Salamander Offshore Wind Farm

Offshore EIA Report

Volume ER.A.3, Chapter 10: Fish and Shellfish Ecology

SALAMANDER

Powered by Ørsted and
Simply Blue Group

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Glossary

Term	Definition
Applicant	Salamander Wind Project Company Limited (formerly called Simply Blue Energy (Scotland) Limited), a joint venture between Ørsted, Simply Blue Group, and Subsea7.
Cumulative Effects	The combined effect of the Offshore Development with the effects from a number of different projects, on the same single receptor/resource.
Cumulative Impact	Impacts that result from changes caused by other past, present or reasonably foreseeable actions together with the Offshore Development.
Design Envelope	A description of the range of possible elements that make up the Salamander Project design options under consideration, as set out in detail in the project description. This envelope is used to define the Salamander Project for Environmental Impact Assessment (EIA) purposes when the exact engineering parameters are not yet known.
Effect	Term used to express the consequence of an impact. The significance of an effect is determined by correlating the magnitude of the impact with the importance, or sensitivity, of the receptor or resource in accordance with defined significance criteria.
Environmental Impact Assessment (EIA)	A statutory process by which the significant effects of certain projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information, which fulfils the assessment requirements of the Environmental Impact Assessment (Scotland) Regulations (2017), including the publication of an Environmental Impact Assessment Report (EIAR).
EIA Regulations	The regulations that apply to this project are the Electricity Works (EIA) (Scotland) Regulations 2017, the Marine Works (EIA) (Scotland) Regulations 2017, the Marine Works (EIA) Regulations 2007, and the Town and Country Planning (EIA) (Scotland) Regulations 2017.
Fish and Shellfish Ecology Study Area	The area of interest when characterising baseline fish and shellfish ecology and potential impacts of the proposed development upon fish and shellfish receptors. Defined as ICES Statistical Rectangles 43E8, 43E9, 44E7, 44E8, and 44E9, totalling 15,057,737,171 m² or approximately 15,058 km².

Term	Definition
Habitats Regulations Appraisal (HRA)	A process which helps determine likely significant effects and (where appropriate) assesses adverse impacts on the integrity of European conservation sites and Ramsar sites (when these are also an SPA or SAC). The process consists of a multi stage assessment which incorporates screening, appropriate assessment, assessment of alternative solutions and assessment of imperative reasons of over-riding public interest (IROPI) and compensatory measures.
Impact	An impact is considered to be the change to the baseline as a result of an activity or event related to the Offshore Development. Impacts can be both adverse or beneficial impacts on the environment and be either temporary or permanent.
Inter-Related Effect (or Inter Relationships)	The likely effects of multiple impacts from the proposed development on one receptor. For example, noise and air quality together could have a greater effect on a residential receptor than each impact considered separately.
Landfall	The generic term applied to the entire landfall area between Mean Low Water Spring (MLWS) tide and the Transition Joint Bay (TJB) inclusive of all construction works, including the offshore and onshore Export Cable Corridor, intertidal working area and landfall compound, where the offshore cables come ashore north of Peterhead.
Offshore Array Area	The offshore area within which the wind turbine generators, foundations, mooring lines and anchors, and inter-array cables and associated infrastructure will be located.
Offshore Development	The entire Offshore Development, including all offshore components of the Salamander Project (WTGs, Inter-array and Offshore Export Cable(s), floating substructures, mooring lines and anchors, and all other associated offshore infrastructure) required across all Salamander Project phases from development to decommissioning, for which the Applicant is seeking consent.
Offshore Development Area	The total area comprising the Offshore Array Area and the Offshore Export Cable Corridor.
Offshore Export Cable(s)	The export cable(s) that will bring electricity from the Offshore Array Area to the Landfall. The cable(s) will include fibre optic cable(s).
Offshore Export Cable Corridor	The area that will contain the Offshore Export Cable(s) between the boundary of the Offshore Array Area and Mean High Water Springs.
Receptor (Offshore)	Any physical, biological or anthropogenic element of the environment that may be affected or impacted by the Offshore Development. Receptors can include natural features such as the seabed and wildlife habitats as well as man-made features like fishing vessels and cultural heritage sites.

Term	Definition
Salamander Project	The proposed Salamander Offshore Wind Farm. The term covers all elements of both the offshore and onshore aspects of the project.
Scoping	An early part of the EIA process by which the key potential significant effects of the Salamander Project are identified, and methodologies identified for how these should be assessed. This process gives the relevant authorities and key consultees opportunity to comment and define the scope and level of detail to be provided as part of the EIAR – which can also then be tailored through the consultation process.
Semi-Submersible	A Semi-Submersible structure is a buoyancy-stabilised platform which floats partially submerged on the surface of the ocean whilst anchored to the seabed. The structure gains its stability through the distribution of buoyancy force associated with its large footprint and geometry which ensures the wind loading on the structure and turbine are countered by an equivalent buoyancy force on the opposite side of the structure. Included in the Project Design Envelope, there are variations of the semi-submersible concept, such as barge, buoy, or hybrid.
Wind Turbine Generator	All the components of a wind turbine, including the tower, nacelle, and rotor.

Acronyms

Term	Definition
ALDFG	Abandoned, lost, or discarded fishing gear
CEA	Cumulative Effects Assessment
Cefas	Centre for the Environment, Fisheries and Aquaculture Science
CEMP	Construction Environmental Management Plan
ECC	Export Cable Corridor
EEA	European Economic Area
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
EMF	Electromagnetic Field
EPS	European Protected Species
EU	European Union
FLOW	Floating Offshore Wind
HRA	Habitats Regulations Appraisal
ICES	International Council for the Exploration of the Sea
INNS	Invasive Non-native Species
INTOG	Innovation and Targeted Oil and Gas
IUCN Red List	The International Union for Conservation of Nature's Red List of Threatened Species
JNCC	Joint Nature Conservancy Council
km	Kilometre
m	Metre
MHWS	Mean High Water Springs

Term	Definition
MMO	Marine Management Organisation
MPA	Marine Protected Area
MW	Megawatt
NCMPA	Nature Conservation Marine Protected Area
OAA	Offshore Array Area
OSPAR Convention	The Convention for the Protection of the Marine Environment of the North-East Atlantic
PTS	Permanent Threshold Shift
SAC	Special Area of Conservation
SELCUM	Cumulative impact from Sound Exposure Level
SELSS	Sound Exposure Level for a single strike
SPA	Special Protection Area
SPL_{PEAK}	Peak Sound Pressure Level
SWPC	Salamander Wind Project Company Ltd (formerly called SBES)
TTS	Temporary Threshold Shift
UXO	Unexploded Ordnance
WTG	Wind Turbine Generator

10 Fish and Shellfish Ecology

10.1 Introduction

10.1.1.1 The Applicant, Salamander Wind Project Company Ltd. (SWPC), a joint venture (JV) partnership between Ørsted, Simply Blue Group and Subsea7, is proposing the development of the Salamander Offshore Wind Farm (hereafter 'Salamander Project'). The Salamander Project will consist of the installation of a floating offshore wind farm (up to 100 megawatts (MW) capacity) approximately 35 km east of Peterhead. It will consist of both offshore and onshore infrastructure, including an offshore generating station (wind farm), export cables to the Landfall, and connection to the electricity transmission network (please see **Volume ER.A.2, Chapter 4: Project Description** for full details on the Project Design).

10.1.1.2 This chapter of the Environmental Impact Assessment Report (EIAR) presents the results of the EIA of potential effects of the Salamander Project on Fish and Shellfish Ecology. Specifically, this chapter considers the potential impact of the Salamander Project seaward of Mean High Water Springs (MHWS) during the Construction, Operation and Maintenance, and Decommissioning of the Offshore Development.

10.1.1.3 The chapter provides an overview of the existing environment for the proposed Offshore Development Area, followed by an assessment of significance of effects on Fish and Shellfish Ecology receptors, as well as an assessment of potential cumulative effects with other relevant projects and effects arising from interactions on receptors across topics.

10.1.1.4 This chapter should be read alongside and in consideration of the following:

- **Volume ER.A.3, Chapter 7: Marine Physical Processes**;
- **Volume ER.A.3, Chapter 8: Water and Sediment Quality**;
- **Volume ER.A.3, Chapter 9: Benthic and Intertidal Ecology**;
- **Volume ER.A.3, Chapter 11: Marine Mammals**;
- **Volume ER.A.3, Chapter 12: Offshore and Intertidal Ornithology**;
- **Volume ER.A.3, Chapter 13: Commercial Fisheries**;
- **Volume ER.A.4, Annex 4.1: Underwater Noise Modelling Report**; and
- **Volume ER.A.4, Annex 6.1: Cumulative Effects Assessment Technical Annex**.

10.1.1.5 This chapter has been authored by ERM. Further competency details of the authors of this chapter are outlined in **Volume ER.A.4, Annex 1.1: Details of Project Team.**

10.2 Purpose

10.2.1.1 The primary purpose of this EIAR is for the application for the Salamander Project satisfying the requirements of Section 36 of the Electricity Act 1989 and associated Marine Licences. This EIAR chapter describes the potential environmental impacts from the Offshore Development and assesses the significance of their effect.

10.2.1.2 The EIAR has been finalised following the completion of the pre-application consultation (**RP.A.2 Pre-Application Consultation (PAC) Report**) and the Salamander EIA Scoping Report (SBES, 2023) (and takes account of the relevant advice set out within the Scoping Opinion from Marine Directorate - Licensing Operations Team (MD-LOT) (MD-LOT, 2023) relevant to the Offshore Development). Comments relating to the Energy Balancing Infrastructure (EBI) will be addressed within the Onshore EIAR. The Offshore EIAR will

accompany the application to MD-LOT for Section 36 Consent under the Electricity Act 1989, and Marine Licences under the Marine (Scotland) Act 2010 and the Marine and Coastal Access Act 2009.

10.2.1.3 This EIAR chapter:

- outlines the existing environmental baseline determined from assessment of publicly available data, project-specific survey data and stakeholder consultation;
- presents the potential environmental impacts and resulting effects arising from the Salamander Project on Fish and Shellfish Ecology receptors;
- identifies mitigation measures designed to prevent, reduce, or offset adverse effects and enhance beneficial effects on the environment; and
- identifies any uncertainties or limitations in the methods used and conclusions drawn from the compiled environmental information.

10.3 Planning and Policy Context

10.3.1.1 The preparation of the Fish and Shellfish Ecology Chapter has been informed by the following policy, legislation, and guidance outlined in **Table 10-1**.

Table 10-1 Relevant policy, legislation and guidance relevant to the Fish and Shellfish Ecology assessment

Relevant policy, legislation, and guidance
Policy
Scotland's Biodiversity: a route map to 2020 (Scottish Government, 2015)
Scottish Biodiversity Strategy to 2045
Scotland's National Marine Plan (2015)
National Planning Framework 4 (NPF4) 2023
Legislation
Wildlife and Countryside Act 1981
Marine and Coastal Access Act 2009
Nature Conservation (Scotland) Act 2004
The Conservation (Natural Habitats, &c.) Regulations 1994
The Conservation of Habitats and Species Regulations 2017
The Conservation of Offshore Marine Habitats and Species Regulations 2017
Wildlife and Natural Environment (Scotland) Act 2011

Relevant policy, legislation, and guidance
The Marine Works (Environmental Impact Assessment) (Scotland) Regulations 2017
The Marine Works (Environmental Impact Assessment) Regulations 2007
Guidance
Impacts from piling on fish and shellfish at offshore wind sites: Collating population information, gap analysis and appraisal of mitigation options (Boyle and New, 2018)
Priority Marine Features (PMFs) as described in NatureScot Commissioned Report 388
Guidance for Ecological Impact Assessment (EIA) in the UK and Ireland. Terrestrial, Freshwater, Coastal and Marine (CEEIM, 2019)
Offshore Wind Farms. Guidance note for EIA in respect of FEPA and CPA requirements (Cefas *et al.* 2004)

10.3.1.2 Further details on the requirements for EIA are presented in **Volume ER.A.2, Chapter 2: Legislative Context and Regulatory Requirements**.

10.4 Consultation

10.4.1.1 Consultation is a key part of the application process. It has played an important part in ensuring that the baseline characterisation and impact assessment is appropriate to the scale of development as well as meeting the requirements of the regulators and their advisors.

10.4.1.2 An overview of the Salamander Project consultation process is outlined in **Volume ER.A.2, Chapter 5: Stakeholder Engagement**. Consultation regarding Fish and Shellfish Ecology has been conducted through the EIA scoping process, via a dedicated Fish and Shellfish Ecology scoping workshop meeting and associated comments.

10.4.1.3 The issues raised during consultation specific to Fish and Shellfish Ecology are outlined in **Table 10-2**, including consideration of where the issues have been addressed within the EIAR.

Table 10-2 Consultation responses specific to the Fish and Shellfish Ecology topic

Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
Marine Scotland Science (was MSS at the time, now Marine Directorate Science)	28 November 2022 Fish and Shellfish Ecology Scoping Workshop	Diadromous fish receptors to be assessed within a catchment area of 100 km radius from the Offshore Development Area. This is to identify Diadromous fish species protected within the River Dee SAC, the Moray Firth SAC and the River Spey SAC as having the potential to interact with the Salamander Project.	Diadromous fish species identified within 100 km by the baseline characterisation have been described in **Section 10.7.1** and assessed in **Section 10.11**. Note that whilst the Moray Firth SAC does not include diadromous fish as qualifying features, it has been included as a vector for migration in alignment with consultees.
Marine Directorate – Licencing Operations Team (MD-LOT)	21 June 2023; Scoping Opinion	Section 4.6.7 of the Scoping Report provides an overview on the pre-construction activities required with these planned to be undertaken approximately one to two years prior to construction. The Scottish Ministers advise that the EIA Report must describe and assess the environmental effects, including in-combination effects, of the range of surveys which may be required such as geophysical and geotechnical survey activities and unexploded ordnance ("UXO") clearance. The EIA Report must also include consideration of the options which will be assessed in relation to UXO clearance, the differences amongst them and an assessment of the environmental effects of these options. In this regard, the Scottish Ministers advise that the EIA Report must include a worst case of high order detonation in terms of impact and mitigation, unless there is robust supporting evidence that can be presented to show consistent performance of the preferred low order or deflagration method.	Underwater noise associated with geophysical and geotechnical surveys are scoped out of assessment as potential effects upon fish and shellfish receptors are not considered likely to be significant in line with current best practice for offshore wind construction. This is in line with the Underwater Noise Assessment undertaken by Subacoustech (**Volume ER.A.4, Annex 4.1: Underwater Noise Modelling Report**) where impact piling and UXO clearance were identified as the most important (and worst-case) sources of continuous and impulsive effect of underwater noise on fish and shellfish receptors. Underwater noise associated with UXO clearance has been included as a substantial source of impulsive underwater noise, informed by the Underwater Noise chapter and associated modelling of noise propagation in relation to UXO clearance at the worst-case magnitude. The potential impacts of the clearance of UXOs are discussed within this EIAR for completeness. However, as it is not possible at this time to precisely define the number of UXO which may

Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
			require detonation, a separate Marine Licence application and European Protected Species (EPS) Licence application (with associated environmental assessments) will be submitted for the detonation of any UXO which may be identified as requiring clearance in pre-construction surveys.
Marine Directorate – Licencing Operations Team (MD-LOT)	21 June 2023; Scoping Opinion	In relation to mitigation, the Scottish Ministers note the proposed embedded mitigation measure to develop and implement an INNS Management Plan post consent, however the Scottish Ministers agree with NatureScot that the EIA Report must provide details on how INNS will be considered, monitored and recorded as well as being taken account of in biosecurity plans for each phase of the development The Scottish Ministers advise that NatureScot comments and recommendations regarding this must be fully considered and included in the EIA Report and that other migratory fish species are scoped in for assessment including sea trout, European eel, and sea and river lamprey. Further to this Freshwater Pearl Mussel must also be included in the assessment.	Mitigation for INNS has been described in **Section 10.8.3** and include the implementation of biosecurity plans.
Marine Directorate – Licencing Operations Team (MD-LOT)	21 June 2023; Scoping Opinion	The Scottish Ministers are content with the study areas as defined in Section 8.2.4 and shown in Figure 8-5 of the Scoping Report.	Noted.
Marine Directorate – Licencing	21 June 2023;	With regard to the baseline information, the Scottish Ministers highlight the additional studies, reports and data sources available	Noted.

Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
Operations Team (MD-LOT)	Scoping Opinion	(and becoming available) as recommended by NatureScot and advise that these are fully considered in the EIA Report.	
Marine Directorate – Licencing Operations Team (MD-LOT)	21 June 2023; Scoping Opinion	With regard to PMF the Scottish Ministers refer the Developer to NatureScot comments that, in addition to being qualifying features of European sites, Atlantic salmon are PMF's along with European eel and sea trout. The Scottish Ministers advise that NatureScot comments and recommendations regarding this must be fully considered and included in the EIA Report and that other migratory fish species are scoped in for assessment including sea trout, European eel, and sea and river lamprey. Further to this Freshwater Pearl Mussel must also be included in the assessment.	Noted. Atlantic salmon has been assessed alongside other PMFs where relevant within **Section 10.11**.
Marine Directorate – Licencing Operations Team (MD-LOT)	21 June 2023; Scoping Opinion	The Scottish Ministers agree with NatureScot comments that under Section 8.2.5 of the report it is not clear which shellfish species may be present in the study area including flame shell, horse mussel, ocean quahog etc., which are PMF's The Scottish Ministers advise that these will require full consideration.	Ocean quahog is considered within the Fish and Shellfish Ecology chapter. It is noted that flame shells and horse mussels are not considered present within the Offshore Development Area following baseline review.
Marine Directorate – Licencing Operations Team (MD-LOT)	21 June 2023; Scoping Opinion	The Scottish Ministers note that there is no mention of basking shark in the fish and shellfish section of the Scoping Report and that basking shark (and turtles) are included in the marine mammal section of the report. The Scottish Ministers are content with this approach however	Noted.

Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
		advise that NatureScot recommendations regarding mitigation must be fully implemented as required.	
Marine Directorate – Licencing Operations Team (MD-LOT)	21 June 2023; Scoping Opinion	The Scottish Ministers broadly agree with the impacts scoped in and out of the EIA Report in Table 8-8 of the Scoping Report including accidental pollution; increased suspended sediment concentrations and barrier effects to migratory fish during operation and maintenance. However, in addition to those scoped in, the Scottish Ministers advise that the colonisation of hard structures, the potential impacts on Southern Trench NCMPA, and the changes in prey species availability must also be scoped into the EIA Report. This is in agreement with the NatureScot representation which must be fully considered and implemented in the EIA Report.	Noted. These pathways have been assessed in other chapters of the EIAR where relevant.
Marine Directorate – Licencing Operations Team (MD-LOT)	21 June 2023; Scoping Opinion	The Scottish Ministers draw the developer attention to the NatureScot representations in regard to habitat loss and disturbance and agree that all appropriate pre-construction seabed preparations must be included in the assessment	Pre-construction seabed preparations have been included within the Offshore Development design parameters listed in **Table 10-9**.
Marine Directorate – Licencing Operations Team (MD-LOT)	21 June 2023; Scoping Opinion	The Scottish Ministers advise that UXO clearance must be fully considered in the assessment with regard to underwater noise and vibration. This is supported by NatureScot representation.	Underwater noise associated with UXO clearance has been included as a substantial source of impulsive underwater noise, informed by the Underwater Noise chapter and associated modelling of noise propagation in relation to UXO clearance at the worst-case magnitude. The potential impacts of the clearance of UXOs are discussed within this EIAR for completeness. However, as it is not

Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
			possible at this time to precisely define the number of UXO which may require detonation, a separate Marine Licence application and EPS Licence application (with associated environmental assessments) will be submitted for the detonation of any UXO which may be identified as requiring clearance in pre-construction surveys.
Marine Directorate – Licencing Operations Team (MD-LOT)	21 June 2023; Scoping Opinion	With regard to Electromagnetic Fields ("EMF") impacts from both buried and dynamic cables, the Scottish Ministers highlight and agree with the NatureScot representation that the impacts from EMF should be considered for all relevant fish species, including elasmobranch species, nephrops and diadromous fish, including migratory fish. The Scottish Ministers advise that the NatureScot representation and further advice on cable burial should be fully considered along with consideration of the SFF comments on this matter	The effects of EMF have been included for all fish and shellfish receptor groups and assessed within **Section 10.11.2**.
Marine Directorate – Licencing Operations Team (MD-LOT)	21 June 2023; Scoping Opinion	With regard to the impact assessment approach, the Scottish Ministers highlight and agree with the NatureScot representation regarding PMF's and advise that the assessment should quantify, where possible, the likely impacts to key fish and shellfish PMF species, and it should assess whether these could lead to a significant impact on the national status of the PMF being considered.	PMFs have been identified in the baseline characterisation in **Section 10.6.2**, and assessed in **Section 10.11**.
Marine Directorate – Licencing	21 June 2023; Scoping Opinion	The Scottish Ministers advise that the EIA Report must consider the cumulative effects of key impacts such as habitat loss/change especially in relation to diadromous fish as well as key fish and	Habitat loss/change is considered within the cumulative effects assessment in **Section 10.13**.

Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
Operations Team (MD-LOT)		shellfish species that contribute ecological importance as a prey resource.	
Marine Directorate – Licencing Operations Team (MD-LOT)	21 June 2023; Scoping Opinion	The Developer outlines embedded mitigation to be considered within the EIA Report in Table 8-7. The Scottish Minister highlight the NatureScot representation regarding this and agree that the full range of mitigation measures and published guidance should be considered and discussed in the EIA Report.	Mitigation measures have been included in **Table 10-8** and **Section 10.8.3** where relevant.
Marine Directorate – Licencing Operations Team (MD-LOT)	21 June 2023; Scoping Opinion	The Scottish Ministers would like to highlight the representation from the Dee District Salmon Fisheries board in relation to their recommendation that further consultation takes place with reference to broadening the understanding of any potential impact upon diadromous fish, specifically feeding into the ScotMER Diadromous Fish Specialist Receptor Group.	Noted.
Marine Directorate – Licencing Operations Team (MD-LOT)	21 June 2023; Scoping Opinion	The Scottish Ministers agree that transboundary/cross border impacts can be scoped out from further consideration.	Noted.
Marine Directorate – Licencing Operations Team (MD-LOT)	21 June 2023; Scoping Opinion	With regard to the HRA Screening Report, the Scottish Ministers highlight the NatureScot representation and agree that migratory fish should be assessed through the EIA process only and not the HRA process.	Noted. Migratory/diadromous fish have been assessed in **Section 10.11**.

Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
NatureScot	21 June 2023; comments on EIA Scoping Report	Appendix E - Fish and Shellfish Impact Assessment Fish and shellfish interests are considered in Section 8.2 of the Scoping Report. Our advice below focuses on those fish and shellfish species, and where appropriate their associated habitats, that are protected features of European sites or ncMPAs as well as those that are of conservation importance including PMFs and key prey species. We have responded to the questions raised in the Scoping Report within our advice below.	Noted.
NatureScot	21 June 2023; comments on EIA Scoping Report	Study Area We are content with the study areas as defined in Section 8.2.4 and shown in Figure 8-5 of the Scoping Report.	Noted.
NatureScot	21 June 2023; comments on EIA Scoping Report	Baseline information Section 8.2.2 correctly identifies the relevant legislation, policy and guidance for this receptor. However, we recommend inclusion of the NatureScot Commissioned Report 791 'Understanding the potential for marine megafauna entanglement risk from marine renewable energy developments' (https://www.nature.scot/doc/naturescot-commissioned-report-791-understanding-potential-marine-megafauna-entanglement-risk).	It is acknowledged that the consultee is accepting of the exclusion of basking shark, which have a similar risk of entanglement as other marine megafauna, as assessed within **Volume ER.A.3, Chapter 11: Marine Mammals**.

Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
NatureScot	21 June 2023; comments on EIA Scoping Report	Table 8-4, Section 8.2.3 captures most of the relevant baseline datasets but we recommend the inclusion of 'Essential Fish Habitat Maps for Fish and Shellfish Species in Scotland' developed by the Scottish Marine Energy Research (ScotMER) programme (https://www.gov.scot/policies/marine-renewable-energy/science-and-research/), which is due for publication imminently. We also recommend inclusion of the Feature Activity Sensitivity Tool (FEAST) (http://www.marine.scotland.gov.uk/FEAST/), which was due to be updated with fish and shellfish information by the end of March 2023.	Essential Fish Habitat Maps for Fish and Shellfish Species in Scotland (Franco *et al*. 2023) has been included in the baseline characterisation study and is presented in **Table 10-3** within **Section 10.6.2**. Tyler-Walters *et al*. (2018) has been used to define receptor sensitivity categories in **Section 10.10.2**. The FEAST tool contains the same information for common skate, European spiny lobster, sandeel, ocean quahog, and blue ling to that of Tyler Walters *et al*. (2018), but does not yet contain information regarding other fish and shellfish receptors identified within the Fish and Shellfish Ecology Study Area. The Feast tool has been used to define sensitivity, in alignment with Tyler Walters *et al*. (2018).
NatureScot	21 June 2023; comments on EIA Scoping Report	With regard to data sources relating to fish and EMF, we recommend that a recent MSc paper by Lucie Hervé 'An evaluation of current practice and recommendations for environmental impact assessment of electromagnetic fields from offshore renewables on marine invertebrates and fish' is included as a data source.	More recent research publications and literature reviews regarding the effects of Electromagnetic Fields (EMF) on fish have been produced, such as Cresci *et al*. (2022a; 2022b) and ERM (2023), that have been used to inform the assessment within **Section 10.11.2**. ERM (2023) conducted a literature review of the potential impacts of EMF from floating offshore wind (FLOW) projects, concluding that there is limited evidence to suggest substantial impacts on fish and shellfish receptors may occur (ERM, 2023). Therefore, the Hervé thesis has not been used to inform this assessment.

Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
NatureScot	21 June 2023; comments on EIA Scoping Report	We support the proposed approach of carrying out a desk-based analysis of existing fish and shellfish data. This will be supplemented by information obtained from site-specific benthic ecology surveys.	This is noted.
NatureScot	21 June 2023; comments on EIA Scoping Report	Priority Marine Features (PMFs) As highlighted in Section 8.2.5.3 of the Scoping Report, a number of marine fish species are PMFs and consideration of impact to these species as PMFs should be included within the EIAR.	PMFs have been identified in the baseline characterisation in **Section 10.6.2**, and assessed in **Section 10.11**.
NatureScot	21 June 2023; comments on EIA Scoping Report	It is also noted in Section 8.2.5.3 that Atlantic salmon are the primary diadromous fish species being considered in the EIAR, although the assessment of other fish and shellfish species (including freshwater pearl mussel and lamprey) will be considered if it is concluded that these species have potential connectivity with the Salamander Project. In addition to being qualifying features of European sites, Atlantic salmon are PMFs along with European eel and sea trout (the anadromous form of brown trout). Atlantic salmon are undergoing a significant decline across their global range, and numbers in Scotland have declined dramatically since 2010. This has led to the recent publication of a Scottish Wild Salmon Strategy (Scottish Government, 2022)	This is noted.

Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
		(https://www.gov.scot/publications/scottish-wild-salmon-strategy/), and continuing high levels of mortality at sea is a significant issue. European eel is a conservation priority due to a dramatic decrease in its population size over the last 20 years; it is listed as 'critically endangered' on the global IUCN Red List. However, very little is known about their local migration pathways, either as juveniles or adults. Malcolm et al. (2010) contains a review of available data in relation to migration routes and behaviour, and Gill & Bartlett (2010) on effects of noise and 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.	
NatureScot	21 June 2023; comments on EIA Scoping Report	We advise that other migratory fish species are scoped in for assessment including sea trout, European eel, sea and river lamprey.	Migratory (diadromous) fish, including sea trout, European eel, sea lamprey, and river lamprey, have been identified in the baseline in **Section 10.6.2**, and assessed in **Section 10.11.**
NatureScot	21 June 2023; comments on EIA Scoping Report	Freshwater Pearl Mussel (FWPM) should also be included in the assessment given that Atlantic salmon (and other salmonids) are integral to the lifecycle of this species. Therefore, any impacts to salmonids that prevent them from returning to their natal rivers may have a resulting effect on FWPM.	FWPM has been identified within **Table 10-7** and scoped out of assessment due to limited pathway for impact associated with a disruption to salmon movement to natal rivers as a result of the Offshore Development.
NatureScot	21 June 2023; comments on EIA Scoping Report	Section 8.2.5 focuses mainly on commercial fish and shellfish species, and it is not clear which shellfish species may be present in the study	All identified PMFs within the Fish and Shellfish Ecology Study Area are presented in **Section 10.7.1**.

Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
		area such as flame shell, horse mussel, ocean quahog etc., which are PMFs and will require consideration.	It is noted that flame shells and horse mussels are not considered to be present within the Offshore Development Area.
NatureScot	21 June 2023; comments on EIA Scoping Report	There is no mention of basking shark, also a PMF, in the fish and shellfish section of the Scoping Report. Basking shark (and turtles) are mentioned in the marine mammal Section (8.3) of the Scoping Report, where they have been scoped out for further assessment. We are content with this approach due to the small numbers likely to be in this area. However, we recommend any mitigation put in place to minimise risks to marine mammals should also be applied to basking shark (and turtles), should they be present.	It is acknowledged that the consultee is accepting of the exclusion of basking shark within **Volume ER.A.3, Chapter 11: Marine Mammals**. No further mention of basking shark will be made in this chapter.
NatureScot	21 June 2023; comments on EIA Scoping Report	Potential Impacts Table 8-8, Section 8.2.7 of the Scoping Report summarises the impacts proposed to be scoped into the assessment. 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.	Seabed preparation works have been considered within the Project Design Envelope presented in **Table 10-9**, **Section 10.9**, and used in subsequent assessments.
NatureScot	21 June 2023; comments on EIA Scoping Report	**Underwater noise and vibration** We agree that underwater noise impacts should be scoped in for all project phases and should include sandeel (as well as migratory fish and spawning fish species) as they are present at the development site	UXO clearance has been identified as a source of impulsive underwater noise but will not be included as part of this application. However, UXO has been described at a high level in **Section 10.11.1** alongside impact piling and other noise making activities for clarity and will be addressed in full within a separate application. All fish and

Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
		all year round, have a close association with the seabed and are unable to flee from noisy activities. UXO clearance should also be considered in the assessment.	shellfish receptors, including sandeel and diadromous fish, have been assigned noise-specific receptor groups based upon those identified by Popper *et al*. (2014).
NatureScot	21 June 2023; comments on EIA Scoping Report	**EMF Impacts** We welcome the scoping in of EMF effects as another impact pathway that is not well understood at present, to increase our understanding of the effects of subsea and dynamic cables, particularly as floating wind becomes an established technology. The impacts from EMF should be considered for all relevant fish species, including elasmobranch species, nephrops and diadromous fish, including migratory fish.	The effects of EMF have been included for all fish and shellfish receptor groups and assessed within **Section 10.11.2**.
NatureScot	21 June 2023; comments on EIA Scoping Report	We note that cable burial is listed as an embedded mitigation measure and assume this is in relation to reducing impacts of EMF - we provide further advice on this below.	The embedded mitigation of cable burial is to mitigate risk to project infrastructure from fishing activity and vessel anchors interacting with the seabed as well as providing cable stability, rather than to provide specific mitigation for potential EMF effects. No additional protection to reduce EMF within the water column is proposed.
NatureScot	21 June 2023; comments on EIA Scoping Report	**Colonisation of hard structures** Due to the novel nature of floating offshore wind foundations, we advise that colonisation of hard structures is scoped in. This potential	Whilst of some relevance to shellfish receptors, this impact is assessed within **Volume ER.A.3, Chapter 9: Benthic and Intertidal Ecology.** For fish species, colonisation is inherently linked as one of the drivers for the fish aggregation effect, assessed in this chapter in **Section 10.11.2.**

Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
		impact is also linked to whether marine growth will need removed, and if so, how will this be carried out.	
NatureScot	21 June 2023; comments on EIA Scoping Report	**Changes in prey species availability** We advise consideration is required in the EIAR to ensure that impacts to key prey species (such as sandeel, herring, mackerel and sprat) and their habitats are considered for this development alone and cumulatively with other wind farms. We recognise that most EIARs concentrate on receptor specific impacts. However, increasingly we need to understand impacts at the ecosystem scale. Therefore, consideration across key trophic levels will enable better understanding of the consequences (positive or negative) of any potential changes in prey distribution and abundance on marine mammal (and other top predator) interests and how this may influence population level impacts. Consideration of how this loss and or disturbance may affect the recruitment of key prey (fish) species through impacts to important spawning or nursery ground habitats should also be assessed.	Impacts on key prey species have been assessed alone in **Section 10.11**, and cumulatively in **Section 10.13.** Inter-related effects have also been considered in **Section 10.16** and **Volume ER.A.3, Chapter 22: Inter-related Effects**.
NatureScot	21 June 2023; comments on EIA Scoping Report	We note and welcome the inclusion of assessing fish and subsequent predator aggregation around the project infrastructure. The PrePARED (Predators and Prey Around Renewable Energy Developments) project (https://owecprepared.org/) may be helpful in the understanding of predator-prey relationships in and around offshore wind farms.	This is noted.

Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
NatureScot	21 June 2023; comments on EIA Scoping Report	**Impacts to be scoped out** We agree with the proposed impacts to be scoped out for fish and shellfish: accidental pollution; increased suspended sediment concentrations and barrier effects to migratory fish during operation and maintenance.	This is noted. Please refer to **Section 10.8.2** for further information on scoped-out impacts.
NatureScot	21 June 2023; comments on EIA Scoping Report	**Approach to Assessment** We broadly support the approach to assessment set out in Section 8.2.10. However, we advise that in relation to PMFs the assessment should quantify, where possible, the likely impacts to key fish and shellfish PMF species. It should assess whether these could lead to a significant impact on the national status of the PMF being considered.	PMFs have been identified as part of the baseline characterisation and assessed where relevant in **Section 10.11**. The magnitude of impact has been quantified in accordance with the Project Design Envelope presented in **Table 10-9**, **Section 10.9**. Impacts upon PMFs have been included within respective receptor groups due to the limited potential for PMFs to receive an increased significance of impact compared to other similar species.
NatureScot	21 June 2023; comments on EIA Scoping Report	**Cumulative impacts** The EIAR should consider the cumulative effects 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.	Temporary habitat loss (construction) and permanent habitat loss (operation) have been assessed alone in **Sections 10.11.1** and **10.11.2** respectively, and included within the cumulative effects assessment within **Section 10.13**.
NatureScot	21 June 2023; comments on EIA Scoping Report	It is noted in Section 8.2.8 that as part of the EIA, the cumulative effects assessment will be undertaken with reference to, and use of, the CEF currently being developed. As noted previously, the CEF tool	The Cumulative Effects Framework (CEF) tool has not been used in the cumulative effect assessment for fish and shellfish receptors.

Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
		is available for ornithology and marine mammal cumulative assessments only at present.	
NatureScot	21 June 2023; comments on EIA Scoping Report	**Mitigation and monitoring** We welcome embedded mitigation measures as detailed in Table 8-7, Section 8.2.6 and advise that the full range of mitigation measures and published guidance is considered and discussed in the EIAR.	Mitigation measures have been included in **Table 10-8, Section 10.8.3**, and **Section 10.11** where relevant.
NatureScot	21 June 2023; comments on EIA Scoping Report	It is noted that cable burial/protection informed by a Cable Burial Risk Assessment (CBRA) is listed as a proposed embedded mitigation measure (Table 8-7). However, we highlight research by Hutchison *et al*. (2020) (Hutchison, Zoe & Gill, A. B. & Sigray, Peter & He, Haibo & King, John. (2020). Anthropogenic electromagnetic fields (EMF) influence the behaviour of bottom-dwelling marine species. Scientific Reports. 10.) which establishes that cable burial may actually generate a response from sensitive species as it reduces EMF levels to the 'normal' range that species use to hunt prey or navigate.	This impact is assessed in **Section 10.11.2**.
NatureScot	21 June 2023; comments on EIA Scoping Report	There is also a proposed embedded mitigation measure to develop and implement an INNS Management Plan post consent. As advised above, the EIAR should provide details on how marine INNS will be considered, monitored and recorded as well as being taken account of in biosecurity plans for each phase of the development.	Mitigation for INNS has been described in **Section 10.8.3** and include the implementation of biosecurity plans.

Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
NatureScot	21 June 2023; comments on EIA Scoping Report	No specific monitoring for fish and shellfish is mentioned in the Scoping Report. We are aware of Marine Directorate proposals to carry out infield measurement of EMF to better understand impacts on benthic and fish species. Therefore, any input this project could assist with, either from project measurements or contributions to this wider work, would be very beneficial.	Ørsted have commissioned a report aiming to help develop industry understanding on potential impacts of EMF (ERM, 2023). The Salamander Project will continue to engage with stakeholders regarding EMF; however, the Salamander Project does not propose specific EMF monitoring for fish and shellfish receptors.
NatureScot	21 June 2023; comments on EIA Scoping Report	**Transboundary / cross border impacts** We agree that transboundary / cross border impacts can be scoped out from further consideration.	Transboundary effects have been scoped out within **Section 10.14.**
NatureScot	21 June 2023; comments on EIA Scoping Report	**Wet storage** Section 4.6.2 (Floating Substructures) refers to the potential for wet storage of the substructures prior to their installation within the array area, either at the initial assembly site, the wind turbine integration site or a separate dedicated storage location. Section 4.7.1 (Floating Assembly) also indicates that once operational the substructures and WTGs will form an integrated assembly piece – the replacement of any major component parts of which is expected to be achieved by towing the assembly to port. Wet storage could represent a significant impact. Consideration of the potential impacts on all receptors needs to be addressed with the EIAR and HRA. We would welcome further discussion on this as and when further details are confirmed, noting	Wet storage of the floating substructures (and integrated WTGs) prior to tow-out to the Offshore Array Area (OAA) is considered to be outside the scope of this EIA and the Marine Licence applications for the Offshore Development. This is due to the fact that at this stage of the Salamander Project it is not known which port(s) will be used for wet storage and therefore it is challenging to undertake a meaningful assessment of impacts related to wet storage. The intent is that the Salamander Project will utilise the services of a port(s) that offer wet storage sites, which will have appropriate consents (obtained by the port authority) for wet storage of floating substructures, fabrication and assembly with the WTGs. To enable the availability of this option for the Salamander Project within the required timeframe, an owner of SWPC is an official member of the TS-FLOW UK-North Joint Industry Project (JIP) exploring the challenges of wet storage and identifying the opportunities and potentially suitable locations for these

Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
		the intention to seek a separate marine licence application for any requirements for wet storage outwith the array area.	activities. This JIP is in collaboration with relevant ports and other floating offshore wind developers. Separate Marine Licences and associated impact assessments for wet storage areas outwith the Offshore Development Area will be applied for and undertaken as appropriate.
Scottish Fisherman's Federation (SFF)	21 June 2023; comments on EIA Scoping Report	P23, of the report notes that the northerly route to the Acorn project at St Fergus Gas Terminal (Option 3, Figure 3-2) was ruled out as the small gap between a patch of Annex 1 reef and the active Fulmar to St Fergus gas pipeline is approximately 250 m. Including required space for trenching the export cable, the minimum separation needed between pipeline and cable was considered to be 170 m; running a high voltage cable close to a gas pipeline can pose a threat as the pipeline could be subject to electrical interference. The nominal distance from the cable corridor to the Annex 1 reef was therefore approximately 70 m and considered a technical and environmental risk to be avoided. If this is the case for pipeline, therefore the SFF expect the EMF effects of the High Voltage Cables on fish and fish habitats be scoped in.	The effects of EMF have been included for all fish and shellfish receptor groups and assessed within **Section 10.11.2**.
Scottish Fisherman's Federation (SFF)	21 June 2023; comments on EIA Scoping Report	In addition, the EMF effects of dynamic cable are not known, SFF expect the EMF effects of these dynamic cables are scoped in and monitored.	The effects of EMF have been included for all fish and shellfish receptor groups and assessed within **Section 10.11.2**.

Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
Scottish Fisherman's Federation (SFF)	21 June 2023; comments on EIA Scoping Report	P47, para "4.6 Construction Activities", indicates the construction period will last for almost 3 years. SFF recommend that in case construction sites lapse with fish spawning and nursery areas, it should be made sure that construction activities are carried out with the spawning and nursery seasons to prevent any disruption and/or damage fish spawning and nursery.	The construction period for the Offshore Development (excluding pre-construction surveys) will last for up to 18 months (refer to **Volume ER.A.2, Chapter 4: Project Description**). Spawning and nursery grounds within the vicinity of the Offshore Development have been identified in **Section 10.7.1** and assessed in **Sections 10.11.1** and **10.11.2** where relevant. Should spawning and nursery grounds have been determined to be at risk of significant effect, temporal restrictions would have been proposed during the relevant project phase. However, the impact assessment in **Section 10.11.1** identifies that the risk to spawning and/or nursery grounds is not significant, and therefore temporal restrictions are deemed disproportionate to the scale of the Offshore Development and have not been proposed as mitigation measures.
Scottish Fisherman's Federation (SFF)	21 June 2023; comments on EIA Scoping Report	8.2 Fish and Shellfish Ecology 8.2.11 Scoping Questions Do you agree that all relevant legislation, policy and guidance documents have been identified for the fish and shellfish ecology assessment, or are there any additional legislation, policy and guidance documents that should be considered? Answer: No specific comment.	This is noted.

Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
		Do you agree with the study area defined for fish and shellfish ecology? Answer: Yes.	
Scottish Fisherman's Federation (SFF)	21 June 2023; comments on EIA Scoping Report	Do you agree with the data and information sources identified to inform the baseline for fish and shellfish ecology, or are there any additional data and information sources that should be considered? Answer: No. Initial discussion was held with SFF & SWFPA and we remain available to provide further information	This consultation comment refers to the scoping report, in which the baseline assessment provides a general, high-level characterisation of the Fish and Shellfish Ecology Study Area. Other relevant publicly available sources should be identified by consultees at this stage if relevant to the EIAR. This EIAR utilises a large number of data sources, primary literature, and grey literature, and therefore presents a more fully informed baseline characterisation (**Section 10.7**) than the scoping report.
Scottish Fisherman's Federation (SFF)	21 June 2023; comments on EIA Scoping Report	Do you agree with the suggested embedded mitigation measures? Answer: No. Experience tells us that post consent is too late to agree much of the mitigation; therefore, it needs to be agreed pre-consent.	Please refer to **Table 10-8** containing the embedded mitigation measures for reducing potential impacts to fish and shellfish. Of note is the development of a piling decision tree presented in **Figure 10-12**.
Scottish Fisherman's Federation (SFF)	21 June 2023; comments on EIA Scoping Report	Do you agree that all potential receptors and impacts have been identified for fish and shellfish ecology? Answer: Yes	This is noted.

Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
Scottish Fisherman's Federation (SFF)	21 June 2023; comments on EIA Scoping Report	Do you agree that the impacts proposed can be scoped out of the fish and shellfish ecology EIA chapter? Answer: No. Following should also be scoped in since they have potential of affecting marine environment and ecology. 1. Impact to habitats or species as a result of pollution or accidental discharge 2. Barrier effects on migratory fish from the presence of the floating platform and associated infrastructure	Refer to **Table 10-7** containing the justification as to why these impact pathways have been scoped out, in line with MD-LOT's recommendation (as per 5.5.6 of their Scoping Opinion) and accepted offshore EIA practice.
Scottish Fisherman's Federation (SFF)	21 June 2023; comments on EIA Scoping Report	As the report indicates that a number of species within the vicinity of the Offshore Development Area, specifically cod and herring, are sensitive to the impacts of underwater noise from activities in relation to offshore construction. Sound pressures and particle motion have exaggerated impacts on the swim bladder of these species which is closely connected to the ear and show a more extended sound frequency range of up to 500 MHz (Popper and Hawkins, 2019). SFF, therefore, expect to see these impact scoped in.	This impact is assessed within **Section 10.11** for receptor groups identified by Popper *et al*. (2014). It is noted that Popper and Hawkins (2019) mention an extended frequency range of up to 500 Hz not 500 MHz.
Ugie District Salmon Fishery Board (DSFB)	21 June 2023; comments on EIA Scoping Report	I would like to know if the people responsible for the Salamander Offshore Windfarm have considered and taken steps to avoid any harm being done to migrating salmon and sea trout in the sea and on the land, in the construction and operating phase of this project. The Ugie District Salmon Fishery Board have responsibility for the	Potential impacts of the Salamander Project upon diadromous fish, including migrating Atlantic salmon and sea trout, have been assessed in the EIA and Cumulative Effect Assessment (CEA) (**Sections 10.11** and **10.13** respectively). No potential significant effects were determined

Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
		protection and enhancing of the populations of Salmon and sea trout in the Peterhead area on the Buchan coast.	alone, or cumulatively, and therefore no additional mitigation measures have been proposed.
Dee District Salmon Fishery Board (DSFB)	21 June 2023; comments on EIA Scoping Report	**Wild Salmon Strategy and Conservation regulations** In January 2022, the Scottish Government released its Wild Salmon Strategy which gave a clear message that there is sadly now unequivocal evidence that populations of Atlantic salmon are at crisis point. The Strategy calls on government agencies, as well as the private sector, to prioritise the protection and recovery of Scotland's wild Atlantic salmon populations. One of the key pressures identified in the strategy is marine development, with marine renewables highlighted as having the potential to impact salmon through noise, water quality and effects on electromagnetic fields (EMFs) used by salmon for migration. Furthermore, the Conservation of Salmon (Scotland) Regulations 2016 has led to the production of stock assessments for all Scottish salmon rivers, based on catch data. The assessments estimate whether the number of adults returning to the river in each of the previous five years will produce enough eggs to keep the population size above a critical threshold. For the Dee, like other north-east rivers, the assessments have shown a declining trend in catches since 2011. Nonetheless, the Dee has been categorised as a Grade 1 river, meaning that the stocks have most	Potential impacts of the Salamander Project upon Atlantic salmon, including underwater noise and EMF, have been assessed in the EIA and CEA (**Sections 10.11** and **10.13** respectively). No potential significant effects were determined alone, or cumulatively, for Atlantic salmon. Water quality effects have been assessed separately in **Volume ER.A.3, Chapter 8: Water and Sediment Quality**.

Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
		likely been above the critical threshold - the Conservation Limit - over the last five years. It is however apparent that specific stock components, such as the Spring salmon stock on the Dee are critically low. Assessment of the juvenile salmon stocks in the Dee through the National Electrofishing Programme for Scotland (NEPS) has evaluated juvenile stocks in the Dee as Grade 2, suggesting that there are significant issues with recruitment and survival within the catchment (Malcolm et al 2020). With greater pressures on marine survival such that only approximately 3% of smolts return to the river as adults, we need to address any pressures within the freshwater and marine environments to protect Dee salmon stocks.	
Dee District Salmon Fishery Board (DSFB)	21 June 2023; comments on EIA Scoping Report	**Position** The Dee DSFB welcomes the opportunity to respond to the scoping opinion and would wish to be consulted further during this process with specific interest in the migratory fish species Atlantic Salmon and sea trout.	The DSFB's comments have been incorporated into this chapter through the assessment of underwater noise and EMF in the EIA and CEA (**Sections 10.11** and **10.13** respectively). No potential significant effects were determined alone, or cumulatively, therefore no further consultation has been undertaken at this stage.
Dee District Salmon Fishery Board (DSFB)	21 June 2023; comments on EIA Scoping Report	We note that the location of the proposed site, cable corridor and landfall are out with the Dee District Salmon Fishery Board district and that the Dee SAC 48 km south-west of the Offshore ECC and 70 km from the Offshore Array Area. Due to the diadromous nature of Atlantic salmon and sea trout we are pleased to see that these migratory fish and their complicated migratory pathways have been	Diadromous fish have been included in this chapter (in **Section 10.7.1**) through screening based on a large range (200 km), to enable the assessment of any potential interactions with migrating populations associated with the Dee SAC. Migratory fish have been assessed in this EIA chapter rather than the Offshore RIAA, based on advice from NatureScot that salmon outside SAC boundaries should be assessed

Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
		considered and agree with potential impacts 'scoped in' to the assessment as identified Table 8.8.	through the EIA process and not the Habitats Regulations Appraisal (HRA process.
Dee District Salmon Fishery Board (DSFB)	21 June 2023; comments on EIA Scoping Report	We also welcome the provision for a separate stand-alone receptor group for diadromous fish within the EIAR as noted in section 8.2.10.1.	Diadromous fish have been identified as a separate receptor group in the baseline (**Section 10.7.1**), and assessed separately in the EIA and CEA (**Sections 10.11** and **10.13** respectively).
Dee District Salmon Fishery Board (DSFB)	21 June 2023; comments on EIA Scoping Report	We welcome the addition of a section on potential cumulative impacts of the development given its proximity to neighbouring developments. We would recommend as we have done for previous developments that further consultation takes place with Marine Scotland Science and Fisheries Management Scotland with reference to broadening our understanding of any potential impact upon diadromous fish because of this proposed development. Specifically feeding into the ScotMER Diadromous Fish Specialist Receptor Group where a series of evidence gaps have been identified in relation to diadromous fish.	The Applicant acknowledges the importance of broadening our understanding of how offshore wind developments may impact diadromous fish populations. In recognition of this, Ørsted fully funds the PREDICT project – a three-year research initiative led by experts at the University of Aberdeen and University of the Highlands and Islands' Environmental Research Institute to develop understanding of fish migration patterns and how these can be better monitored. The ultimate goal is to improve understanding of how to site offshore wind farms to minimise any impact on fish and their predators (birds and marine mammals). As an extension of this work, the Salamander Project will install sensors at and near the site during the development, construction and operational stages of the wind farm to gather data on fish stocks, but this is not proposed as a mitigation measure within this EIA. Impacts associated with fish stock species and alteration to habitat are assessed within **Section 10.11**.

10.5 Study Area

10.5.1.1 The Fish and Shellfish Ecology Study Area has been defined as ICES Statistical Rectangles 43E8, 43E9, 44E7, 44E8, and 44E9, totalling 15,057,737,171 m² or approximately 15,058 km². Both the OAA and Offshore Export Cable Corridor (ECC) (hereby referred to as the Offshore Development Area) are located within ICES Statistical Rectangle 44E8. Adjacent rectangles have been included to provide wider context for Fish and Shellfish Ecology within the region, in line with the scoping report. The Fish and Shellfish Ecology Study Area will be supplemented by a wider catchment area when considering the potential effects of the Offshore Development upon diadromous fish receptors. This is due to the greater spatial range of diadromous fish populations compared to other fish and shellfish receptor groups; the latter of which will be assessed within the Fish and Shellfish Ecology Study Area only.

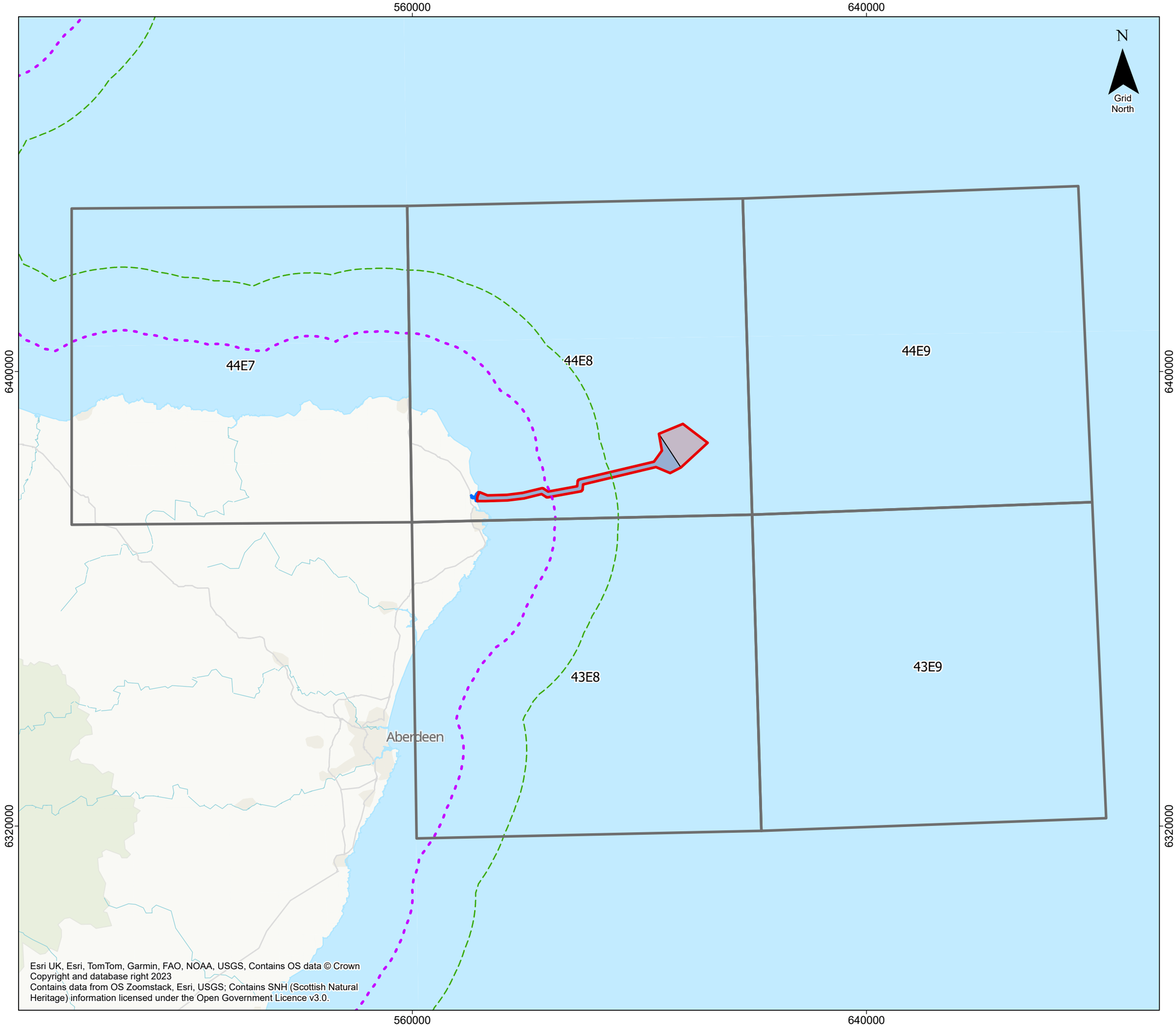
10.5.1.2 The Study Area for Fish and Shellfish Ecology is shown in **Figure 10-1.** As well as the Fish and Shellfish Ecology Study Area, the following key aspects of the Salamander Project that collectively form the Offshore Development Area are shown on **Figure 10-1**.

- OAA; and
- Offshore ECC.

Salamander

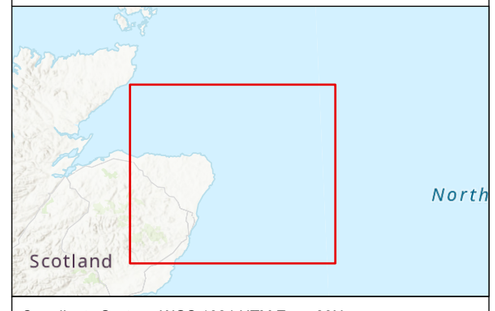
Figure 10-1

Fish and Shellfish Study Area



Legend

- Offshore Development Area
- Offshore Export Cable Corridor
- Offshore Array Area
- Indicative Onshore Development Area
- 6nm limit
- 12nm limit
- Study Area



Coordinate System: WGS 1984 UTM Zone 30N

Scale @ A3 : 1:650,858

0 10 20 Kilometers

0 5 10 20 Nautical Miles

Rev	Description	Date
01	Final Issue	10/04/2024
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Doc. Title : Fish and Shellfish Ecology Study Area
Doc. No : SWF01ER0323
Created by : NB
Checked by : IW
Approved by : MKH

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10.6 Methodology to Inform Baseline

10.6.1 Site Specific Surveys

10.6.1.1 No site specific surveys were undertaken for Fish and Shellfish Ecology as publicly available data originating from primary and grey literature is considered sufficient to characterise the Fish and Shellfish Ecology Study Area within a desk based assessment.

10.6.2 Data Sources

10.6.2.1 The data sources that have been used to inform this Fish and Shellfish Ecology Chapter of the EIA Report are presented within **Table 10-3**.

Table 10-3 Summary of key publicly available datasets for Fish and Shellfish Ecology

Source	Year	Spatial Coverage	Summary
MMO Landings data (value and weight) by species (MMO, 2021; 2022)	2016-2021	Specific to the Fish and Shellfish Ecology Study Area	Data identifying the landed weight and monetary value of fisheries (and shellfisheries) within the Fish and Shellfish Ecology Study Area.
Fish tagging and genetic studies and reviews on migratory fish published by Marine Scotland (Malcolm *et al.* 2010 ; Godfrey *et al.* 2014 ; Cauwelier *et al.* 2015 ; Downie *et al.* 2018 ; and Armstrong *et al.* 2018)	2010-2018	Specific to Scottish waters within the UK EEZ	Research on the migratory patterns of salmonids and European eels within Scottish waters.
International Bottom Trawl Survey (IBTS) data from ICES Rectangles 43E8, 43E9, 44E7, 44E8, and 44E9. (ICES Data Portal, 2023)	2013-2023	Specific to the Fish and Shellfish Ecology Study Area	Primary datasets stored on the ICES DATRAS database, containing information from various bottom trawl surveys. Used to inform the baseline section.
Fisheries sensitivity maps in British waters (Coull *et al.* 1998; Frost and Diele, 2022)	1998	National coverage	The known extent of spawning grounds within British Waters.
Spawning and nursery grounds of selected fish species in UK waters (Ellis *et al.* 2012)	2012	National coverage	Update to the known extent of spawning grounds within British Waters identified by Coull *et al.* (1998).
Updated fisheries sensitivity maps in British waters	2014	National coverage	Update to the known extent of spawning grounds within British Waters, identified by Coull *et al.* (1998) and Ellis *et al.* (2012). This report should be used as a

Source	Year	Spatial Coverage	Summary
(Aires *et al.* 2014)			supplement to the determinations made by Coull *et al.* (1998) and Ellis *et al.* (2012).
List of threatened and/or declining species and habitats (OSPAR Commission, 2008)	2008	National coverage	List of threatened species and habitats within north-east Atlantic waters.
Scottish Priority Marine Features (Tyler-Walters *et al.* 2016; inclusive of information on FEAST)	2016	Specific to Scottish waters within the UK EEZ	List of species and habitats considered to be marine nature conservation priorities within Scottish waters.
SiteLink Map Search (NatureScot, 2023a)	2023	Specific to Scottish waters within the UK EEZ	List of MPAs within Scottish waters and their designated features.
ORJIP Impacts from Piling on Fish at Offshore Wind Farms: Collating population information, gap analysis and appraisal of mitigation options. Final Report – June 2018 (Boyle and New, 2018)	2018	N/A	A literature review identifying current knowledge and data gaps associated with piling impacts, associated with offshore wind developments, on Atlantic herring spawning populations.
Essential Fish Habitat Maps for Fish and Shellfish Species in Scotland (Franco *et al*. 2022)	2022	Specific to Scottish waters within the UK EEZ	Identification of Essential Fish Habitats within Scottish waters and output spatial data.

10.7 Baseline Environment

10.7.1 Existing Baseline

10.7.1.1 Within the Fish and Shellfish Ecology Study Area, water depth ranges from 0 m (coast) to a maximum of 104.6 m (offshore). Within the OAA, water depths range from 86.5 m to 101.6 m below the lowest astronomical tide (LAT).

10.7.1.2 The water column within the Fish and Shellfish Ecology Study Area is characterised by vertical temperature stratification during summer months and weak stratification in winter months in offshore areas, with mixed inshore waters separated by the Buchan Front (**Volume ER.A.3, Chapter 7: Marine Physical Processes**).

10.7.1.3 The Offshore Development Area is characterised by a variety of sediment types, consisting primarily of sand in the OAA, with increasing gravel content moving inshore along the Offshore ECC. Within the wider Fish and Shellfish Ecology Study Area, sediments consist primarily of sand, slightly gravelly sand, and muddy sand (**Volume ER.A.3, Chapter 7: Marine Physical Processes**). These sediments provide potential spawning grounds for sandeel (Ammodytidae) throughout the Fish and Shellfish Ecology Study Area, and Atlantic herring (*Clupea harengus*) within the Offshore ECC.

10.7.1.4 Background suspended sediment concentrations (SSC) within the Fish and Shellfish Ecology Study Area are low at 0-1 mg l^{-1} year-round (Cefas, 2016). Sediment movement is notably low as the northward littoral drift of the sediment is counteracted by southward tidal currents (JNCC, 1996). The Landfall of the Offshore ECC is characterised by east-facing sandy beaches, that may be considered prone to coastal erosion under the highest emissions (worst-case) scenario within the lifetime of the Offshore Development (Dynamic Coast, 2023).

10.7.1.5 Further information regarding the offshore physical environment is described within **Volume ER.A.3, Chapter 7: Marine Physical Processes** within this EIAR.

Offshore Biological Environment

10.7.1.6 Fish and shellfish are an essential component of marine ecosystems due to the transfer of nutrients from primary producers to secondary predators. Specifically, fish and shellfish species underpin food availability for the majority of marine megafaunal populations. Atlantic herring, sprat and sandeel in particular are key prey species for ornithological receptors, as detailed in **Volume ER.A.3, Chapter 12: Offshore and Intertidal Ornithology**.

10.7.1.7 Fish and shellfish species have been characterised into five groups dependent on similarities in association with different habitat types, physiologies, and life history traits. These categories include:

- elasmobranchs;
- demersal fish;
- pelagic fish;
- diadromous fish; and
- shellfish (commercially and/or ecologically important, or protected shellfish species).

10.7.1.8 Identifying all fish and shellfish species within the Fish and Shellfish Ecology Study Area is not within the scope of this assessment, however data from commercial fishing operations, ICES Data Portal (2023), and published literature provide a sufficient characterisation of the key species present within the Fish and Shellfish Ecology Study Area.

Elasmobranchs

10.7.1.9 Elasmobranch species within the Fish and Shellfish Ecology Study Area have been identified as present by numerous literature sources containing information regarding commercial value and conservation status. Fisheries landing data from 2016-2021 showed a presence of blonde ray (*Raja brachyura*), blue skate/flapper skate complex (*Dipturus batis*/*Dipturus intermedius*), cuckoo ray (*Leucoraja naevus*), nursehound (*Scyliorhinus stellaris*), sandy ray (*Leucoraja circularis*), small-spotted catshark (*Scyliorhinus canicular*), smoothound (*Mustelus mustelus*), spotted ray (*Raja montagui*), spurdog (*Scyliorhinus acanthias*), and thornback ray (*Raja clavata*) within the Fish and Shellfish Ecology Study Area (MMO, 2021; MMO, 2022).

10.7.1.10 The blue skate/flapper skate complex was historically considered a single species; however evidence suggests that the combination of morphological and genetic distinctions between individuals was representative of two distinct species: blue skate and flapper skate (Griffiths *et al.*, 2010; Iglésias *et al.*, 2010; McGeady *et al.*, 2022). Both species are considered Critically Endangered on the IUCN Red List of Threatened Species (Ellis *et al.*, 2021a; Ellis *et al.*, 2021b). Landings data identify blue skate (labelled as common skate (blue/grey) within landings data) as present within the Fish and Shellfish Ecology Study Area, but do not reference flapper skate between 2016-2021 as a result of a ban on landings since 2009 (MMO, 2021; MMO

2022; NatureScot, 2023b). Due to the presence of blue skate, and the historical presence of flapper skate on the east coast of Scotland (Thorburn *et al.*, 2022), and the conservation status of the blue skate/flapper skate complex, it is assumed that flapper skate is also present within the Fish and Shellfish Ecology Study Area; despite the low probability of occurrence identified by McGeady *et al.*, 2022.

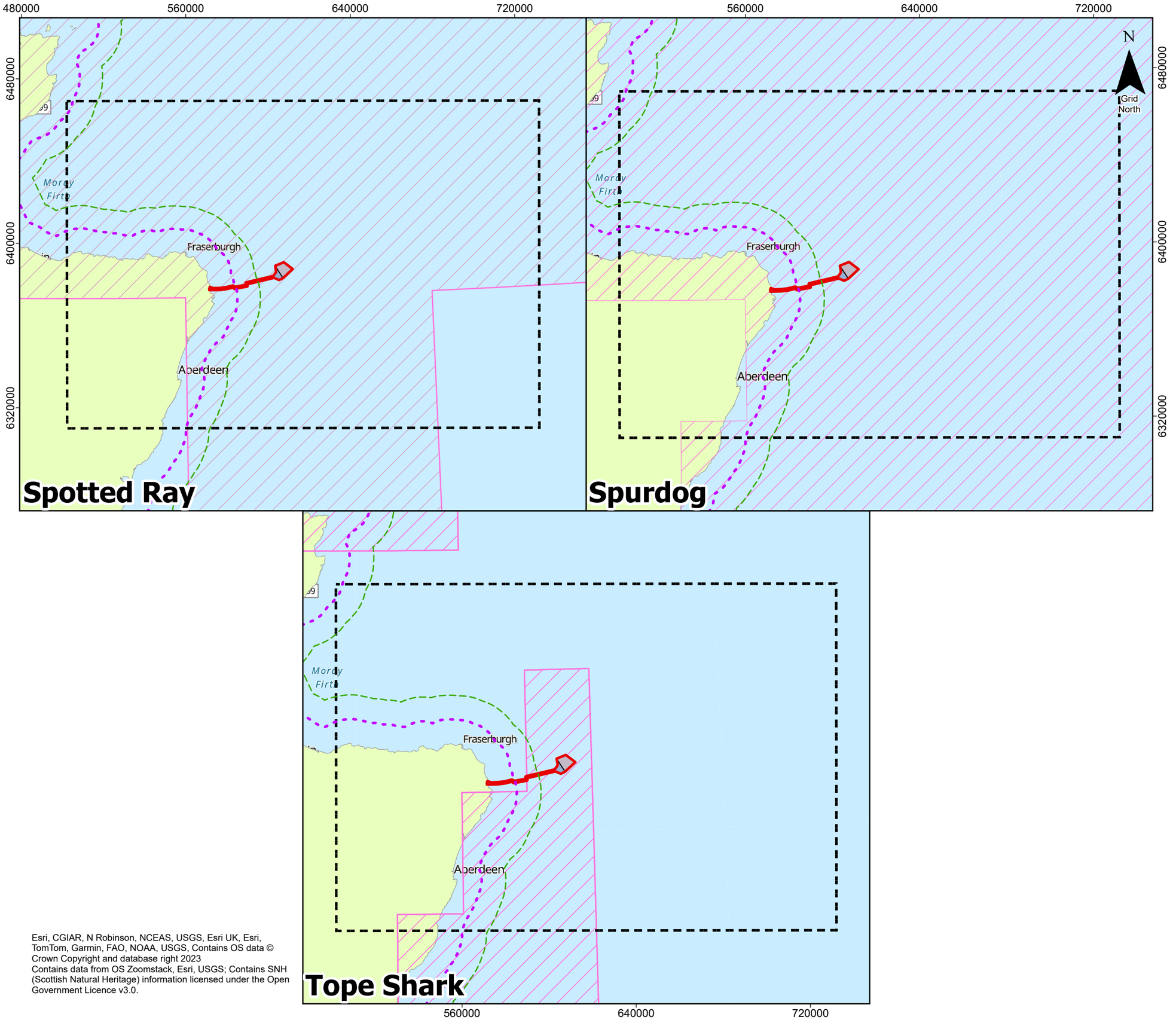
10.7.1.11 The majority of elasmobranch species within Scottish waters are listed as Threatened (Vulnerable, Endangered, or Critically Endangered) on the IUCN Red List, with the exception of bluntnose sixgill shark (*Hexanchus griseus*), cuckoo ray, small spotted catshark, spotted ray, and starry skate (*Amblyraja radiata*) listed as least concern; and blonde ray, blue shark (*Prionace glauca*), Greenland shark (*Somniosus microcephalus*), and starry smoothhound (*Mustelus asterias*) listed as Near Threatened.

