cumulative noise or visual effects would be localised in extent and still leave large areas unaffected.

Considering the above, there is considered to be a limited potential for cumulative developments to increase the magnitude of the barrier effects from the offshore Project. There are only a small number of cumulative developments in the vicinity of the offshore Project, and therefore, the potential for a cumulative effect in relation to any barriers to migration are limited, including to / from Forss Water as fish are expected to have some capacity to tolerate a small number of diversions. There are no developments in the nearshore area of the offshore Project that could affect post-smolts in their early stages of migration from Forss Water. Therefore, the impact remains as being of low magnitude and the overall effect is assessed to be minor. This cumulative effect is not significant in EIA terms.

11.7.3.5 Indirect effects related to changes in availability and distribution of prey species

Other cumulative developments may result in changes in fish or invertebrate abundance and distribution which could affect the availability of prey for fish and shellfish ecology receptors during the operation and maintenance. The sensitivities presented for the offshore Project alone are also relevant to the cumulative effects assessment.

As described in sections 11.7.3.1 to 11.7.3.4, the effects of the offshore Project alone are not expected to be substantially exacerbated by impacts associated with other cumulative developments. The impact remains as being at a low magnitude, and therefore the overall effect remains as being minor for Atlantic salmon, seatrout, European eel and flapper skate and negligible for all other fish and shellfish ecology receptors. All cumulative effects are not significant in EIA terms.

11.7.4 Cumulative decommissioning effects

There is limited information on the decommissioning of the offshore Project and that of other developments. However, the cumulative effects are expected to be less than or equal to the construction stage. Furthermore, decommissioning of multiple other developments would not be expected to occur at the same time as the decommissioning stage of the offshore Project.

A Decommissioning Programme will be developed pre-construction to address the principal decommissioning measures for the offshore Project and will be written in accordance with applicable guidance. The Decommissioning Programme will detail the environmental management, and schedule for decommissioning and will be reviewed and updated throughout the lifetime of the offshore Project to account for changing best practices.

11.7.5 Summary of cumulative effects

A summary of the outcomes of the assessment of cumulative effects for the construction, operation and maintenance and decommissioning stages of the offshore Project is provided in Table 11-29.

As detailed in the assessment of potential cumulative construction, operation and maintenance and decommissioning effects, no significant cumulative effects on sandeel designated within the North-West Orkney NCMPA have been identified from the offshore Project alone. The conservation objectives of this site are to:

- "So far as already in favourable condition, remain in such condition; and
- so far as not already in favourable condition, be brought into such condition, remain in such condition."

In the latest conservation statement for this NCMPA (December 2020), sandeels were categorised as being in a favourable condition (JNCC, 2020). As no significant cumulative effects are anticipated on sandeels as a result of the offshore Project, including those designated within the North-West Orkney NCMPA, the offshore Project is not expected to hinder the achievement of the site objectives or affect the wider ecosystem benefits that the site supports, either alone (as described in section 11.6.4) or cumulatively with other developments. None of the cumulative developments identified are expected to overlap with the North-West Orkney NCMPA.

Table 11-29 Summary of assessment of cumulative effects

POTENTIAL EFFECT	RECEPTOR	SENSITIVITY OF RECEPTOR	MAGNITUDE OF IMPACT	CONSEQUENCE (SIGNIFICANCE OF EFFECT)	SECONDARY MITIGATION REQUIREMENTS	RESIDUAL CONSEQUENCE (SIGNIFICANT OF EFFECT)
Construction and decommissioning						
Temporary habitat loss and disturbance	Sandeel	High	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	Herring	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	All other marine finfish	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
	Shellfish	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	Flapper skate	High	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)

POTENTIAL EFFECT	RECEPTOR	SENSITIVITY OF RECEPTOR	MAGNITUDE OF IMPACT	CONSEQUENCE (SIGNIFICANCE OF EFFECT)	SECONDARY MITIGATION REQUIREMENTS	RESIDUAL CONSEQUENCE (SIGNIFICANT OF EFFECT)
	Spotted ray, thornback ray, spurdog and blue skate	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	All other elasmobranchs	Negligible	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
	Diadromous fish	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
Underwater noise	Sandeel	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	All other Group 1 marine finfish	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
	Group 3 and 4 marine finfish	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)