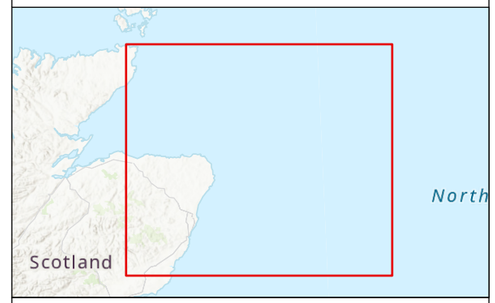
10.7.1.12 Known spawning and nursery grounds for spotted ray, spurdog, tope shark (*Galeorhinus galeus*) have been identified within the Fish and Shellfish Ecology Study Area (Coull *et al.*, 1998; Ellis *et al.*, 2012). The extent of overlap between elasmobranch spawning and/or nursery grounds with the Fish and Shellfish Ecology Study Area is shown in **Figure 10-2**.

Salamander

Figure 10-2

Spawning Nursery - Elasmobranchs





Legend

- Offshore Development Area
- Offshore Array Area
- Offshore Export Cable Corridor
- Fish and Shellfish Ecology Study Area
- Low Intensity Nursery Grounds
- 6nm limit
- 12nm limit

Coordinate System: WGS 1984 UTM Zone 30N

Scale @ A3 : 1:250,000

0 7.5 15 Kilometers

0 1.75 3.5 7 Nautical Miles

Rev	Description	Date
01	Final Issue	22/03/2024
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Doc. Title : Spawning Nursery - Elasmobranchs
Doc. No : SWF01ER0324
Created by : NB
Checked by : IW
Approved by : MKH

SALAMANDER

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Demersal and Pelagic Fish

10.7.1.13 The demersal fish species present within the Fish and Shellfish Ecology Study Area are ultimately dependent on the seabed sediment type and associated habitats, characterising benthos and therefore prey availability, and abiotic condition. Further information regarding the habitats and associated benthic prey of fish and shellfish, specific to the Offshore Development Area, will be provided in **Volume ER.A.3, Chapter 9: Benthic and Intertidal Ecology**. Pelagic fish species are less reliant on the seabed than demersal fish species and are often migratory, with interaction on the seabed limited to benthic spawning species (e.g. Atlantic herring).

10.7.1.14 Commercially important species present within the Fish and Shellfish Ecology Study Area have been identified via numerous datasets, including MMO landings data for ICES Statistical Rectangles 43E8, 43E9, 44E7, 44E8, and 44E9 (MMO, 2021; MMO, 2022); and resources from the Scottish Government's Scottish Marine Assessment Portal (Marine Scotland, 2023). 2021 catch statistics (MMO, 2021) show that the Fish and Shellfish Ecology Study Area contains a diverse fishery comprising of both fish and shellfish species and represents a similar relative contribution of each species group to the combined MMO landings data collected over a five-year period between 2016-2020 for landed weight and (MMO, 2022).

10.7.1.15 In terms of landed weight, the most significant fish species in 2021 (MMO, 2021) included Atlantic herring (3,334 tonnes), followed by haddock (*Melanogrammus aeglefinus*) (2,751 tonnes), and Atlantic mackerel (*Scomber scombrus*) (592 tonnes). By value (MMO, 2021), the most significant species was haddock (£3,176,111), followed by Atlantic herring (£2,066,837).

10.7.1.16 Other notable fish species of commercial value within the Fish and Shellfish Ecology Study Area include monkfish or anglerfish spp. (e.g. *Lophius piscatorius*), and whiting (*Merlangius merlangus*). Further information regarding commercial fisheries is presented within **Volume ER.A.3, Chapter 13: Commercial Fisheries**.

10.7.1.17 When considering the baseline environment for the potential presence of species within the Fish and Shellfish Ecology Study Area that may be impacted by the Offshore Development, consideration must include a temporal scale, and not solely a spatial scale. Spawning and nursery periods are considered sensitive stages of the marine fish lifecycle, in which impacts associated with offshore development may be heightened for eggs and larvae in comparison to adults. The physical environment within the Fish and Shellfish Ecology Study Area represents potential spawning grounds for numerous commercially important species, including Atlantic cod (*Gadus morhua*), European plaice (*Pleuronectes platessa*), lemon sole (*Microstomus kitt*), Norway pout (*Trisopterus esmarkii*), sandeel, sprat (*Sprattus sprattus*), and whiting (Coull *et al.*, 1998; Ellis *et al.*, 2012). Spawning grounds for demersal fish species are shown in relation to the Fish and Shellfish Ecology Study Area in **Figure 10-3**, **Figure 10-4**, and **Figure 10-5**; and for pelagic fish species in **Figure 10-6**.

10.7.1.18 Furthermore, Gonzalez-Irusta and Wright (2016; 2017a-b) have conducted spawning habitat preference modelling for several commercially important Gadidae species (Atlantic cod, haddock, and whiting) in the North Sea. This modelling indicates that the Offshore Development overlaps with potential spawning grounds for all 3 species. Therefore, whilst not indicated by Coull *et al*. (1998) or Ellis *et al*. (2012), haddock is also likely to spawn within the Fish and Shellfish Ecology Study Area (Gonzalez-Irusta and Wright, 2017a).

10.7.1.19 Whilst Coull *et al.* (1998) and Frost and Diele (2022) identify Atlantic herring spawning grounds to be present within the majority of the Fish and Shellfish Study Area, the presence of sandy and muddy sediment types, combined with knowledge of Atlantic herring preference for gravel and sandy gravel (with no mud component) spawning substrata (Reach *et al.*, 2013) implies that potential spawning grounds within the plausible areas of effect associated with the Offshore Development are restricted to isolated areas within the Offshore ECC.

10.7.1.20 The Fish and Shellfish Ecology Study Area also represents nursery grounds for numerous important demersal fish and pelagic fish species; including anglerfish (*L. piscatorius*), Atlantic cod, Atlantic herring, Atlantic mackerel, blue whiting (*Micromesistius poutassou*), European hake (*Merluccius merluccius*), European plaice, haddock, lemon sole, ling (*Molva molva*), Norway pout, sandeel, sprat, and whiting (Coull *et al.*, 1998; Ellis *et al.*, 2012). Haddock, Norway pout, anglerfish, and whiting are the only species considered to have a high probability/confidence of juvenile aggregation (<1 year old) within the Fish and Shellfish Study Area (Aires *et al.*, 2014; Franco *et al*., 2023). Nursery grounds for these aforementioned species are shown in relation to the Fish and Shellfish Ecology Study Area in **Figure 10-3**, **Figure 10-4**, and **Figure 10-5**; and for pelagic fish species in **Figure 10-6**.

10.7.1.21 Other species of demersal and pelagic fish have been identified as present within the Fish and Shellfish Ecology Study Area via data extraction from ICES Bottom Trawl Surveys (ICES Data Portal, 2023). The following demersal and pelagic fish species of conservation importance in the UK, but without commercial value or spawning grounds within the Fish and Shellfish Ecology Study Area, have been identified as present (ICES Data Portal, 2023):

- Atlantic halibut (*Hippoglossus hippoglossus*), Endangered (IUCN Red List) and listed as a PMF under the Marine (Scotland) Act 2010;
- saithe (*Pollachius virens*), listed as a PMF under the Marine (Scotland) Act 2010; and
- sand goby (*Pomatoschistus minutus*), listed as a PMF under the Marine (Scotland) Act 2010.

10.7.1.22 No additional species of particular ecological, conservation, or commercial importance within the Fish and Shellfish Ecology Study Area have been identified.

Salamander

Figure 10-3

Spawning Nursery - Demersal 1/3

Atlantic Cod

Norway Pout

Haddock

Whiting

Legend

- Offshore Export Cable Corridor
- Offshore Array Area
- Offshore Development Area
- Fish and Shellfish Ecology Study Area
- 6nm limit
- 12nm limit
- High Intensity Spawning grounds
- Low Intensity Spawning grounds
- High Intensity Nursery grounds
- Low Intensity Nursery grounds

Coordinate System: WGS 1984 UTM Zone 30N

Scale @ A3 : 1:250,000

0 7.5 15 Kilometers

0 1.75 3.5 7 Nautical Miles

Rev	Description	Date
01	Final Issue	22/04/2024
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Doc. Title : Spawning Nursery - Demersal 1/3
Doc. No : SWF01ER0326
Created by : NB
Checked by : IW
Approved by : MKH

SALAMANDER

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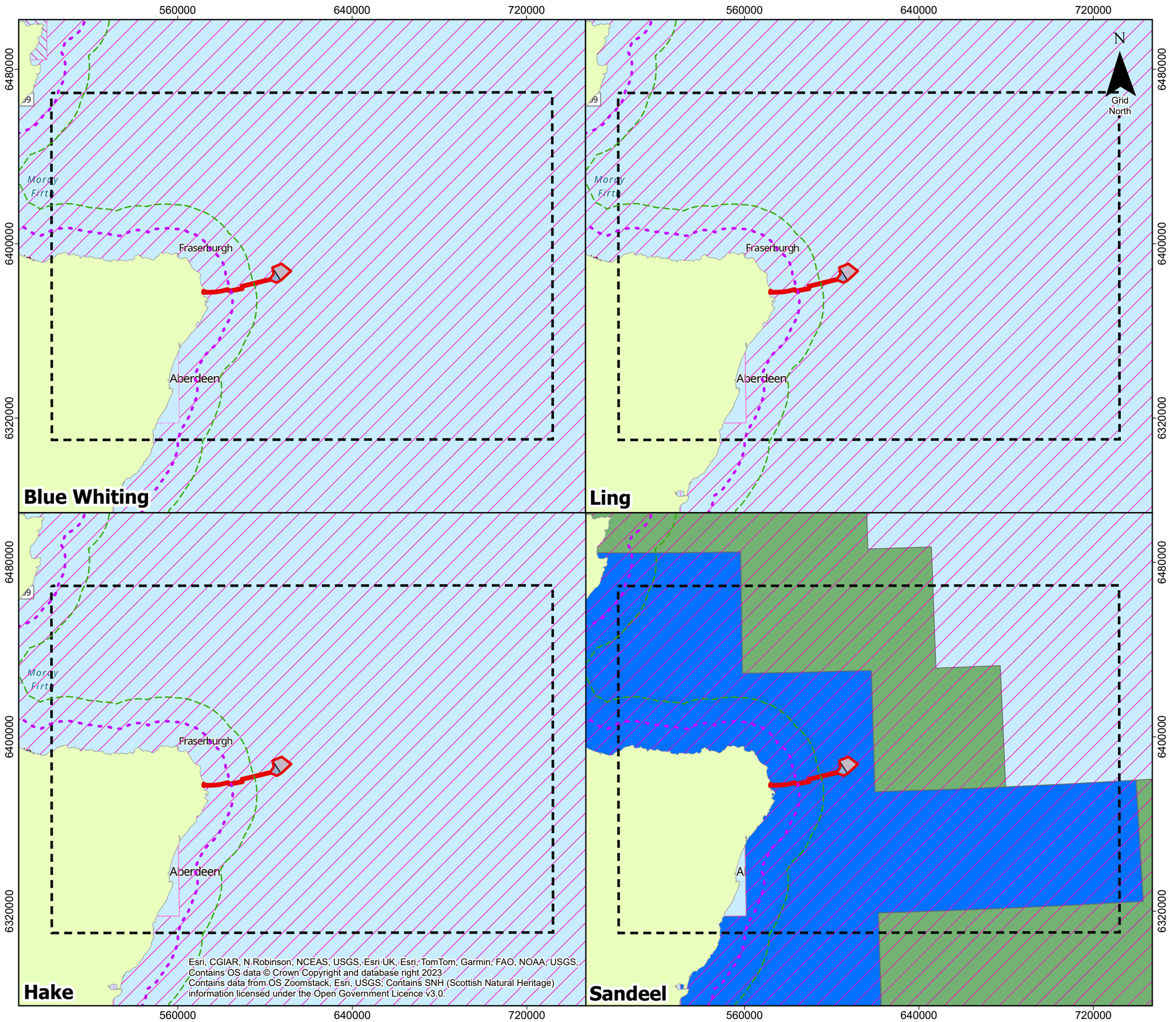
Salamander

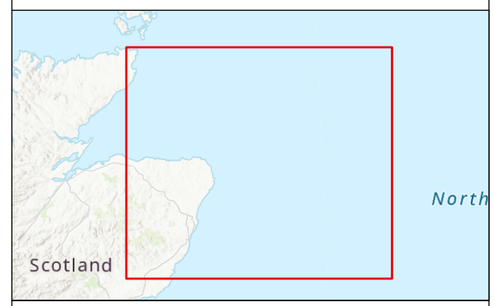
Figure 10-4

Spawning Nursery - Demersal 2/3



Legend

- Offshore Export Cable Corridor
- Offshore Array Area
- Offshore Development Area
- 6nm limit
- 12nm limit
- Fish and Shellfish Ecology Study Area
- High Intensity Spawning grounds
- Low Intensity Spawning grounds
- Low Intensity Nursery Grounds



Coordinate System: WGS 1984 UTM Zone 30N

Scale @ A3 : 1:250,000

0 7.5 15 Kilometers

0 1.75 3.5 7 Nautical Miles

Rev	Description	Date
01	Final Issue	22/03/2024
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Doc. Title : Spawning Nursery - Demersal 2/3
Doc. No : SWF01ER0326
Created by : NB
Checked by : IW
Approved by : MKH

SALAMANDER

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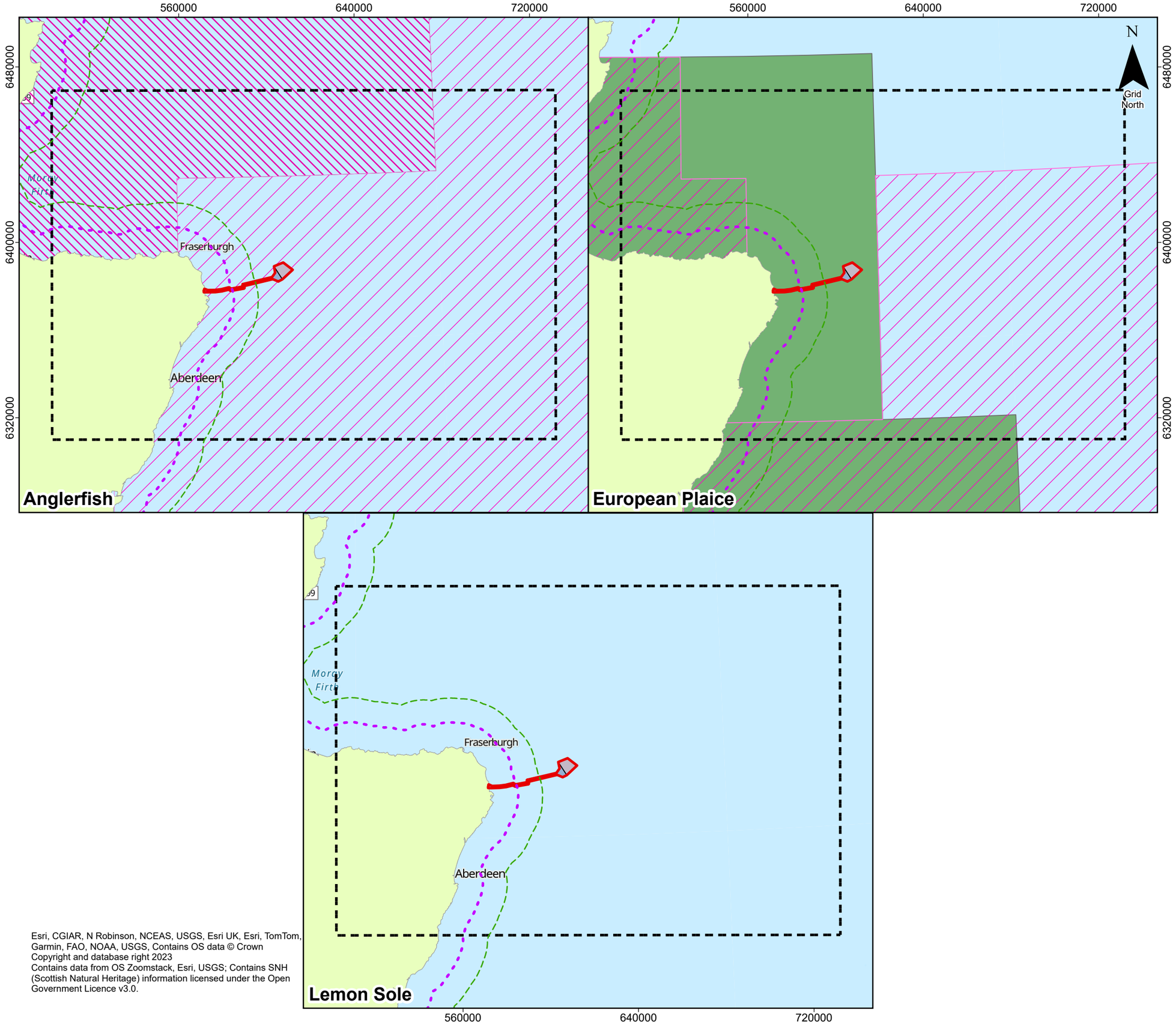
Salamander

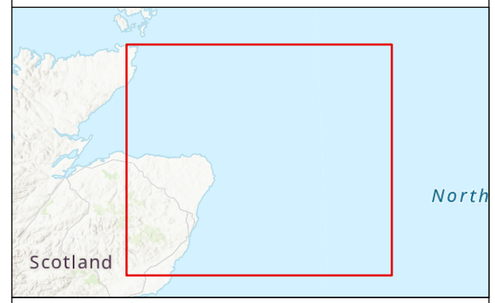
Figure 10-5

Spawning Nursery - Demersal 3/3



Legend

- Offshore Export Cable Corridor
- Offshore Array Area
- Offshore Development Area
- Fish and Shellfish Ecology Study Area
- 6nm limit
- 12nm limit
- High Intensity Spawning Grounds
- Low Intensity Spawning Grounds
- High Intensity Nursery Grounds
- Low Intensity Nursery Grounds



Coordinate System: WGS 1984 UTM Zone 30N

Scale @ A3 : 1:250,000

0 7.5 15 Kilometers

0 1.75 3.5 7 Nautical Miles

Rev	Description	Date
01	Final Issue	22/03/2024
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Doc. Title : Spawning Nursery - Demersal 3/3
Doc. No : SWF01ER0327
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Checked by : IW
Approved by : MKH

SALAMANDER

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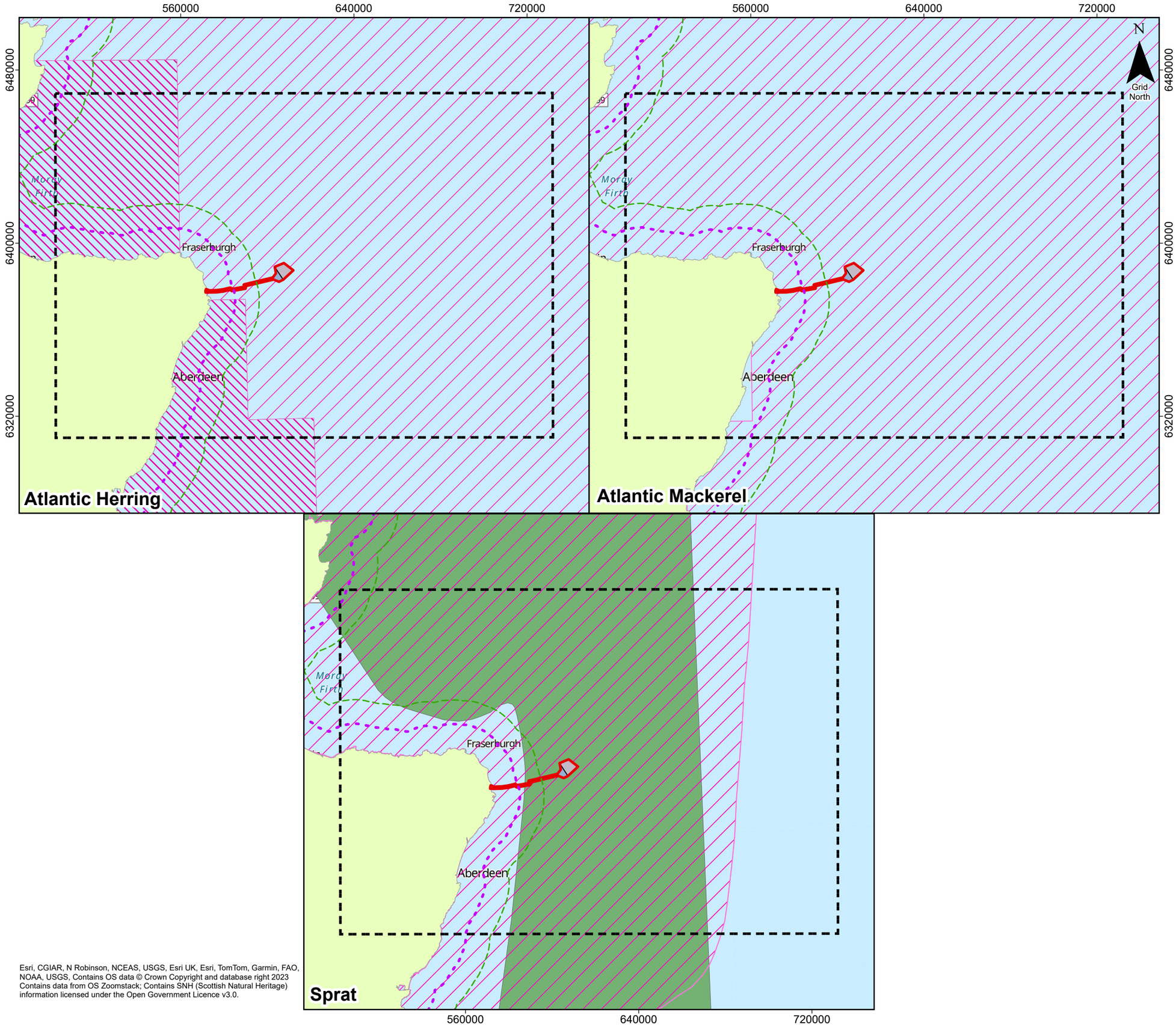
Salamander

Figure 10-6

Spawning Nursery - Pelagic



Legend

- Offshore Development Area
- Offshore Array Area
- Offshore Export Cable Corridor
- 6nm limit
- 12nm limit
- Fish and Shellfish Ecology Study Area
- High Intensity Nursery Grounds
- Low Intensity Nursery Grounds
- Low Intensity Spawning Grounds

Coordinate System: WGS 1984 UTM Zone 30N

Scale @ A3 : 1:840,000

0 25 50 Kilometers

0 5 10 20 Nautical Miles

Rev	Description	Date
01	Final Issue	25/03/2024
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Doc. Title : Spawning Nursery - Pelagic
Doc. No : SWF01ER0329
Created by : NB
Checked by : IW
Approved by : MKH

SALAMANDER

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Sandeel

10.7.1.23 The Offshore Development is located in an area of high intensity spawning grounds for sandeel, as identified by Langton *et al*., 2021 in **Figure 10-8**, and by Coull *et al.* (1998) and Ellis *et al.* (2012) in **Figure 10-4**. Sandeel are considered a key prey species for protected bird and mammal species, in addition to predatory fish species, and are particularly sensitive to marine development activities involving direct and indirect seabed disturbance.

10.7.1.24 Sandeel show preference for sand-dominated seabed habitats (Latto *et al*., 2013), within which they burrow and shelter. As described in Latto *et al.* (2013), potential supporting habitat for sandeel has been categorised into preferred (Sand, slightly gravelly Sand, and gravelly Sand) and marginal (sandy Gravel) habitats in accordance with the Folk 16 sediment classification (Folk, 1954). Seabed sediments that do not fall within these categories are deemed unsuitable for sandeel.

10.7.1.25 In line with current UK guidance, specific modelling of potential supporting habitat for sandeel has been undertaken as part of the baseline characterisation of the Fish and Shellfish Ecology Study Area. The aim of this modelling is to identify areas in which seabed sediments have a high likelihood of supporting sandeel, and uses the methodology and rationale described in Latto *et al.* (2013). Alternative modelling approaches are available (e.g. Langton *et al.*, 2021), however the approach described by Latto *et al*. (2013) represents a precautionary approach to identifying potential supporting habitat, rather than estimating population density or probability of occurrence of individuals. The precautionary approach of Latto *et al.* (2013) is deemed more applicable to the aims of this EIA, in line with other offshore developments in the North Sea and reflecting changes in UK guidance in the near future.

10.7.1.26 The output of the modelling process is presented in **Figure 10-7** and shows that the Offshore Development is located within Medium-High potential supporting habitat for sandeel. The total area of Low, Medium, and High potential supporting habitat within the Fish and Shellfish Ecology Study Area and the Offshore Development Area is shown in **Table 10-4.**

Table 10-4 The extents (km²) of potential supporting habitat for sandeel within the Fish and Shellfish Ecology Study Area and the Offshore Development Area

Potential supporting habitat for sandeel	Total area within the Fish and Shellfish Ecology Study Area (km²)	Total area within the Offshore Development Area (km²)
Low	2,571	0
Medium	7,965	23
High	4,709	58

10.7.1.27 The extent of High potential within the Fish and Shellfish Ecology Study Area is in part due to the extent of the Coull *et al*. (1998) data-layer indicating supporting habitat for sandeel, which results in a score of 9 (High potential). Due to the vintage of the Coull *et al*. (1998) data-layer, confidence in the heat map indicating High potential is low. For context, modelling undertaken by Langton *et al*. (2021) identifies the OAA as having a very low/negligible probability of sandeel presence or density; whereas the landward extent of the export cable is likely to interact with an area of moderate-high probability of sandeel presence or density to the north of Peterhead. As identified by Langton *et al*. (2021), it is well known that external factors such as water depth and seabed slope angles contribute to the suitability of supporting habitats. The Latto *et al*. (2013)

methodology makes no consideration for site-specific detail, such as bathymetry, and therefore provides an over-representative indication of potential supporting habitat for sandeel.

10.7.1.28 Due to the likelihood of interaction with high density sandeel populations at the landward extent of the Offshore ECC, the Impact Assessment for temporary/lasting habitat loss or disturbance will consider sandeel separately alongside (as opposed to within) the demersal fish receptor group in **Sections 10.11.1** and **10.11.2**.

Salamander

Figure 10-7

Sandeel potential habitat

560000
640000
6400000
6320000
N
Grid North
44E7
44E8
44E9
43E8
43E9

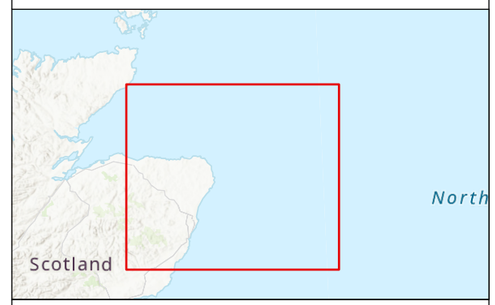
Legend

- Offshore Development Area
- Offshore Array Area
- Offshore Export Cable Corridor
- Indicative Onshore Development Area
- Study Area
- 6nm limit
- 12nm limit

HEAT score

- 0
- 2
- 3
- 4
- 5
- 6
- 7
- 9

Low
Medium
High



Coordinate System: WGS 1984 UTM Zone 30N

Scale @ A3 : 1:673,916

0 20 40 Kilometers

0 5 10 20 Nautical Miles

Rev	Description	Date
01	Final Issue	26/03/2024
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Doc. Title : Sandeel potential habitat
Doc. No : SWF01ER0329
Created by : NB
Checked by : IW
Approved by : MKH

SALAMANDER

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480000
560000
640000
6480000
6400000
6320000

N
Grid North

44E7
44E8
44E9
43E8
43E9

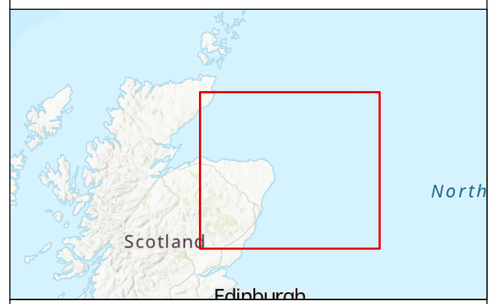
Salamander

Figure 10-8

Probability of presence of buried sandeel (Langton *et al* , 2021)

Legend

- Offshore Development Area
- Offshore Array Area
- Offshore Export Cable Corridor
- Indicative Onshore Development Area
- Fish and shellfish Ecology Study Area
- 1 (More Probable)
- 0 (Less Probable)
- 6nm limit
- 12nm limit



Coordinate System: WGS 1984 UTM Zone 30N

Scale @ A3 : 1:740,810

0 20 40 Kilometers

0 5 10 20 Nautical Miles

Rev	Description	Date
01	Final Issue	26/03/2024
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Doc. Title : Probability of presence of buried sandeel
Doc. No : SWF01ER0330
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Approved by : MKH

SALAMANDER
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Atlantic herring

10.7.1.29 The Offshore Development is located in an area of low intensity nursery grounds for Atlantic herring, as identified by Coull *et al.* (1998) and Ellis *et al.* (2012) in **Figure 10-6**. Atlantic herring are considered a key prey species for protected bird and mammal species, in addition to predatory fish species; and are particularly sensitive to marine development activities involving direct and indirect seabed disturbance during their spawning period. North Sea Autumn Spawning (NSAS) populations of Atlantic herring are categorised based upon location and spending period, with the Buchan population relevant to the Fish and Shellfish Ecology Study Area.

10.7.1.30 Atlantic herring show preference for gravel-dominated seabed habitats (Reach *et al*., 2013), upon which they lay demersal egg masses. As described in Reach *et al.* (2013), potential spawning habitat for Atlantic herring has been categorised into preferred (Gravel and sandy Gravel) and marginal (gravelly Sand) habitats in accordance with the Folk 16 sediment classification (Folk, 1954). Seabed sediments that do not fall within these categories are deemed unsuitable for Atlantic herring.

10.7.1.31 In line with current UK guidance, specific modelling of potential spawning habitat for Atlantic herring has been undertaken as part of the baseline characterisation of the Fish and Shellfish Ecology Study Area. The aim of this modelling is to identify areas in which seabed sediments have a high likelihood of supporting Atlantic herring egg laying and egg survival, and uses the methodology and rationale described in Reach *et al.* (2013), in line with other offshore developments in the North Sea at the time of writing.

10.7.1.32 The output of the modelling process is presented in **Figure 10-9** and shows that the Offshore Development is located within Medium-High potential spawning habitat for Atlantic herring. The total area of Low, Medium, and High potential supporting habitat within the Fish and Shellfish Ecology Study Area and the Offshore Development Area is shown in **Table 10-5**.

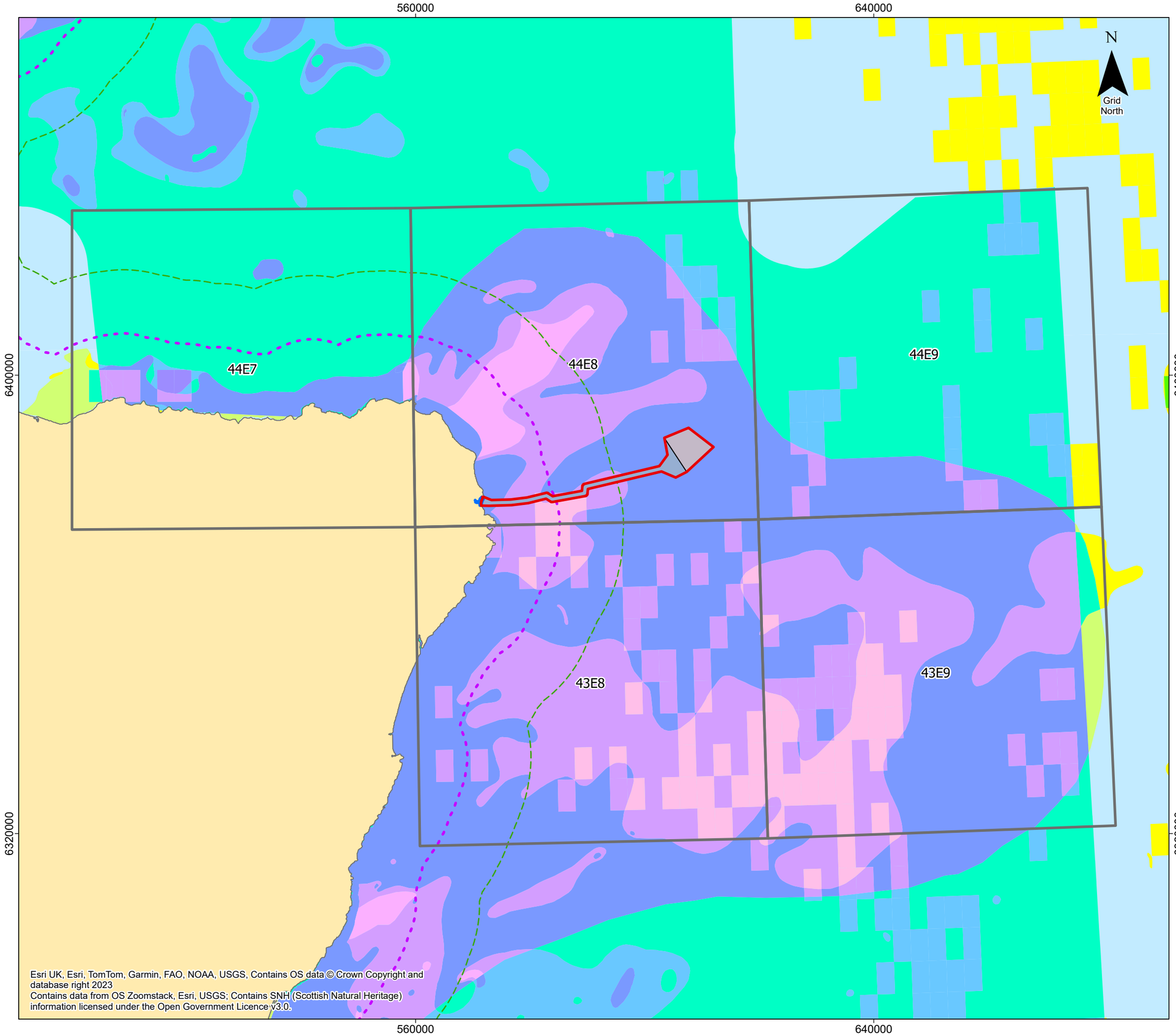
Table 10-5 The extents (km²) of potential spawning habitat for Atlantic herring within the Fish and Shellfish Ecology Study Area and the Offshore Development Area

Potential spawning habitat for Atlantic herring	Total area within the Fish and Shellfish Ecology Study Area (km²)	Total area within the Offshore Development Area (km²)
Low	197.5	0
Medium	10,078.6	57.2
High	4,370.3	23.3

10.7.1.33 The extent of High potential within the Fish and Shellfish Ecology Study Area is in part due to the extent of the Coull *et al*. (1998) data-layer indicating spawning habitat for Atlantic herring, which results in a score of 8+ (Medium-High potential). The heat map produced in accordance with Reach *et al*. (2013) is inherently limited by the datasets included. The Coull *et al*. (1998) dataset, included within Ellis *et al*. (2012) dataset, indicates spawning grounds to the south of the Offshore ECC are of undefined intensity, and indicated to be of low larval productivity within IHLS data in comparison to the Shetland/Orkney, Banks, and Downs NSAS populations (Ellis *et al*., 2012). Furthermore, the vintage score of the Coull *et al*. (1998) data has not been updated from that allocated within the Reach *et al*. (2013) method, and the underlying EMODnet data identifies the area of High potential within **Figure 10-9** as consisting of preferred and marginal potential spawning habitat for Atlantic herring (sandy Gravel and gravelly Sand), confirmed via ground truthing by

project-specific geophysical and benthic surveys (**Volume ER.A.3, Chapter 7: Marine Physical Processes**; Ocean Infinity, 2022a; 2022b).

10.7.1.34 Therefore, it is concluded that confidence in the heat map indicating Medium-High potential within the Offshore ECC is low, and that the Offshore Development Area does not represent a substantial extent of potential spawning habitat for Atlantic herring in the Fish and Shellfish Ecology Study Area or the wider eastern Scottish coast region available to the Buchan Atlantic herring population. As such, no specific Atlantic herring assessments will be included within the Fish and Shellfish Ecology chapter of the EIAR.



Salamander

Figure 10-9

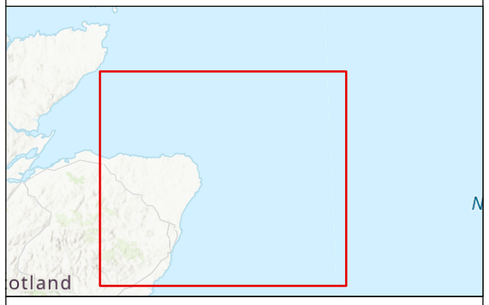
Herring potential habitat

Legend

- Offshore Development Area
- Offshore Array Area
- Offshore Export Cable Corridor
- Indicative Onshore Development Area
- 6nm limit
- 12nm limit
- Study Area

HEAT score

2	
3	Low
4	
5	
7	Medium
8	
9	
10	High
11	
12	



Coordinate System: WGS 1984 UTM Zone 30N

Scale @ A3 : 1:650,488

0 10 20 Kilometers

0 5 10 20 Nautical Miles

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Doc. Title : Herring potential habitat
Doc. No : SWF01ER0331
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Diadromous Fish

10.7.1.35 The River Dee SAC, the Moray Firth SAC, and the River Spey SAC will be included within the assessment for diadromous fish receptors. Off the Scottish coast, there is particular emphasis on the conservation importance of anadromous Atlantic salmon *Salmo salar* as an Annex II species, which may be present within the Fish and Shellfish Ecology Study Area when migrating to offshore feeding grounds.

10.7.1.36 Tagging studies suggest that the Atlantic salmon sub-populations on the east coast of Scotland return to the coastline enroute to specific spawning river systems but undergo spatial population mixing in coastal environments before returning to freshwater (Cauwelier *et al.*, 2015; Downie *et al.*, 2018; Armstrong *et al.*, 2018). Therefore, the Atlantic salmon population within the Fish and Shellfish Ecology Study Area is likely to consist of multiple sub-populations.

10.7.1.37 A report produced by Marine Scotland (Malcolm *et al.*, 2010), subsequently updated in 2020, provides a broad-scale overview of the adult and juvenile migration patterns of Atlantic salmon, sea trout *Salmo trutta*, and European eel *Anguilla anguilla* within Scottish coastal waters. Atlantic salmon show limited fidelity to coastal environments around source rivers during post-smolt anadromous migrations, migrating offshore relatively quickly after leaving estuarine environments (Malcolm *et al*., 2010; McIlvenny *et al*., 2021); whereas smolts are thought to migrate towards the Faroe Islands and Greenland. Studies have suggested that Atlantic salmon prefer depths of ~10 m (Holm *et al*., 2000; Davidsen *et al*., 2008; Godfrey *et al*., 2015) and that migratory routes are not defined by current-following behaviour but specific directional swimming in surface waters (~5 m depth) (Ounsley *et al*., 2020; Newton *et al*., 2021). Despite these recent studies furthering our understanding of general migratory patterns, Atlantic salmon migration routes and behaviour remains poorly understood at a site-specific scale.

10.7.1.38 For sea trout, knowledge of migratory routes within the marine environment is lacking, however it is thought that, like Atlantic salmon, sea trout on the east coast of Scotland show little fidelity to local coastal environments during post-smolt anadromous migrations. Therefore, in line with the conclusions made within the Marine Scotland report (Malcolm *et al.*, 2010), the extent of available data is insufficient to inform site-specific risk assessment for sea trout. As such, sea trout are considered to have similar sensitivity to Atlantic salmon for the purposes of this assessment.

10.7.1.39 In the case of catadromous fish, such as European eel, adults may transit through the Fish and Shellfish Ecology Study Area during migration. Little is known regarding the migration routes taken by European eel from the east coast of Scotland to spawning grounds in the Sargasso Sea, however it is expected that populations from river systems south of the Fish and Shellfish Ecology Study Area are likely to migrate north, through the Fish and Shellfish Ecology Study Area, and around the northern coast of Scotland to join populations from other Scottish river systems (Malcolm *et al.*, 2010).

10.7.1.40 For juvenile European eel (glass eels), Atlantic currents may facilitate passive migration around the European Continental Shelf past Ireland and across the Hebrides and north Scotland, feeding into the Northern North Sea (Malcom *et al*., 2010). However, it has not been confirmed that glass eels undergo passive or active migration into source river systems (Malcom *et al*., 2010). It is expected that the European Eel population within the vicinity of the Offshore Development are a result of a combination of mass transport of glass eels by the Scottish Coastal Current and the Fair Isle Current, supplemented by active migration within smaller subsidiary currents closer to shore. Due to the lack of research regarding the migration of glass eels within eastern Scottish coastal waters, it must be assumed that migration pathways intersect the Fish and Shellfish Ecology Study Area at all European eel life stages (Cresci *et al.*, 2021).

10.7.1.41 In addition, sea lamprey (*Petromyzon marinus*) are designated under Annex II of the EU Habitats Directive, and a designated feature of the River Spey SAC, 94 km northeast of the Offshore Development Area (and outside of the Fish and Shellfish Ecology Study Area), but within the wider catchment area for diadromous fish. Other diadromous fish species identified as present within the Fish and Shellfish Ecology Study Area include:

- river lamprey (Lampetra fluviatilis);
- allis shad (*Alosa alosa*);
- twaite shad (*Alosa fallax*); and
- three-spined stickleback (*Gasterosteus aculeatus*).

10.7.1.42 Whilst allis shad and twaite shad have unknown distributions in northern UK waters, there is historical evidence to suggest their presence in the Fish and Shellfish Ecology Study Area (Potts and Swaby, 1993; Aprahamian *et al*., 1998). Therefore, both species have been included in this assessment as a precaution.

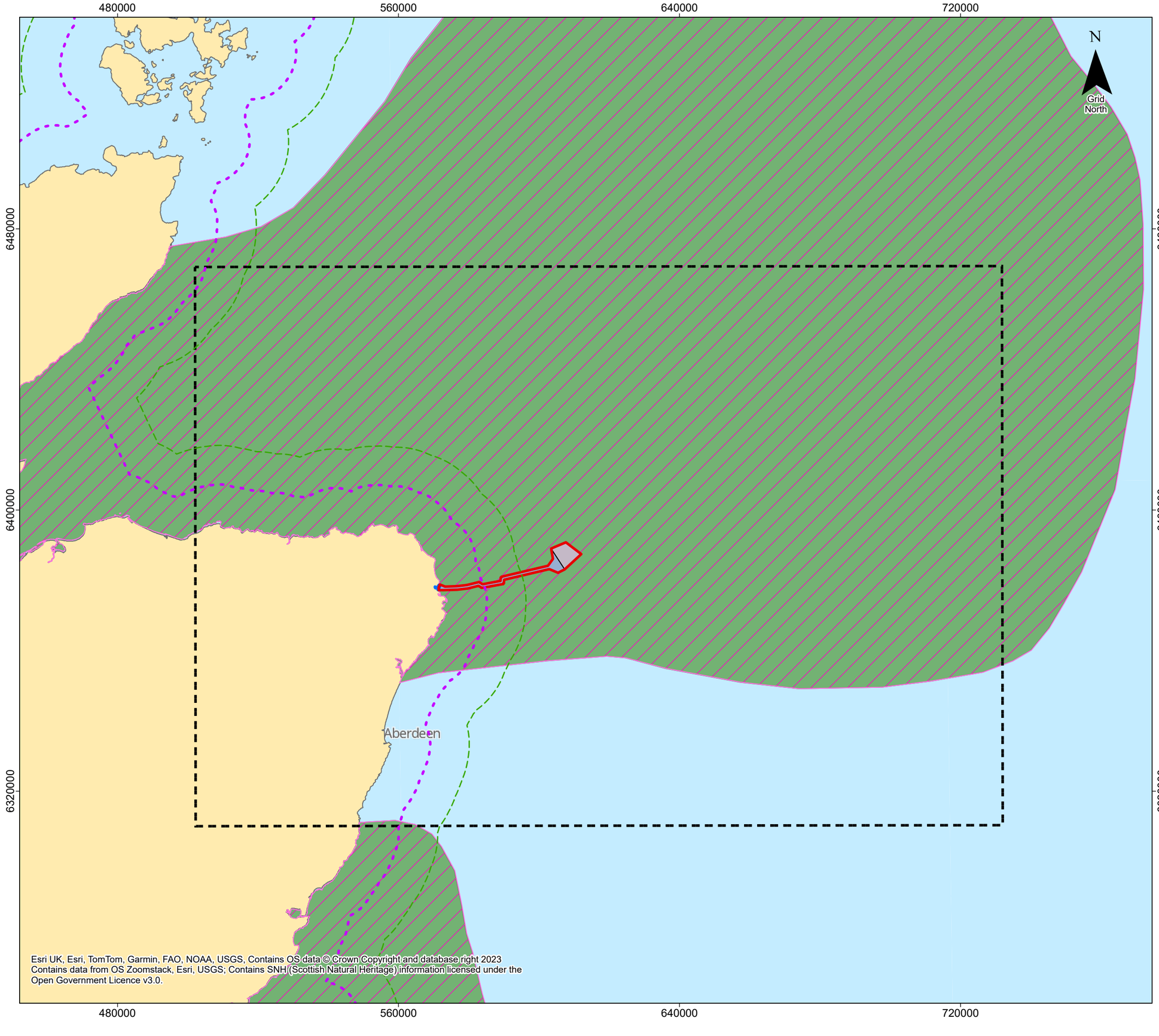
Shellfish

10.7.1.43 This receptor group consists of commercially and/or ecologically important, or protected shellfish species.

10.7.1.44 2021 catch statistics (MMO, 2021) show that the Fish and Shellfish Ecology Study Area contains a number of shellfisheries and represents a similar relative contribution of each species group to the combined MMO landings data collected over a five-year period between 2016-2020 for landed weight and (MMO, 2022). The only noticeable difference being the percentage of total catch value (£) represented by squid (Loliginidae and/or Ommastrephidae), which decreased from 12% between 2016-2020 (inclusive) to 4% in 2021 (only).