POTENTIAL EFFECT	RECEPTOR	SENSITIVITY OF RECEPTOR	MAGNITUDE OF IMPACT	CONSEQUENCE (SIGNIFICANCE OF EFFECT)	SECONDARY MITIGATION REQUIREMENTS	RESIDUAL CONSEQUENCE (SIGNIFICANT OF EFFECT)
	Eggs and larvae	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	Shellfish	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	Elasmobranchs	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
	Salmonids (Atlantic salmon and sea trout), and European eel	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	Lamprey species	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
Indirect effects related to changes in availability or	Atlantic salmon, sea trout, European eel and flapper skate	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)

POTENTIAL EFFECT	RECEPTOR	SENSITIVITY OF RECEPTOR	MAGNITUDE OF IMPACT	CONSEQUENCE (SIGNIFICANCE OF EFFECT)	SECONDARY MITIGATION REQUIREMENTS	RESIDUAL CONSEQUENCE (SIGNIFICANT OF EFFECT)
distribution of prey species	All other fish and shellfish ecology receptors	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
Operation and maintenance						
Long-term habitat loss and disturbance	Sandeel	High	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	Herring	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	All other marine finfish	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
	Shellfish	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)

POTENTIAL EFFECT	RECEPTOR	SENSITIVITY OF RECEPTOR	MAGNITUDE OF IMPACT	CONSEQUENCE (SIGNIFICANCE OF EFFECT)	SECONDARY MITIGATION REQUIREMENTS	RESIDUAL CONSEQUENCE (SIGNIFICANT OF EFFECT)
	Flapper skate	High	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	Spotted ray, thornback ray, spurdog and blue skate	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	All other elasmobranchs	Negligible	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
	Diadromous fish	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
EMF	Marine finfish	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
	Shellfish	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)

POTENTIAL EFFECT	RECEPTOR	SENSITIVITY OF RECEPTOR	MAGNITUDE OF IMPACT	CONSEQUENCE (SIGNIFICANCE OF EFFECT)	SECONDARY MITIGATION REQUIREMENTS	RESIDUAL CONSEQUENCE (SIGNIFICANT OF EFFECT)
	Elasmobranchs	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	Diadromous fish	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
Potential fish or predator aggregation	Marine finfish	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
	Shellfish	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
	Elasmobranchs	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)
	Diadromous fish	High	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)

POTENTIAL EFFECT	RECEPTOR	SENSITIVITY OF RECEPTOR	MAGNITUDE OF IMPACT	CONSEQUENCE (SIGNIFICANCE OF EFFECT)	SECONDARY MITIGATION REQUIREMENTS	RESIDUAL CONSEQUENCE (SIGNIFICANT OF EFFECT)
Barrier effects to diadromous fish	Diadromous fish	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
Indirect effects related to changes in availability or distribution of prey species	Atlantic salmon, sea trout, European eel and flapper skate	Medium	Low	Minor (not significant)	None required above embedded mitigation measures.	Minor (not significant)
	All other fish and shellfish ecology receptors	Low	Low	Negligible (not significant)	None required above embedded mitigation measures.	Negligible (not significant)

11.8 Inter-related effects

Inter-related effects are the potential effects of multiple impacts, affecting one receptor or a group of receptors. Inter-related effects include interactions between the impacts of the different stages of the offshore Project (i.e. interaction of impacts across construction, operation and maintenance and decommissioning), as well as the interaction between impacts on a receptor within an offshore Project stage. The potential inter-related effects for fish and shellfish ecology receptors are described below.

11.8.1 Inter-related effects between offshore Project stages

All offshore Project stages have the potential to impact various fish and shellfish ecology receptors. Impacts relating to EMF and potential reef effects or fish and predator aggregation will only occur during the operation and maintenance stage. Therefore, there will be no combined effect with the construction or decommissioning stages.

Habitat loss and disturbance during operation and maintenance may occur in the same areas as construction and decommissioning (e.g. WTG and OSP foundations (and associated scour protection) will be located in areas disturbed by bedform clearance). However, the majority of habitat disturbance and loss during the construction stage will be temporary and localised, with a recovery of the seabed once construction activities have ceased. Therefore, there is considered to be a limited potential for an interaction between the habitat loss and disturbance during the construction, operation and maintenance and decommissioning stages to result in a greater effect than when each stage is assessed in isolation.

The majority of underwater noise disturbance associated with the offshore Project will occur from impact piling activities and UXO clearance in the construction stage. Underwater noise during the operation and maintenance stage will be highly localised and this impact was scoped out for all receptors with the exception of barrier effects to diadromous fish. Underwater noise during construction will be intermittent and temporary, and once the piling activities and UXO clearance activities have ceased, no displacement or barrier effect would be expected to persist as a result of these activities. Therefore, there is considered to be a limited potential for an interaction between the underwater noise (and barrier effects to diadromous fish) during the construction, operation and maintenance and decommissioning stages to result in a greater effect than when each stage is assessed in isolation.