10.7.1.45 In terms of landed weight, the most important shellfish species in 2021 (MMO, 2021) is Norway lobster (*Nephrops norvegicus*) (1,350 tonnes), followed by king or queen scallop (*Pecten maximus* or *Aequipecten opercularis*) (1,152 tonnes). By value (MMO, 2021), Norway lobster was the most valuable (£5,101,798), followed by king or queen scallop (£1,909,662), and brown crab (*Cancer pagurus*) (£1,805,791). Other notable shellfish of commercial value within the Fish and Shellfish Ecology Study Area include European lobster (*Homarus gammarus*) and various squid species targeted in the Fish and Shellfish Ecology Study Area (MMO, 2021). Further information regarding commercial fisheries is presented within **Volume ER.A.3, Chapter 13: Commercial Fisheries**.

10.7.1.46 As stated above, consideration must be made for at a temporal scale, and not solely a spatial scale. Spawning and nursery periods are considered sensitive stages of the marine shellfish lifecycle (as they are for marine fish), in which impacts associated with offshore development may be heightened for eggs and larvae in comparison to adults. Due to the limited mobility and lack of migratory behaviour exhibited by most shellfish species (excluding Cephalopoda), the physical environment within the Fish and Shellfish Ecology Study Area represents potential spawning grounds for all shellfish species. Female decapod crustaceans have greater sensitivity to impacts upon the seabed when berried and immobile, such as brown crab; whilst others have defined spawning grounds, such as Norway lobster (Coull *et al.*, 1998; Ellis *et al.*, 2012), as presented within **Figure 10-10**.



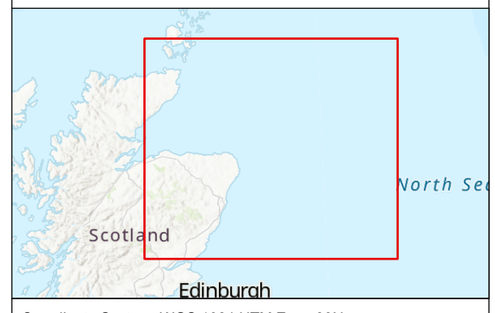
Salamander

Figure 10-10

Spawning Nursery - Nephrops

Legend

- Offshore Development Area
- Offshore Array Area
- Offshore Export Cable Corridor
- Indicative Onshore Development Area
- Fish and Shellfish Ecology Study Area
- Low Intensity Spawning Grounds
- Low Intensity Nursery Grounds
- 6nm limit
- 12nm limit



Coordinate System: WGS 1984 UTM Zone 30N

Scale @ A3 : 1:1,044,184

0 30 60 Kilometers

0 5 10 20 Nautical Miles

Rev	Description	Date
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Doc. Title : Spawning Nursery - Nephrops
Doc. No : SWF01ER0332
Created by : NB
Checked by : IW
Approved by : MKH

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Fish Receptor Groups for the Underwater Noise Assessment

10.7.1.47 In addition to the Elasmobranch, Demersal Fish, Pelagic Fish, Diadromous Fish, and Shellfish receptor groups identified above, the following receptor groups are required for categorising fish and shellfish species with sensitivity to underwater noise in accordance with Popper *et al.* (2014):

- fish with a swim bladder-inner ear connection used in hearing;
- fish with a swim bladder not used in hearing;
- fish with no swim bladder;
- eggs and larvae; and
- shellfish.

10.7.1.48 For fish species, sensitivity to unwanted underwater sounds (underwater noise) has been identified as related to the interconnectivity of the inner ear to a swim bladder. The swim bladder-inner ear connections in fish consist of gas-filled ducts or arrangements of bones, converting sound pressure received by the swim bladder into particle motion detected by otoliths within the inner ear (Popper and Hawkins, 2018). Detection of particle motion in can also be achieved by other specialised organs (e.g. lateral lines), however the absence of a physical connection between the inner ear and the swim bladder removes the ability to detect sound pressure. Whilst fish with a swim bladder-inner ear connection used in hearing are able to detect both particle motion and sound pressure, fish without a swim bladder are considered to respond to underwater sound pressure and vibration via particle motion only (Popper *et al.*, 2014; Popper and Hawkins, 2018).

10.7.1.49 Species without a swim bladder are generally considered less sensitive to sound pressure than those with a swim bladder (regardless of interconnectivity with the inner ear). Temporary but recoverable effects of high amplitude sounds, indicated by temporary threshold shift (TTS), are likely to occur for the most sensitive species (i.e. those with interconnectivity between the swim bladder and the inner ear, used in hearing) at 186 dB SEL_{CUM}. Lasting injury and potential mortality, indicated by permanent threshold shift (PTS), is likely to occur at >203 dB SEL_{CUM} for sensitive species (Popper *et al.*, 2014). See **Table 10-6** for all thresholds associated with the fish receptor groups for underwater noise assessment.

10.7.1.50 For the allocation of sensitivity scores against underwater noise, fish and shellfish species have been considered in relation to their sensitivity to anchor piling, which results in the worst-case zone of effect relating to the emission of underwater sound associated with the Offshore Development.

Table 10-6 Sound exposure thresholds for marine fish to various underwater noise sources (Popper *et al.*, 2014). RMS – Root Mean Square; SEL_{CUM} – Cumulative Sound Exposure Level; dB peak for pile driving assumes a single strike

Receptor Group	Underwater Sound Source	Direct Mortality and Potential Mortal Injury	Impairment	
			Recoverable Injury	*Temporary Threshold Shift*
Fish with a swim bladder-inner ear connection used in hearing	Continuous sound	NA	170 dB RMS for 48 hrs	158 dB RMS for 12 hrs
	Pile driving	207 dB SEL_{CUM} >207 dB peak	203 dB SEL_{CUM} >207 dB peak	186 dB SEL_{CUM}

Receptor Group	Underwater Sound Source	Direct Mortality and Potential Mortal Injury	Impairment	
			Recoverable Injury	*Temporary Threshold Shift*
	Explosions	229 – 234dB peak	NA	NA
Fish with a swim bladder not used in hearing	Pile driving	210 dB SEL_{CUM} >207 dB peak	203 dB SEL_{CUM} >207 dB peak	>186 dB SEL_{CUM}
	Explosions	229 – 234 dB peak	NA	NA
Fish with no swim bladder	Pile driving	>219 dB SEL_{CUM} >213 dB peak	>216 dB SEL_{CUM} >213 dB peak	>>186 dB SEL_{CUM}
	Explosions	229 – 234 dB peak	NA	NA
Eggs and larvae	Pile driving	210 dB SEL_{CUM} >207 dB peak	Moderate impact nearfield (tens of metres), low impact beyond	Moderate impact nearfield (tens of metres), low impact beyond
	Explosions	>13 mm s^{-1} peak velocity	NA	NA

10.7.1.51 Species with a swim bladder-inner ear connection (and therefore allocated the greatest sensitivity to underwater sound) identified within the Fish and Shellfish Ecology Study Area include:

- Atlantic cod;
- Atlantic herring;
- sprat;
- allis shad;
- twaite shad; and
- European eel.

10.7.1.52 The remaining fish species are allocated into the other receptor groups based upon the presence or absence of a swim bladder. Species with spawning grounds within the Fish and Shellfish Ecology Study Area will be noted within the Eggs and Larvae receptor group, which has a separate sensitivity to underwater noise to adult fish (Popper *et al.*, 2014).

Species of Conservation Importance

10.7.1.53 The location of the Offshore Development's OAA and Offshore ECC in relation to nature conservation sites is presented in **Figure 10-11**.

10.7.1.54 Anglerfish, Atlantic cod, Atlantic herring, Atlantic mackerel, blue whiting, blue skate/flapper skate complex, ling, Norway pout, sandeel, spurdog, and whiting are listed as Scottish PMFs (Tyler-Walters *et al.*, 2016). Atlantic cod, blue skate/flapper skate complex, spurdog, and spotted ray are listed on the OSPAR List of Threatened and/or Declining Species and Habitats.

10.7.1.55 Diadromous fish and sandeel are the only marine fish species designated under Annex II of the EU Habitats Directive, which has been incorporated into UK legislation within the Habitats Regulations. The Fish and Shellfish Ecology Study Area (excluding any extent of the Offshore Development Area) overlaps with the Turbot Bank NCMPA (designated for sandeel), whilst the Offshore ECC overlaps with the southern extent of the Southern Trench NCMPA (designated for minke whale *Balaenoptera acutorostrata*, burrowed mud (an indicator of Norway lobster), fronts, shelf deeps, and geological features representative of the Quaternary of Scotland and submarine mass movement). Further information regarding the potential for impact to qualifying features of the Southern Trench NCMPA are provided within the relevant sections of **Volume ER.A.3, Chapter 9: Benthic and Intertidal Ecology** and **Volume ER.A.3, Chapter 11: Marine Mammals**; and their associated MPA Assessment Annexes.

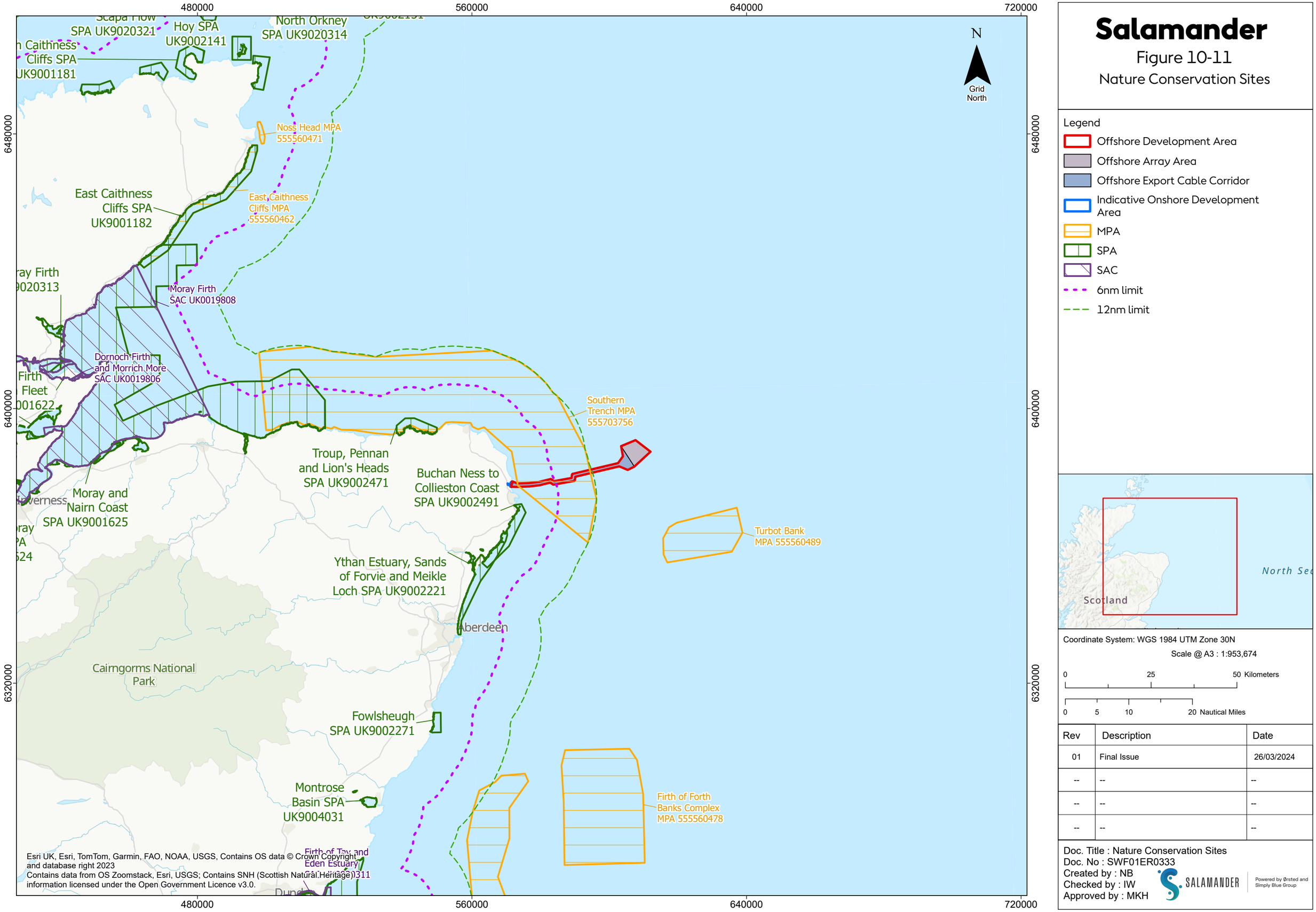
10.7.1.56 It is noted that a limited number of physical records of ocean quahog *Arctica islandica* have been identified within the northern and northwestern extents of the Fish and Shellfish Ecology Study Area (ICES Statistical Rectangles 44E7, 44E8, and 44E9), confirming an extent of low-moderate probability distribution of the species as presented by Reiss *et al.* (2011). However, no physical records are present within the Offshore Development Area. The Offshore Development is not located within the vicinity of any Marine Protected Areas (MPAs) designated for ocean quahog (e.g. Firth of Forth Banks Complex MPA or East of Gannet and Montrose Fields MPA), nor within key distributions for European spiny lobster *Palinurus elephas* (a PMF).

10.7.1.57 No other sites with qualifying fish or shellfish features (excluding the aforementioned River Dee, Moray Firth, and River Spey SACs) are considered within the influence of the Offshore Development (i.e. <100 km from the Offshore Development Area). The Moray Firth SAC has been included, despite a lack of qualifying features, based upon the highlighted importance of this region as a migratory pathway for Annex II species following discussions with consultees (28 November 2022).

Salamander

Figure 10-11

Nature Conservation Sites



Legend

- Offshore Development Area
- Offshore Array Area
- Offshore Export Cable Corridor
- Indicative Onshore Development Area
- MPA
- SPA
- SAC
- 6nm limit
- 12nm limit

Coordinate System: WGS 1984 UTM Zone 30N

Scale @ A3 : 1:953,674

0 25 50 Kilometers

0 5 10 20 Nautical Miles

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Doc. Title : Nature Conservation Sites
Doc. No : SWF01ER0333
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Approved by : MKH

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10.7.2 Future Baseline

10.7.2.1 Determining the effects of climate change upon the baseline characteristics of the Fish and Shellfish Ecology Study Area, as a variation of the 'do nothing scenario', should be conducted with accurate scientific data and detailed interrogation of existing evidence. Therefore, full assessment of the potential future baseline environment is not within the scope of this chapter. However, there is an increasing trend in abiotic oceanographic data showing that the UK's waters are experiencing effects of climate change.

10.7.2.2 Burrows *et al.* (2019) provide evidence highlighting the relative changes in abundance of fish species present within the North Atlantic with affinity to different temperature regimes. The results show a relative shift in the dominance of fish species with an affinity to warmer water, provided strong temperature gradients were not present. This indicates a northward creep of warm-water species and a northward retreat of cold-water species at a rate consistent with global ocean warming and is likely to be more pronounced within shallow coastal waters. In practice, cold-water species such as Atlantic herring and dab *Limanda limanda* have reduced in abundance, whereas warm-water species such as hake, Atlantic mackerel, and Atlantic horse mackerel have increased in occurrence. Recently, Atlantic cod has been identified as having particular vulnerability to ocean warming by virtue of a temperature-sensitive ovulation cycle, and a reduction in food availability for larvae (Kjesbu *et al.*, 2023). Whilst the risk to Atlantic cod is more prevalent in the warmer seas around the southern UK, the potential spawning grounds for Atlantic cod within the North Sea are expected to dramatically reduce in correlation with historic temperature fluctuations off the east coast of Scotland (Kjesbu *et al.*, 2023).

10.7.2.3 The climate change and carbon impact assessment for the Salamander Project is set out in **Volume ER.A.3, Chapter 20: Climate Change and Carbon**. Key aspects of the future baseline which are of relevance to the assessment of marine and coastal processes, and therefore indirectly associated with fish and shellfish ecology, are described in **Volume ER.A.3, Chapter 7: Marine Physical Processes**.

10.7.2.4 The baseline environment for the Fish and Shellfish Ecology assessment is therefore expected to show signs of northwards retreat of cold water species and northwards ingress of warm water species, in line with current scientific predictions for the North Sea (Burrows *et al.* 2019). Whilst this may alter relative abundances of species, the current baseline species presence is expected to remain representative of the future baseline species presence in the Fish and Shellfish Ecology Study Area.

10.7.3 Summary of Baseline Environment

10.7.3.1 The baseline information collected for the Fish and Shellfish Ecology Study Area identifies the presence of key fish and shellfish species of commercial importance, ecological value, and conservation interest characteristic of the central and northern North Sea environment. Several key species of note, such as PMFs and those designated under Annex II of the Habitats Directive, have been identified as present, alongside species with UK-wide migration ranges or specific habitat requirements. These species require additional consideration within the impact assessment due to their potentially elevated sensitivity to impacts associated with the Offshore Development.

10.7.3.2 Following the review of baseline information for the Offshore Development, the following key sensitivities have been identified that require specific consideration within the Impact Assessment in **Section 10.11**:

- spawning grounds of demersal fish, pelagic fish, and shellfish within the Fish and Shellfish Ecology Study Area that may be at an elevated risk due to habitat loss and/or disturbance associated with the Construction/Decommissioning and/or Operation and Maintenance Phases of the Offshore Development;

- the presence of sandeel supporting habitat within the Fish and Shellfish Ecology Study Area is likely to provide a key food resource to ornithological receptors assessed within **Volume ER.A.3, Chapter 12: Offshore and Intertidal Ornithology**, and may be at an elevated risk due to habitat loss and/or disturbance associated with Construction/Decommissioning and/or Operation and Maintenance Phases of the Offshore Development; and
- several fish species, including Atlantic cod, Atlantic herring, sprat, allis shad, and twaite shad are at an elevated risk of underwater noise-induced physiological damage as a result of swim bladder-inner ear connections used in hearing.

10.8 Limitations and Assumptions

10.8.1.1 The following limitations and assumptions have been identified for Fish and Shellfish Ecology:

- it is assumed that the worst-case scenario for habitat loss and/or disturbance is represented by the cumulative area for all infrastructure on, or directly interacting with, the seabed. Therefore, the assessment assumes no overlap in footprint for each of the design elements (excluding those for mooring clumps that are assumed to occupy the swept area associated with mooring lines);
- in line with industry standards, the scope of impacts associated with the Decommissioning Phase reflect that of the Construction Phase, but with a reduced magnitude. This assumption will be subject to best practice methods and technology appropriate at the time of decommissioning; and
- whilst fish are likely to aggregate around the infrastructure, as would be the case for large/massive infrastructure such as monopile foundations, it is difficult to quantify the extent of aggregation outside of the volume of substructures in which fish may take shelter from a stressor. Therefore, for the assessment of fish aggregation effects, it is assumed that fish aggregation will occur within the same volume of water as the floating substructures.

10.8.2 Impacts Scoped Out of the EIAR

10.8.2.1 The Fish and Shellfish Ecology assessment covers all potential impacts identified during scoping, as well as any further potential impacts that have been highlighted as the EIA has progressed as outlined in **Section 10.4**.

10.8.2.2 However, following consideration of the baseline environment, the project description outlined in **Volume ER.A.2, Chapter 4: Project Description** and in line with the Scoping Opinion, a number of impacts are not considered in detail within this EIAR, as illustrated in **Table 10-7**.

Table 10-7 Impacts scoped out of the Fish and Shellfish Ecology assessment

Potential Impact	Project Aspect	Project Phase	Justification
Impact to habitats or species as a result of pollution or accidental discharge	Offshore Array and Offshore ECC	Construction and Decommissioning	Accidental release of pollutants contained within the Wind Turbine Generators (WTGs), and oil and fluid emissions from vessels. The potential for full inventory release for any individual turbine is considered extremely rare. The potential slow release of fluids is considered the only avenue through which pollution or discharge would enter the water column and sediment from WTGs. Further, the magnitude of an accidental spill incident from vessels is limited by the size of chemical or oil inventory on such vessels. Embedded mitigation measures will be adopted to limit the potential for accidental release of pollutants as low as reasonably practicable, including strict controls on vessel activities and procedures. For these reasons, the impacts of pollution or accidental discharge to fish and shellfish ecology has not been considered further.
Disturbance of contaminated sediments	Offshore Array and Offshore ECC	Construction and Decommissioning	Neither the OAA or Offshore ECC is located on or near contaminated sediments (**Volume ER.A.3, Chapter 8: Water and Sediment Quality**). It is therefore unlikely that there will be any significant release of contaminants from sediments within the Offshore Development Area, confirmed by the assessment conclusions in **Volume ER.A.3, Chapter 8: Water and Sediment Quality**. In order to minimise risk, the potential for disturbance of contaminated sediment will be controlled by implementation of an appropriate project Construction Environmental Management Plan (CEMP), Marine Pollution Contingency Plan (MPCP), and Decommissioning Programme. This potential impact has been scoped out of assessment as agreed with stakeholders within the scoping workshop, as the Offshore Development was deemed to be unlikely to result in a significant effect and therefore does not require further assessment within this chapter.
Temporary increases in suspended sediment concentrations and potential sedimentation/smothering of fish and shellfish	Offshore Array and Offshore ECC	Operation and Maintenance	There is the potential for operation and maintenance activities to result in increased suspended sediment concentrations which may result in indirect impacts on fish and shellfish ecology receptors. The nature of works associated with operation and maintenance activities and the discrete areas within which these activities will be undertaken, will result in significantly lower suspended sediment concentrations than those associated with natural storm events or construction activities. For this reason, this impact has been scoped out for further assessment within the EIAR.

Potential Impact	Project Aspect	Project Phase	Justification
Impact to habitats or species as a result of pollution or accidental discharge	Offshore Array and Offshore ECC	Operation and Maintenance	Accidental release of pollutants contained within the WTGs and oil and fluid emissions from vessels. The potential for full inventory release for any individual turbine is considered extremely rare. The potential slow release of fluids is considered the only avenue through which pollution or discharge would enter the water column and sediment from WTGs. Further, the magnitude of an accidental spill incident from vessels is limited by the size of chemical or oil inventory on such vessels. Embedded mitigation measures will be adopted to limit the potential for accidental release of pollutants, including strict controls on vessel activities and procedures. For these reasons, the impacts of pollution or accidental discharge to fish and shellfish ecology has not been considered further.
Barrier effects on diadromous fish from the presence of the floating platform and associated infrastructure	Offshore Array	Operation and Maintenance	The offshore location of the development, with ca. 1,000 metres between each WTG enabling passage either side, is unlikely to present a significant barrier to movement for diadromous fish. For this reason, the impact of barrier effects on diadromous fish has been scoped out. It is noted that the PMF freshwater pearl mussel *Margaritifera margaritifera* is dependent on salmonids to complete its lifecycle. Based upon the expected non-significant effect of barriers to salmonid movements between freshwater and marine environments, it is unlikely that freshwater pearl mussels will be adversely affected.
Disturbance of contaminated sediments	Offshore Array and Offshore ECC	Operation and Maintenance	Neither the OAA or Offshore ECC is located on or near contaminated sediments (**Volume ER.A.3, Chapter 8: Water and Sediment Quality**). It is therefore unlikely that there will be any significant release of contaminants from sediments within the Offshore Development Area. In order to minimise risk, the potential for disturbance of contaminated sediment will be controlled by implementation of an appropriate project CEMP, MPCP, and Decommissioning Programme.

10.8.3 Embedded Mitigation

10.8.3.1 The embedded mitigation relevant to the Fish and Shellfish Ecology assessment is presented in **Table 10-8.**

Table 10-8 Embedded mitigation for the Fish and Shellfish Ecology assessment

Potential Impact and Effect	Mitigation ID	Mitigation	Project Aspect	Project Phase
Primary				
Temporary habitat loss or disturbance during the installation of all infrastructure and placement of vessel anchors on the seabed.	Co14	Avoidance of sensitive features during cable routing wherever practicable. Cables will be buried as the primary cable protection method, however other cable protection methods will be used where adequate burial cannot be achieved. A Cable Burial Risk Assessment (CBRA) will be completed to determine suitable cable protection measures, and will be implemented within relevant Project plans.	OAA and Offshore ECC	Construction
Tertiary				
Impact to habitats or species as a result of pollution or accidental discharge (scoped out); Disturbance of contaminated sediments (scoped out).	Co9	Construction Environmental Management Plan (CEMP) will be developed and will include details of: - A MPCP to address the risks, methods and procedures to protect the Offshore Development Area from potential polluting events associated with the Offshore Development; - A chemical risk review to include information regarding how and when chemicals are to be used, stored and transported in accordance with recognised best practice guidance; - A biosecurity plan (offshore) detailing how the risk of introduction and spread of invasive non-native species will be minimised; - Waste management and disposal arrangements; and - Protocol for management of Dropped Objects.	OAA and Offshore ECC	Construction
Ghost fishing due to lost fishing gear becoming entangled in	Co10	Operational Environmental Management Plan (OEMP) will be developed and will include details of: - A MPCP to address the risks, methods and procedures to protect the Offshore Development Area from	OAA and Offshore ECC	Operation and Maintenance

Potential Impact and Effect	Mitigation ID	Mitigation	Project Aspect	Project Phase
installed infrastructure.		potential polluting events associated with the Offshore Development; and - Waste management and protection of the marine environment.		
	Co17	Mooring lines and floating dynamic Inter-array Cables will be inspected according to the maintenance plan to confirm the structural integrity of the cable systems using a risk-based adaptive management approach. During these inspections, the presence of discarded fishing gear will be evaluated for entanglement risk and appropriate actions to remove will be taken if deemed necessary.	OAA and Offshore ECC	Operation and Maintenance
Disturbance or damage to sensitive species due to underwater noise generated from construction activities	Co15	Development and adherence to a Piling Strategy which defines how the noise mitigation measures will be implemented if piling forms part of the final Project Description (e.g. soft-start and ramp-up procedures) to reduce potential underwater noise effects during construction.	OAA	Construction

10.9 Project Design Envelope Parameters

10.9.1.1 Given that the realistic worst-case scenario is based on the design option (or combination of options) that represents the greatest potential for change, as set out in **Volume ER.A.1, Chapter 4: Project Description**, confidence can be taken that development of any alternative options within the Project Design Envelope parameters will give rise to no effects greater or worse than those assessed in this impact assessment. The design option parameters relevant to the Fish and Shellfish Ecology assessment are outlined in **Table 10-9**.

Table 10-9 Project Design Envelope parameters for Fish and Shellfish Ecology

Potential Impact and Effect	Project Design Envelope parameters
Construction	
Disturbance or damage to sensitive species due to underwater noise generated from construction activities	**Vessel trips (660 trips per year):** • Jack-up Vessel trips per year: 2; • Heavy lift Vessel trips per year: 21; • Cable Laying Vessel trips per year: 14; • Cable Burial/Jointing Vessel trips per year: 14; • Shallow Water Cable Barge trips per year: 2; • Anchor handling Vessel trips per year: 161; • Offshore Construction Vessel trips per year: 14; • Support Vessel trips per year: 238; and • Crew Transfer Vessel trips per year: 194. **Total number of pile anchors to be installed: 80:** • Number of floating substructure pile anchors (≤ 3 m diameter): 56; • Number of subsea hub(s) pile anchors (≤ 1.5 m diameter): 24; • Maximum hammer energy during piling Scenario 1 (up to 1 pile per day): 2,500 kJ; • Maximum hammer energy during piling Scenario 2 (up to 4 piles per day): 1,500 kJ; and • No concurrent piling will occur.

Potential Impact and Effect	Project Design Envelope parameters
Temporary habitat loss or disturbance during the installation of all infrastructure and placement of vessel anchors on the seabed	**Vessels and mobile equipment (244,440 m²):** • Total area of seabed disturbance from vessel anchors during installation: 242,400 m²; and • Total area of seabed disturbance from Jack-up events: 2,040 m². **Within the OAA (1,532,900 m²):** • Total area of seabed disturbance during installation of array cables: 1,400,000 m²; • Total area of seabed disturbance during installation of anchors (gravity anchor): 125,900 m²; and • Total area of seabed disturbance during installation of the subsea hub(s): 7,000 m². **Within the Offshore ECC (3,400,000 m²):** • Dimensions of seabed disturbance: 85,000 m length at 40 m width. **Total: 5,177,340 m².**
Temporary increases in suspended sediment concentrations and potential sedimentation/smothering of fish and shellfish	**Maximum extent of tidally aligned sediment plume (17,000 m):** • 17,000 m (maximum value based on the maximum tidal excursion range provided in **Volume ER.A.3, Chapter 7: Marine Physical Processes**, located close to landfall).
Operation and Maintenance	
Disturbance or damage to sensitive species due to underwater noise generated from operation and maintenance activities	**Vessel trips (210 per year):** • Support/Crew Transfer Vessel trips per year: 190; • Heavy lift Vessel trips per year: 3; • Towing Spread trips per year: 5; and • Anchor handling Vessel trips per year: 12.
Habitat loss due to the presence of infrastructure on the seabed and	**Within the OAA (4,911,300 m²):** • Total footprint of anchors (56 * gravity anchors) on seabed after installation: 8,100 m²;

Potential Impact and Effect	Project Design Envelope parameters
associated scour protection (Assumes habitat loss = direct seabed footprint of permanent infrastructure)	• Total area of scour protection on seabed (56 * gravity anchors): 117,800 m²; • Total area of cable stabilisation protection: 70,000 m²; • Total area of scour protection on seabed (cable jointing): 64,000 m²; • Total swept area of dynamic array cables on seabed (untethered[1]): 700,000 m²; • Footprint of dynamic cable tether anchors: 22,400 m²; • Total swept area of mooring lines (56 * catenary mooring lines) on the seabed: 3,920,000 m²; • Total footprint of the subsea hub(s) (including cable protection) on seabed: 7,000 m²; and • Total seabed footprint of other equipment (e.g. wave buoys, navigational aids, etc): 2,000 m². **Within the Offshore ECC (344,160 m²):** • Total area of cable stabilisation/protection: 170,000 m²; • Total area of scour protection on seabed (cable jointing): 16,000 m²; and • Total area of cable crossing protection material on seabed: 158,160 m². **Offshore Cable Replacement (1,520,800 m²):** • Total area of seabed impacted by cable repair and reburial: 1,468,000 m²; • Total area of new cable stabilisation protection for cable repair and replacement: 36,000 m²; and • Total area of seabed impact from vessel anchors during operations: 16,800 m². **Offshore Anchor and Mooring Replacement (174,200 m²):** • Total area of seabed impacted by anchor and mooring replacement: 90,000 m²; and • Total area of new scour protection for anchor and mooring replacement: 84,200 m². **Total: 6,950,460 m²**

[1] The worst-case scenario assumes dynamic cables are untethered. The total swept area of tethered cable is 420,000 m², with a maximum (combined) tether footprint of 22,400 m², totalling 442,400 m² if the swept area and tether footprints do not overlap; which is smaller than the 700,000 m² value for untethered cables.

Potential Impact and Effect	Project Design Envelope parameters
Effects of thermal load and EMFs from subsea and dynamic cables on sensitive species (Assumes static cable covered by cable protection or stabilisation is sufficiently buried such that EMF effects within the water column will be equal to that of static cable buried at a minimum target depth of 0.6 m where technically feasible; subject to cable burial risk assessment outcomes)	**Volume of detectable EMF, assuming a 2.75 m radius[2] from the surface of the cable:** • Volume of detectable EMF surrounding dynamic array cables (0.32 m diameter) in the water column (radius of detectable EMF from the centre of the array cable (2.91 m) * length of dynamic array cable in the water column (3,500 m)): 93,064 m³; • Volume of detectable EMF[3] surrounding static array cables (0.32 m diameter), buried at a minimum target of 0.6 m below relative seabed level, or buried within cable protection/stabilisation (height of detectable EMF above the seabed (radius of EMF effect from the centre of the cable (2.91 m) - minimum target depth of lowering (0.6 m) + array cable radius[4] (0.16 m) = 2.47 m), length of static array cable (35,000 m – 3,500 m = 31,500 m): 338,646 m³; and • Volume of detectable EMF surrounding static export cables (0.32 m diameter), buried at a minimum target depth of 0.6 m below relative seabed level, or buried within cable protection/stabilisation (height of detectable EMF above the seabed (radius of EMF effect from the centre of the cable (2.91 m) - minimum target depth of lowering (0.6 m) + export cable radius (0.16 m) = 2.47 m), length of static export cable (85,000 m): 913,805 m³. **Total: 1,345,515 m³**
Fish aggregation around the floating substructures and associated infrastructure	**Volume of interstitial spaces within floating substructures and external water volume considered to contribute to fish aggregation effects (6,585,600 m³):** • Assumes the volume of water occupied by fish within or surrounding infrastructure in the water column is equal to that of the infrastructure itself. For substructures with interstitial space, it is assumed that the volume of water occupied by fish also includes the volume within the infrastructure, therefore doubling the volume; • Volume of semi-submersible WTG platform[5] and external water column contributing to the fish aggregation effect (footprint (2 * 137,200 m²) * draught depth (24 m)): 6,585,600 m³.

[2] Calculated as the distance at which <0.01µT is achieved. See Section 4.10.7 in **Volume A.1, Chapter 4 Project Description** for further details.

[3] Calculated using the following equations (r = radius of EMF from the centre of the cable, h = height above seabed):

$$Area = \cos^{-1}\left(\frac{r-h}{r}\right)r^2 - (r-h)\sqrt{2rh - h^2}$$

$$Volume = Area \times Length$$

[4] The addition of the cable radius accounts for the depth of lowering of the centre of the cable at 1.89 m, as the cable is assumed to lie at the base of a 0.6 m deep trench.

[5] Semi-submersible platforms are typically designed to include interstitial space between pillars and bars and allow fish to shelter within the structure. As such, the volume of water associated with the fish aggregation effect includes both this internal volume and the volume of water surrounding the semi-submersible platform (assuming that the external volume is equal to the volume of the substructure itself).

Potential Impact and Effect	Project Design Envelope parameters
Fish aggregation around the floating substructures and associated infrastructure (cont.)	**Volume of mooring lines and cables in the water column (9,286 m³):** • Volume of mooring lines (0.5 * mooring line diameter (0.3 m)² * π * total length of mooring lines for 56 anchors (92,400 m)): 6,531 m³; • Volume of dynamic cables suspended in the water column (0.5 * dynamic cable diameter (0.32 m)² * π * length (3,500 m)): 281 m³; and • Volume of buoyancy modules on dynamic cables (0.5 * diameter of buoyancy modules (1.5 m)² * π * total length of buoyancy module sections (1,400 m)): 2,474 m³. **Volume of infrastructure on the seabed protruding into the water column (699,304 m³):** • Volume of (gravity) anchors in the water column (0.5 * diameter (13.5 m)² * π * height above seabed (5 m) * 56 units: 40,079 m³; • Volume of scour protection surrounding (gravity) mooring line anchors: 266,300 m³; • Volume of scour protection surrounding static array cables: 57,750 m³; • Volume of scour protection surrounding subsea array cable joints: 66,000 m³; • Volume of scour protection surrounding export cables: 140,250 m³; • Volume of scour protection surrounding subsea export cable joints: 16,500 m³; • Volume of cable crossing protection surrounding export cables: 99,600 m³; • Volume of two subsea hub(s): 4,500 m³; • Volume of scour protection surrounding subsea hub(s): 4,200 m³; and • Volume of cable protection surrounding subsea hub(s): 4,125 m³. **Volume of predicted Operation and Maintenance works (195,775 m³):** • Volume of new cable protection surrounding static array and export cables: 27,375 m³; and • Volume of new scour protection surrounding moorings and anchors: 168,400 m³. **Total: 7,489,965 m³**

Potential Impact and Effect	Project Design Envelope parameters
Ghost fishing due to lost fishing gear becoming entangled in installed infrastructure	Due to the unpredictable nature of this impact, it is difficult to accurately quantify the likelihood of occurrence of lost fishing gear entering the Offshore Development Area, let alone the subsequent risk of snagging on infrastructure.
Decommissioning	
Currently, realistic, worst-case, and likely scenarios for decommissioning operations will involve full removal of all infrastructure above the seabed. Therefore, similar impacts to the Construction phase and magnitude of seabed disturbance have been considered. This assumption is subject to best practice methods and technology appropriate at the time of decommissioning. Further assessment of potential impacts associated with the Decommissioning Phase of the Offshore Development will be assessed as part of a Marine Licence application that will be submitted prior to the commencement of any Project-specific decommissioning works. In addition, a Decommissioning Programme will be submitted to MD-LOT for approval by the Scottish Ministers prior to commencement of the Construction Phase. This document will then be reviewed and updated at various points during the lifetime of the Offshore Development prior to the commencement of any Project-specific decommissioning works.	

10.10 Assessment Methodology

10.10.1.1 **Volume ER.A.2, Chapter 6: EIA Assessment Methodology** sets out the general approach to the assessment of significant effects that may arise from the Offshore Development.

10.10.1.2 Whilst **Volume ER.A.2, Chapter 6: EIA Assessment Methodology** provides a general framework for identifying impacts and assessing the significance of their effects, in practice the approaches and criteria applied across different topics vary.

10.10.1.3 The proposed approach to the Fish and Shellfish Ecology assessment that has been addressed in the EIA is outlined below.

10.10.2 Impact Assessment Criteria

10.10.2.1 The Impact Assessment identifies the significance of effect based upon the sensitivity of a receptor and the magnitude of impact. For the purposes of this assessment, the definition of sensitivity of a receptor is described in **Table 10-10**. The definition of the magnitude of impact is described in **Table 10-11**. Sensitivity is defined based upon the Feature Activity Sensitivity Tool (FEAST) (based upon the methods of Tyler-Walters *et al.*, 2018).

Table 10-10 Categories and definitions used to determine the level of sensitivity of a receptor

Sensitivity	Definition
High	Very limited tolerance to the impact for a receptor of international or national importance. The receptor is unable to adapt to the impact and will be unable to undergo a permanent recovery.
Medium	Very limited tolerance to the impact for a receptor of regional importance. The receptor is unable to adapt to the impact and will be unable to undergo a permanent recovery. Or

Sensitivity	Definition
	Limited tolerance to the considered impact is displayed by a receptor of international or national importance, where adaptability and recovery is limited, with return to acceptable status taking 1-5 years.
Low	Limited tolerance to the considered impact is displayed by a receptor of local importance, where adaptability and recovery is very limited, with return to acceptable status taking 5-10 years. Or Moderate tolerance to the considered impact is displayed by a receptor of regional importance, where adaptability and recovery is limited, with return to acceptable status taking 1-5 years. Or High tolerance to the considered impact is displayed by a receptor of international or national importance, where adaptability and recovery is rapid, with return to acceptable status taking 0-12 months.
Negligible	High tolerance to the considered impact is displayed by a receptor of local importance, where adaptability and recovery is rapid, with return to acceptable status taking 0-12 months. Or Total tolerance to the considered impact is displayed by a receptor of international, national or regional importance.

Table 10-11 Categories and definitions used to determine the level of magnitude of an impact

Magnitude	Definition
High	Total change or major alteration to key elements/features of the baseline conditions: Occurs over a large spatial extent, resulting in widespread, long-term, or permanent changes of the baseline conditions, or affects a large proportion of a receptor population. And/or The impact is very likely to occur and/or will occur at a high frequency or intensity.
Medium	Partial change or alteration to one or more key elements/features of the baseline conditions: The impact occurs over a local to medium extent with a short- to medium-term change to baseline conditions or affects a moderate proportion of a receptor population. And/or The impact is likely to occur and/or will occur at a moderate frequency or intensity.
Low	Minor shift away from the baseline conditions: The impact is localised and temporary or short-term, leading to a detectable change in baseline conditions or a noticeable effect on a small proportion of a receptor population. And/or The impact is unlikely to occur or may occur but at low frequency or intensity.

Magnitude	Definition
Negligible	Very slight change from baseline conditions: The impact is highly localised and short-term, with full rapid recovery expected to result in very slight or imperceptible changes to baseline conditions or a receptor population. And/or The impact is very unlikely to occur; if it does, it will occur at a very low frequency or intensity.
No change	No change from baseline conditions.

10.10.2.2 The significance of an effect based upon the sensitivity or a receptor and magnitude of an impact is determined using the matrix shown in **Table 10-12**. The threshold for a significant effect is defined as Moderate or higher.

Table 10-12 Significance of effect matrix

Significance of effect		Receptor Sensitivity			
		Negligible	*Low*	*Medium*	*High*
Magnitude of impact	*Negligible*	Negligible	Negligible	Negligible	Negligible
	Low	Negligible	Negligible	Minor	Minor
	Medium	Negligible	Minor	Moderate	Moderate
	High	Negligible	Minor	Moderate	Major

10.11 Impact Assessment

10.11.1 Construction

10.11.1.1 Under the construction phase, the following potential impacts have been assessed:

- Disturbance or damage to sensitive species due to underwater noise generated from construction activities;
- Temporary habitat loss or disturbance during the installation of all infrastructure and placement of vessel anchors on the seabed; and
- Temporary increases in suspended sediment concentrations and potential sedimentation/ smothering of fish and shellfish.

Disturbance or Damage to Sensitive Species due to Underwater Noise Generated from Construction Activities

Background

10.11.1.2 This section assesses the potential impacts of underwater noise associated with the Construction Phase upon Fish and Shellfish Ecology, drawing on further detail from within **Volume ER.A.4, Annex 4.1:**

Underwater Noise Modelling Report. Underwater noise during Construction may originate from three primary sound sources, including unexploded ordinance (UXO) detonation/clearance, impact piling into the seabed, and other noise-emitting activities (e.g. vessel transit).

10.11.1.3 The potential impacts of the clearance of UXOs are discussed within this EIAR for completeness. However, as it is not possible at this time to precisely define the number of UXO which may require detonation, a separate Marine Licence application and EPS Licence application (with associated environmental assessments) will be submitted for the detonation of any UXO which may be identified as requiring clearance in pre-construction surveys.

10.11.1.4 UXO may be present within the Fish and Shellfish Ecology Study Area, which may require clearance before construction activities commence. A detailed assessment of UXO will be undertaken as part of a separate application, due to the uncertainty of UXO presence within the Offshore Development Area. As such, the assessment presented in this chapter acknowledges the potential impact of UXO but does not form part of the assessment conclusion. A comparison between high-order (detonation) and low-order (deflagration) clearance has been conducted within **Volume ER.A.4, Annex 4.1: Underwater Noise Modelling Report** to provide supplementary information alongside modelling of other noise-producing activities; with results summarised in **Table 10-13**.

Table 10-13 Summary of the unweighted SPL_{peak} and SEL_{ss} source levels used for Unexploded Ordinance (UXO) clearance modelling (Volume ER.A.4, Annex 4.1: Underwater Noise Modelling Report)

Charge weight (TNT equivalent)	Unweighted SPL_{peak} source level	Unweighted SEL_{ss} source level
Low order (0.25 kg)	269.8 dB re 1 µPa @ 1 m	215.2 dB re 1 μPa^2s @ 1 m
25 kg + donor	284.9 dB re 1 µPa @ 1 m	228.0 dB re 1 μPa^2s @ 1 m
55 kg + donor	287.5 dB re 1 µPa @ 1 m	230.1 dB re 1 μPa^2s @ 1 m
120 kg + donor	290.0 dB re 1 µPa @ 1 m	232.2 dB re 1 μPa^2s @ 1 m
240 kg + donor	292.3 dB re 1 µPa @ 1 m	234.2 dB re 1 μPa^2s @ 1 m
525 kg + donor	294.8 dB re 1 µPa @ 1 m	236.4 dB re 1 μPa^2s @ 1 m
698 kg + donor	295.7 dB re 1 µPa @ 1 m	237.1 dB re 1 μPa^2s @ 1 m

10.11.1.5 Impact piling may be used as a method for installing pile anchors for anchoring floating substructures. Calculations to describe the noise output of piling activities take into account: the energy involved per hammer blow; soft start and ramp-up profile, and strike rate; and the duration of piling activities. Impact piling has been calculated and assessed in greater detail within **Volume ER.A.4, Annex 4.1: Underwater Noise Modelling Report**. Underwater noise modelling was undertaken using the following scenarios:

- Scenario 1: Installation of one piled anchor in one day, with a maximum of 2,500 kJ hammer energy; and
- Scenario 2: Installation of four piled anchors in one day, with a maximum of 1,500 kJ hammer energy.

10.11.1.6 If piling is used, the standard operating procedure that Salamander Project proposes to implement during piling operations is Scenario 2 (four piles per day, up to 1,500 kJ), with Scenario 1 (one pile per day, up to 2,500 kJ) only being implemented as a contingency in two specific situations.

10.11.1.7 If, following the driveability studies that will be undertaken during detailed design post-consent and prior to the piling operations commencing, it is anticipated that hard driving (a situation where tougher seabed conditions than expected is encountered and the progress of a particular pile is not sufficient) may be met at a specific target location, only one pile will be installed using a hammer energy of up to 2,500 kJ within 24 hours (h). In the unlikely event that hard driving is met whilst the pile is being installed (i.e. not predicted by the drivability study), hammer energy will be increased to up to 2,500 kJ to enable a safe installation of the pile, after which no additional piles will be installed within 24 h. These two procedures are shown by the decision tree presented in **Figure 10-12**. This will be secured through development and implementation of a Piling Strategy post-consent (Co15 in **Table 10-8**).