11.8.2 Inter-related effects within an offshore Project stage

During the construction and decommissioning stages, underwater noise effects associated with impact piling and UXO clearance will have the greatest spatial extent. Therefore, there is a limited area of spatial overlap with any highly localised temporary habitat loss and disturbance or changes in prey availability and distribution. Therefore, only a small number of individuals will be concurrently affected by these three temporary impacts. Considering this, the combined effect of these three impacts during the construction and decommissioning stages is not expected to result in a greater effect than the assessment of these impacts in isolation.

During the operation and maintenance stage, the spatial extent associated with habitat loss and disturbance, EMF and potential reef effects or fish and predator aggregation will be similar, and receptors may be affected by these impacts simultaneously. However, considering the highly localised extent of these effects, the combined effect of these impacts during the operation and maintenance stage is not expected to result in a greater effect than the assessment of these impacts in isolation.

The assessment of potential barrier effects to diadromous fish has considered the interaction between EMF, underwater noise and visual effects. Therefore, no combined effect greater than what has already been assessed is expected.

11.9 Whole Project assessment

The onshore Project is summarised in chapter 5: Project description and a summary of the effects of the onshore Project is provided in chapter 21: Onshore EIA summary. These onshore aspects of the Project have been considered in relation to the impacts assessed in section 11.6. The findings are presented below.

The onshore Project may potentially impact diadromous fish that have life history strategies that utilise the freshwater environment (e.g. damage to freshwater habitats or interruptions to fish passage). Effects on freshwater ecology will be mitigated using standard embedded mitigation measures (e.g. standard best practice mitigation to avoid sedimentation and pollution) and in line with any conditions issued under the Planning Permission in Principle and/or licences issued under the Controlled Activities (Scotland) Regulations 2005 (CAR). Therefore, the potential for effects is expected to be low and no significant effects are expected to arise.

The onshore Project will undertake HDD operations above Mean High Water Springs (MHWS), with an HDD exit point offshore. The impacts from the HDD exit point on fish and shellfish ecology receptors have been assessed in full in section 11.6. It is not anticipated that there will be any additional impacts from the onshore Project on fish and shellfish ecology receptors within the marine environment as all other activities from the onshore Project are fully terrestrial.

11.10 Ecosystem effects

Fish and shellfish operate at various levels of the food chain, acting as both predators and prey and playing an important role in the transfer of energy (both consumption and production) across trophic levels within the ecosystem (BEIS, 2022). A holistic approach has been undertaken in the identification of impacts to consider any potential impacts that may occur at an ecosystem scale and particularly across trophic levels (e.g. impacts on prey species affecting their availability for predators). Changes in the availability or distribution of fish and shellfish species can have cascading effect on other species within the ecosystem and may indirectly affect those species that feed on them (predator species including piscivorous fish, marine mammals and birds) and also the species that they feed upon (prey-species including fish and shellfish and benthic species).

Benthic species (along with other fish and shellfish) can act as prey species for fish and shellfish receptors. Therefore, the impacts discussed in chapter 10: Benthic subtidal and intertidal ecology may indirectly affect certain fish and shellfish ecology receptors. As assessed in section 11.6.1.3 and 11.6.2.5 no significant effect has been concluded as a result of indirect effects related to in availability or distribution of prey species.

The effect of changes on fish prey for marine mammals and offshore ornithology is assessed in chapter 12: Marine mammals and megafauna and chapter 13: Offshore and intertidal ornithology, respectively. Marine mammals and megafauna, as largely generalist feeders, highly mobile and wide ranging were considered to be of low sensitivity to changes in prey availability. A number of offshore ornithology species (kittiwakes, Arctic terns, guillemots, razorbills, puffins, fulmars and gannets) are considered to be of medium sensitivity to indirect effects to prey species. The fish and shellfish assessment has concluded that there will be no significant effects and as such no significant effect has also been concluded for indirect effects to marine mammals and megafauna and offshore ornithology.

Changes in predator distribution and abundance also have the potential to effect fish and shellfish prey species, for example, resulting from predator aggregation around the subsea infrastructure at the offshore Project (as assessed in section 11.6.2.3). However, no significant effects on predator species, including piscivorous fish, marine mammals or ornithology receptors were identified, including in relation to predator aggregation (see section 11.6.2.3, chapter 12: Marine mammals and megafauna and chapter 13: Offshore and intertidal ornithology for further details).

Consideration of ecosystem effects has been considered holistically throughout the ecological chapters of the Offshore EIA. The fish and shellfish assessment has concluded that there are no significant effects to fish and shellfish species. As such there will be no significant implications to any prey species due to changes in predators and no significant effects to predator species due to changes in prey availability. No ecosystem effects are concluded.

11.11 Transboundary effects

Transboundary effects arise when impacts from a development within one European Economic Area (EEA) state's territory affects the environment of another EEA state(s). Fish, particularly diadromous fish, are mobile species and may extend beyond Scottish or UK waters. Furthermore, as described in chapter 14: Commercial fisheries, non-UK fishing activity does occur in the vicinity of the offshore Project, and these receptors could be affected by impacts on commercially important species. Therefore, there is the potential for transboundary impacts upon fish and shellfish ecology receptors due to construction, operation and maintenance and decommissioning of the offshore Project. The potential transboundary impacts for fish and shellfish ecology receptors include:

- Habitat loss and disturbance;
- Underwater noise;
- Potential fish or predator aggregation;
- EMF;
- Barrier effects to diadromous fish; and
- Indirect effects related to changes in availability or distribution of prey species.

The assessment of potential effects from the offshore Project alone and cumulatively with other developments has been undertaken based on the distribution of fish and shellfish ecology receptors being independent of national geographical boundaries. Therefore, the assessments presented within this chapter are also anticipated to be relevant to other EEA state(s). Consequently, there is no potential for any significant transboundary effects upon fish and shellfish receptors due to construction, operation and maintenance and decommissioning of the offshore Project. The potential impacts are localised and are not expected to affect other EEA states (other than insignificantly).

11.12 Summary of mitigation and monitoring

No secondary mitigation, over and above the embedded mitigation measures proposed in section 11.5.4, is either required or proposed in relation to the potential effects of the offshore Project on fish and shellfish ecology receptors, as no adverse significant impacts are predicted.

Details of the monitoring have not yet been confirmed. There are potential uncertainties in the knowledge base in relation to the diadromous fish abundance, distribution and origin within the offshore Project area. There remain data gaps in our understanding of the spatial and temporal patterns of diadromous fish movements not only in the offshore Project area but throughout / around Scotland. Strategic research initiatives beyond the scope of a single project developer are required to address these data gaps, as identified in the ScotMER diadromous fish and fish and fisheries evidence maps.

The final details of the monitoring will be presented within the Project Environmental Monitoring Plan (PEMP) that will be subject to approval as part of the discharge of consent conditions.

ScotMER

The ScotMER fish and fisheries[16] and diadromous fish[17] receptor groups have identified a number of key research themes which this EIA can both inform and address as the Project moves forward to development. These include:

- Data and mapping; surveys trials and monitoring; spatial and temporal distribution (diadromous fish) – the Project has undertaken an eDNA analysis of water samples collected throughout the offshore Project area, for fish and invertebrate communities. This is a novel approach to baseline characterisation for offshore wind projects;
- Stakeholder engagement – extensive stakeholder engagement with respect to fish and fisheries, including establishment of a Project specific Commercial Fisheries Working Group, has provided essential input to the EIA; and
- Surveys trials and monitoring – commitment to support strategic research initiatives to address data gaps identified by ScotMER.

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[16] https://www.gov.scot/publications/fish-and-fisheries-specialist-receptor-group/#:~:text=The%20Fish%20and%20Fisheries%20ScotMER%20Receptor%20Group%20is,related%20to%20fish%20ecology%20and%20the%20fishing%20industry.

[17] https://www.gov.scot/publications/diadromous-fish-specialist-receptor-group/#:~:text=The%20Diadromous%20Fish%20ScotMER%20Receptor%20Group%20is%20concerned,impacts%20on%20Diadromous%20fish%20%28salmon%2C%20sea%20trout%2C%20etc.%29.

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11.14 Abbreviations

TERM	DEFINITION
1SW	One Sea-Winter
AC	Alternating Current
AIS	Automatic Identification System
AST	Atlantic Salmon Trust
BEIS	Department for Business, Energy and Industrial Strategy
B-field	Magnetic field
CaP	Cable Plan
CAR	Controlled Activities (Scotland) Regulations
CBD	Convention on Biological Diversity
CBRA	Cable Burial Risk Assessment
CDSFB	Caithness District Salmon Fisheries Board
Cefas	The Centre for Environment, Fisheries and Aquaculture Science
CMS	Construction Method Statement
CPS	Cable Protection System
CPUE	Catch Per Unit Effort
DC	Direct Current
DDV	Drop Down Video
DSFB	District Salmon Fisheries Board

TERM	DEFINITION
ECC	Export Cable Corridor
ECoW	Environmental Clerk of Works
eDNA	Environmental DNA
EEA	Exclusive Economic Area
E-field	Electric field
EIA	Environmental Impact Assessment
EMF	Electromagnetic Field
EMP	Environmental Management Plan
EPS	European Protected Species
FAD	Fish Aggregation Device
FeAST	Feature Activity Sensitivity Tool
FMS	Fisheries Management Scotland
FWPM	Freshwater Pearl Mussel
GMF	Geomagnetic Field
HDD	Horizontal Directional Drilling
HRA	Habitats Regulation Appraisal
HVAC	High Voltage Alternating Current
HVDC	High Voltage Directional Current
Hz	Hertz

TERM	DEFINITION
IBTS	International Bottom Trawl Survey
ICES	International Council for Exploration of the Sea
iE-field	Induced electric field
IFG	Inshore Fisheries Group
IHLS	International Herring Larvae Survey
INNS	Invasive Non-Native Species
INTOG	Innovation and Targeted Oil and Gas
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
LAT	Lowest Astronomical Tide
LSE	Likely Significant Effect
MarLIN	Marine Life Information Network
MARPOL	International Convention for the Prevention of Pollution from Ships
MD-LOT	Marine Directorate - Licensing Operations Team
MEA	Marine Environmental Appraisal
MHWS	Mean High Water Springs
MMO	Marine Management Organisation
MPCP	Marine Pollution Contingency Plan
MSS	Marine Scotland Science

TERM	DEFINITION
MS-LOT	Marine Scotland - Licensing Operations Team
MSW	Multiple Winters at Sea
MW	Megawatt
NCMPA	Nature Conservation Marine Protected Area
NDSFB	Northern District Salmon Fisheries Board
NECRIFG	North and East Coast Regional Inshore Fisheries Group
nm	nautical miles
NMPI	National Marine Plan Interactive
OAA	Option Agreement Area
OESEA	Offshore Energy Strategic Environmental Assessment
OFA	Orkney Fisheries Association
OIC	Orkney Islands Council
OSF	Orkney Sustainable Fisheries
OSP	Offshore Substation Platform
OIRMP	Orkney Islands Regional Marine Plan
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic
OWPL	Offshore Wind Power Limited
PEMP	Project Environmental Monitoring Plan
PFOWF	Pentland Floating Offshore Wind Farm

TERM	DEFINITION
PMF	Priority Marine Feature
PS	Piling Strategy
PSA	Particle Size Analysis
RIAA	Report to Inform the Appropriate Assessment
SAC	Special Area of Conservation
ScotMER	Scottish Marine Energy Research
SEL	Sound Exposure Level
SFF	Scottish Fishermen's Federation
SHET-L	Scottish Hydro Electric Transmission Limited
SOPEP	Shipboard Oil Pollution Emergency Plans
SPL	Sound Pressure Level
SST	Seasonal Sensitivity Table
TAC	Total Allowable Catch
TTS	Temporary Threshold Shift
UK	United Kingdom
USB	Universal Serial Bus
UXO	Unexploded Ordnance
WTG	Wind Turbine Generator
ZoI	Zone of Influence

11.15 Glossary

TERM	DEFINITION
Anadromy	Life history strategy where a species migrates from marine waters to freshwater to spawn.
Catadromy	Life history strategy where a species migrates from freshwater to spawn in seas and oceans.
Clupeid	Fish of the Clupeidae family (e.g. herring and sprat).
Crustacean	Large, mainly aquatic arthropods (e.g. crabs and lobster).
Demersal marine finfish	Fish that live on or near the seabed.
Diadromous fish	Fish that migrate between freshwater and marine environments to fulfil their lifecycle.
eDNA	DNA that accumulates in the environment (e.g. through excretions or secretions), rather than through direct sampling of an organism.
Elasmobranch	Cartilaginous fish.
Gadoid	Fish from the Gadiformes order (e.g. cod, haddock and whiting).
Glochidial	Microscopic larval stage of some freshwater mussels.
ICES rectangle	Standardised 30 min latitude by 1 degree longitude' rectangle part of a gridded system used to divide sea areas for statistical analysis.
Pelagic marine finfish	Fish that live in the water column.
Piscivorous	Feeding on fish.
Swim bladder	Gas filled sac present in teleost fish.
Temporary Threshold Shift	A temporary reduction in hearing sensitivity after a noise exposure.