10.11.1.8 Other noise-emitting activities have been estimated based upon values provided in Popper *et al*. (2014), and include vessel transit, seabed dredging and trenching, rock placement, and suction pile anchor installation. As with UXO clearance and impact piling, other noise-emitting activities are also assessed in greater detail within **Volume ER.A.4, Annex 4.1: Underwater Noise Modelling Report**. Based on the outcomes within **Volume ER.A.4, Annex 4.1: Underwater Noise Modelling Report**, impact piling represents the greatest distance of potential effect for stationary fish receptors, and therefore represents the worst-case activity for the purposes of this assessment.

10.11.1.9 Approximate values for subsea noise sources have been used within this assessment to predict the likely noise output of impact piling associated with the worst-case scenario Project Design Envelope. Noise associated with construction activities is measured as the maximum pressure amplitude of a single event (e.g. a hammer blow, SPL_{PEAK}), the energy experienced during a single strike (sound exposure level, SEL_{SS}), and the energy experienced following multiple events (SEL_{CUM}).

10.11.1.10 Whilst UXO clearance would represent the worst-case SPL_{PEAK}, impact piling and other sources of noise (e.g. vessels and installation of foundations without impact piling) are expected to constitute the background SELCUM associated with the Construction Phase of the Offshore Development. The installation of a single pile anchor in a 24 h period will be achieved using a maximum hammer energy of 2,500 kJ in order to drive the pile through tough seabed conditions/hard driving, whereas the sequential installation of four pile anchors within a 24 h period will be achieved using a maximum hammer energy of 1,500 kJ. This lower maximum hammer energy has been refined to reduce the maximum range at which TTS thresholds for stationary fish are met. Based on the analysis of Scenario 1 and Scenario 2 in **Volume ER.A.4, Annex 4.1: Underwater Noise Modelling Report**, four sequential pile anchors in a 24 h period represents the worst-case scenario for consideration within the assessment, with a maximum TTS impact range of 57 km for stationary fish receptors.

10.11.1.11 The impact ranges for each SEL_{CUM} threshold identified by underwater noise modelling (Volume ER.A.4, Annex 4.1: Underwater Noise Modelling Report) are shown in **Table 10-15**.

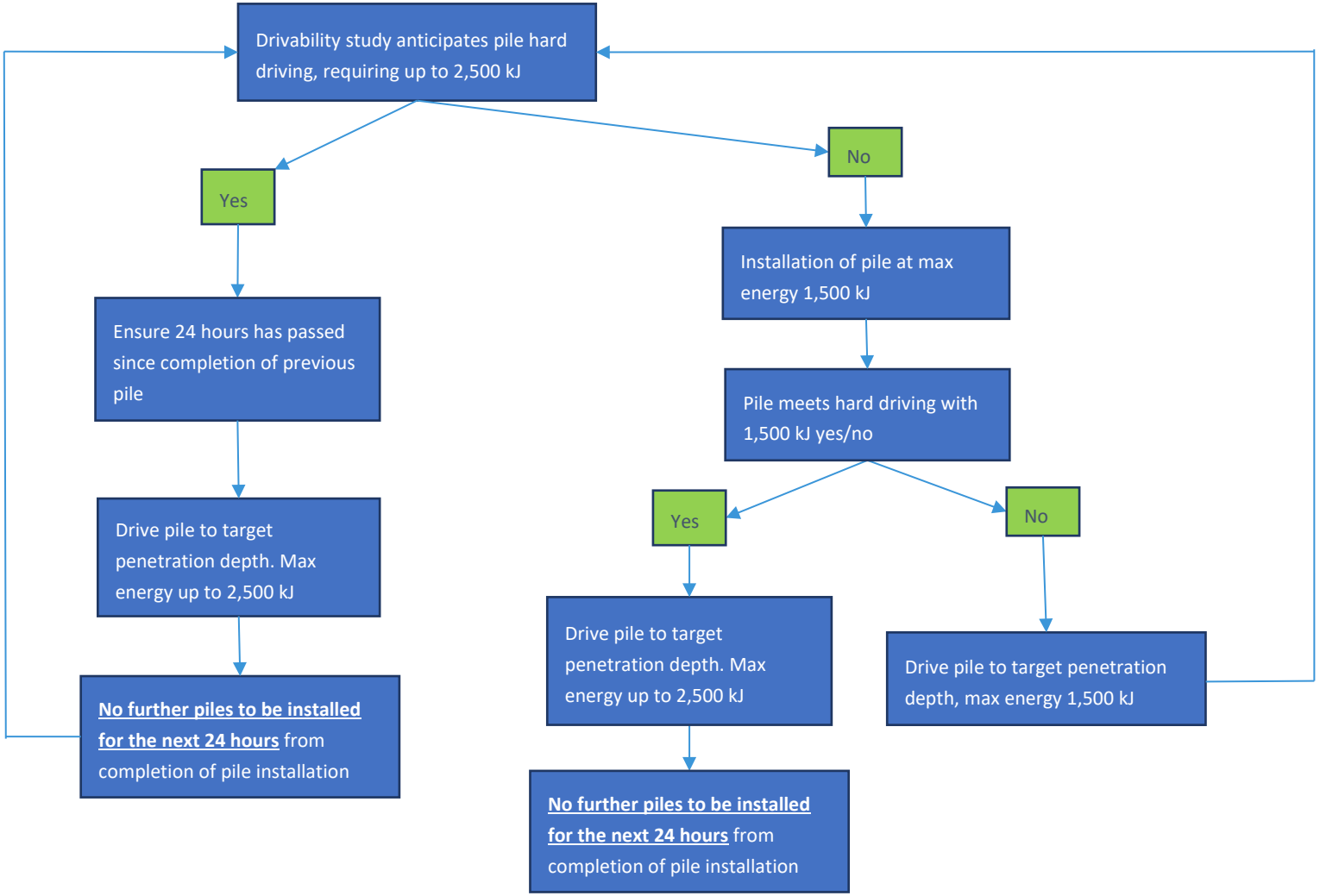

Figure 10-12 The proposed piling decision tree, developed to ensure minimal potential impact upon sensitive fish receptors, to be secured by Co15 Piling Strategy

Sensitivity of Receptors

10.11.1.12 Both demersal and pelagic fish can be characterised by the role of the swim bladder-inner ear connection in hearing. Species with the connection, such as Atlantic cod and Atlantic herring (both PMFs), may experience irrecoverable physiological damage in the event that noise is emitted above the PTS threshold, however, individual mortality as a result of exceedance of the PTS threshold are unlikely to be of a significant scale to have population-level effects. Furthermore, the mortality results from exposure to underwater noise of magnitude >207 dB SEL_{CUM}, which will be of a limited spatial extent (160 km²) compared to the normal range of the population (**Volume ER.A.4, Annex 4.1: Underwater Noise Modelling Report**). Therefore, all species with a swim bladder-inner ear connection used in hearing are considered to have a **Medium** sensitivity to disturbance or damage (TTS and PTS) due to underwater noise generated by impact piling during the Construction Phase.

10.11.1.13 Conversely, the remaining elasmobranch, adult demersal and pelagic fish species, and eggs and larvae, are generally considered to have an increased tolerance of elevated underwater noise due to the absence of a swim bladder-inner ear connection used in hearing, or an absence of a swim bladder all together (Popper *et al.*, 2014). Elasmobranch species are considered tolerant to variation in pressure associated with high-amplitude underwater noise sources, due to the absence of a swim bladder and reliance on particle displacement stimuli when detecting sound and other particle vibration fields (Myrberg, 2001; Casper and Mann, 2006). However, it cannot be assumed that species without a swim bladder-inner ear connection used in hearing do not exhibit a degree of sensitivity to underwater noise, due to an absence of data regarding the potential and extent of physiological damage caused by high intensity particle motion, upon such species (Hawkins and Popper, 2017). Taking this important consideration into account, fish species lacking a swim bladder-inner ear connection used in hearing are considered to have a **Low** sensitivity to disturbance or damage due to underwater noise generated by construction activities.

10.11.1.14 Similarly, shellfish species are generally considered tolerant to underwater noise; with some species, such as European lobster, shown to be unaffected in terms of body condition by the construction of offshore wind farms (Roach *et al.*, 2022). There is currently an evidence gap regarding the responses of shellfish to underwater noise, outside of the reception of vibration in sediments and low-frequency (<1 kHz) particle motion (Hawkins and Popper, 2017). Numerous *ex situ* laboratory studies have been conducted in recent years to understand the potential responses of shellfish to noise (summarised by Di Franco *et al.*, 2020). However, limited behavioural study has been conducted in the field, where test subjects would not be exposed to additional pressures and factors such as habituation in comparison to laboratory animals. Whilst these studies would be less focussed on physiological damage, changes in behaviour in response to *in situ* underwater noise may reflect damage and indicate sensitivity. Therefore, shellfish species are considered to have a **Low** sensitivity to disturbance or damage due to underwater noise generated by construction activities, as a precaution, noting the existence of evidence gaps.

10.11.1.15 Atlantic salmon, a key diadromous fish species and PMF within the Fish and Shellfish Ecology Study Area, has been shown to exhibit no physiological or behavioural response to noise sources replicating those of impact piling in offshore environments (Harding *et al.*, 2016). This is likely due to an absence in the swim bladder-inner ear connection used in hearing, and subsequent reliance on particle movement to detect vibrations (Hawkins and Popper, 2017). Other diadromous species, such as sea lamprey, are noted as having the potential to respond to low-frequency sound, and that such frequencies are characterised by extensive particle motion (Mickle *et al.*, 2019). Despite the identification of limited behavioural and/or physiological change species, our current understanding of the thresholds for damage and disturbance to diadromous fish due to underwater noise is limited (Popper and Hawkins, 2019). However, due to the presence of a swim

bladder-inner ear connection used in hearing for allis shad and twaite shad, diadromous fish species are considered to have a **Medium** sensitivity to disturbance or damage due to underwater noise generated by construction activities as a precaution, noting the existence of evidence gaps.

Magnitude of Impact (UXO)

10.11.1.16 For each high-order UXO clearance event, using an estimate for the worst-case size for each detonation as 698 kg + donor (**Volume ER.A.4, Annex 4.1: Underwater Noise Modelling Report**), the resulting mortal and potential injury impact zone (at 229 dB SPL_{RMS}) has been modelled at a radius of 890 m around each detonation, representing the greatest distance of mortal and potential injury considered for various charge sizes used to inform this assessment (**Table 10-14**).

Table 10-14 Summary of the impact ranges for UXO detonation using the unweighted SPLpeak¬ explosion noise criteria from Popper *et al*. (2014) for species of fish (from Volume ER.A.4, Annex 4.1: Underwater Noise Modelling Report)

Popper *et al*. (2014)	Mortality and potential mortal injury	
Unweighted SPLRMS	*234 dB*	*229 dB*
Low order (0.25 kg)	40 m	70 m
25 kg + donor	170 m	290 m
55 kg + donor	230 m	380 m
120 kg + donor	300 m	490 m
240 kg + donor	370 m	620 m
525 kg + donor	490 m	810 m
698 kg + donor	530 m	890 m

10.11.1.17 If UXO clearance is needed, it is likely that a limited number of detonations would be initiated sequentially, and that the zone of effect would affect a smaller number of individuals during each event and allow populations to recover from any disturbance or damage incurred. Based upon the irregular occurrence and temporary nature of the effect, and the localised distance at which TTS and PTS/mortality are modelled to occur compared to the wider population, the magnitude of disturbance or damage due to underwater noise generated by UXO detonation activities is considered **Negligible**. This assessment will be conducted in further detail for a separate Marine Licence and EPS Licence application, as appropriate following UXO surveys.

Magnitude of Impact (Impact Piling)

10.11.1.18 For impact piling, the magnitude of effect is determined as the distance at which fish and shellfish receptors experience TTS and PTS/mortality. As fish and shellfish receptors have a lower tolerance of SEL_{CUM}, the piling scenario of four pile anchors within a 24 h period at 1,500 kJ represents the worst-case scenario for impacts associated with piling noise (**Volume ER.A.4, Annex 4.1: Underwater Noise Modelling Report**), and inadvertently the worst-case scenario for underwater noise during the Construction Phase in general.

Table 10-15 Impact ranges for installing four piles at a maximum energy of 1,500 kJ within 24 hours relevant to fish receptors, utilising the unweighted SEL_{CUM} thresholds identified by Popper *et al.* (2014) (Volume ER.A.4, Annex 4.1: Underwater Noise Modelling Report)

Receptor state	TTS, recoverable injury, and mortality SEL_{CUM} thresholds (dB)	Area of effect (km²)	Mean range (km)	Maximum range (km)
Fleeing	219	<0.1	<0.1	<0.1
	216	<0.1	<0.1	<0.1
	210	<0.1	<0.1	<0.1
	207 (Mortality)	<0.1	<0.1	<0.1
	203 (Recoverable Injury)	<0.1	<0.1	<0.1
	186 (TTS)	660	14	18
Stationary	219	1.2	0.63	0.63
	216	2.9	0.98	0.98
	210	19	2.50	2.50
	207 (Mortality)	49	4	4
	203 (Recoverable Injury)	160	7.20	7.30
	186 (TTS)	8,200	51	57

10.11.1.19 The underwater noise modelling results shown in **Table 10-15** identify conservative zones of effect for TTS, recoverable injury, and mortality onset as a result of installing four pile anchors, using a 1,500 kJ hammer energy, within a 24-hour period. TTS (at 186 dB re 1 µPa SEL_{CUM}) is predicted to occur within an area of 660 km² (for fleeing receptors) and 8,200 km² (for stationary receptors). For stationary receptors, this translates to approximately 54.5% of the Fish and Shellfish Ecology Study Area (at approximately 15,058 km²), and a maximum distance of TTS effect of 57 km from the source. For recoverable injury, the maximum distance of effect is significantly smaller at 7.3 km for stationary receptors and <100 m for fleeing receptors.

10.11.1.20 A piling decision tree (**Figure 10-12**) has been developed to ensure that, where ground conditions may require a higher piling energy than 1,500 kJ (maximum of 2,500 kJ), piling operations will be limited to the installation of one pile per 24 h period. The rationale behind this is to ensure that SEL_{CUM} does not exceed that of the worst-case scenario of four piles at 1,500 kJ per 24 h period.

10.11.1.21 Based upon the temporary nature of the effect, the distance at which TTS and PTS/mortality are modelled to occur, but the noticeable effect on the population, the magnitude of disturbance or damage due to underwater noise generated by construction activities is considered **Low**.

Magnitude of Impact (Other Noise-producing Activities)

10.11.1.22 Other anchoring methods that do not require impact piling (e.g. drag embedment) are expected to result in underwater noise levels similar to other construction activities, such as cable laying, rock placement, and dredging. The noise outputs of these activities are within the order of 158 dB within 50 m from the source (**Volume ER.A.4, Annex 4.1: Underwater Noise Modelling Report**). Based upon the low likelihood of TTS and PTS/mortality occurrence, the magnitude of disturbance or damage due to underwater noise generated by construction activities is considered **Negligible**.

Significance of Effect

10.11.1.23 Due to the medium sensitivity of fish with a swim bladder-inner ear connection used in hearing and the low magnitude of impact, disturbance or damage due to underwater noise generated by construction activities (impact piling) has been assessed as having a **Minor** effect. As such, disturbance or damage due to underwater noise generated by construction activities is **Not Significant** in EIA terms.

10.11.1.24 Due to the low sensitivity of (a.) fish with a swim bladder not used in hearing; (b.) fish with no swim bladder; (c.) eggs and larvae; and (d.) shellfish, and the low magnitude of impact, disturbance or damage due to underwater noise generated by construction activities (impact piling) has been assessed as having a **Negligible** effect for these remaining receptor groups. As such, disturbance or damage due to underwater noise generated by construction activities is **Not Significant** in EIA terms.

10.11.1.25 Due to the negligible magnitude of impact, disturbance or damage due to underwater noise generated by construction activities (UXO and other noise-producing activities) has been assessed as having a **Negligible** effect for all receptor groups. As such, disturbance or damage due to underwater noise generated by construction activities is **Not Significant** in EIA terms.

Further Mitigation

10.11.1.26 No further mitigation is required following the assessment of disturbance or damage due to underwater noise generated by construction activities as having a **Minor** or **Negligible** effect, which is **Not Significant** in EIA terms.

Temporary Habitat Loss or Disturbance During the Installation of all Infrastructure and Placement of Vessel Anchors on the Seabed

Background

10.11.1.27 The Construction Phase of the Offshore Development has the potential to introduce temporary habitat loss or disturbance to the seabed, as a result of activities such as sandwave levelling, cable trenching, and vessel anchors, to name a few. Temporary habitat loss for fish and shellfish species may occur in the water column and on/within the seabed. However, due to the negligible volume of water that is directly replaced by infrastructure, and the generally high mobility of fish and shellfish species within the water column, this impact exclusively refers to the temporary habitat loss resulting from the Construction Phase of the Offshore Development on and/or within the seabed. This includes trenchless operations within the intertidal and subtidal zones at the Landfall.

10.11.1.28 In this case, the primary impact of temporary habitat loss or disturbance during the installation of all infrastructure and placement of vessel anchors on the seabed is most relevant to demersal fish species, pelagic species with demersal spawning strategies, and shellfish species.

Sensitivity of Receptors

10.11.1.29 Elasmobranch species are considered tolerant and adaptable to temporary habitat loss or disturbance due to their high mobility and varied diet. The wide range of habitats elasmobranchs typically roam within their home ranges reduce the likelihood of secondary impact upon elasmobranchs at an individual scale, such as the potential reduction in prey availability. Therefore, elasmobranch species are considered to have a **Low** sensitivity to temporary habitat loss or disturbance during the installation of all infrastructure and placement of vessel anchors on the seabed.

10.11.1.30 Both demersal and pelagic fish species are typically mobile and are therefore capable of avoiding the disturbed habitats during construction activities, and consequently recolonising disturbed habitats. Temporary habitat loss or disturbance is more likely to have an impact upon spawning populations, particularly for pelagic species with demersal spawning strategies, which require specific substrata and abiotic seabed conditions. Therefore, for demersal and pelagic fish species that do not rely on specific seabed substrates to facilitate successful spawning events, or those that show a site-specific dependence on the seabed (e.g. for burrows), sensitivity to temporary habitat loss or disturbance during the installation of all infrastructure and placement of vessel anchors on the seabed is initially considered **Low** (for demersal fish) and **Negligible** for (pelagic fish).

10.11.1.31 The Fish and Shellfish Ecology Study Area is characterised by Sand, slightly gravelly Sand, and gravelly Sand seabed substrate types (as categorised by Folk, 1954), which are considered preferred potential supporting habitats for sandeel (Reach *et al.*, 2013). Temporary habitat loss or disturbance during the installation of all infrastructure and placement of vessel anchors on the seabed is therefore likely to have negative impacts upon individual sandeel within the Offshore Development Area. However, population-level effects are unlikely to occur due to the extensive area of preferred potential supporting habitat surrounding the Offshore Development Area. As identified in the baseline section (**Section 10.7**), marginal potential spawning habitat for Atlantic herring (gravelly Sand) is restricted to the Offshore ECC, with the OAA and surrounding area representing unsuitable potential spawning habitats for Atlantic herring (sand-dominated sediments).

10.11.1.32 Whilst sandeel and Atlantic herring are sensitive to temporary habitat loss or disturbance during the installation of all infrastructure and placement of vessel anchors on the seabed at an individual-level (specifically eggs and 0-ringer larvae), consideration must be made of population-level effects. This is achieved by comparing the relative extent of potential supporting/spawning habitat available within the Fish and Shellfish Ecology Study Area, which is an over-representative quantification of areas with highest spawning potential, with that of the area available to the spawning population.

10.11.1.33 There is 58 km² of High potential supporting habitat for sandeel within the Offshore Development Area, which is of limited extent in comparison to the 4,709 km² of High potential supporting habitat within the wider Fish and Shellfish Ecology Study Area (<1.25 %). As such, there is unlikely to be a vector for population-level effects in the context of the habitat available to sandeel within the Fish and Shellfish Ecology Study Area, and the wider central North Sea. Therefore, for sandeel, sensitivity to temporary habitat loss or disturbance during the installation of all infrastructure and placement of vessel anchors on the seabed is considered **Medium** as a precaution. Sensitivity for all other demersal fish will remain as **Low**.

10.11.1.34 The 23.3 km² extent of low confidence High potential spawning habitat for Atlantic herring within the Offshore ECC, which is 0.5% of the 4,370 km² of low-confidence High potential spawning habitat within the Fish and Shellfish Ecology Study Area, sensitivity to temporary habitat loss or disturbance during the

installation of all infrastructure and placement of vessel anchors on the seabed is considered **Medium** for Atlantic herring as a precaution. Sensitivity for all other pelagic fish will remain as **Negligible**.

10.11.1.35 Diadromous fish species are not generally considered reliant on the condition of the seabed during any phase of their life history. Therefore, a **Negligible** impact pathway related to temporary habitat loss or disturbance during the installation of all infrastructure and placement of vessel anchors on the seabed has been identified for diadromous fish.

10.11.1.36 Shellfish species present within the Fish and Shellfish Ecology Study Area are inherently dependent on the seabed following pelagic larval stages. For some crustacean species, such as brown crab, berried females are noticeably less mobile during the breeding season whilst eggs develop and are therefore less tolerant of temporary habitat loss or disturbance than males, or females outside of the breeding season. Similarly, European lobster form burrows within which berried females will shelter, which may be disturbed or damaged by construction activities and have the potential to reduce the fecundity of a few individuals during a single breeding event. Whilst individuals may have a heightened sensitivity to seabed disturbance in their immediate vicinity, the wide range of habitat available to the UK population means that sensitivity at a population scale is considered low. The remaining shellfish species identified within the Fish and Shellfish Ecology Study Area are considered more tolerant of temporary habitat loss or disturbance, due to relatively high fecundity and fast growth rates. Therefore, shellfish are considered to have a **Low** sensitivity to temporary habitat loss or disturbance during the installation of all infrastructure and placement of vessel anchors on the seabed.

Magnitude of Impact

10.11.1.37 The magnitude of temporary habitat loss or disturbance is based upon the maximum extent of seabed footprint associated with the preparatory works and subsequent installation of infrastructure that directly interacts on and/or within the seabed. The maximum extent of footprint associated with the Offshore Development is therefore calculated as the sum of the total footprint of infrastructure, total footprint of vessel anchor deployments, and the total footprint of jack-up events. Using values presented in **Table 10-9**, this equates to 5,177,340 m² of seabed footprint associated with the Construction Phase of the Offshore Development.

10.11.1.38 This value constitutes approximately 6.4% of the combined area of the OAA and the Offshore ECC (33,250,000 m² + 47,400,000 m² = 80,650,000 m²), and approximately 0.035% of the Fish and Shellfish Ecology Study Area, assuming the Fish and Shellfish Study Area is 15,058 km².

10.11.1.39 In addition, 5,177,340 m² is considered highly precautionary as it assumes there is no spatial overlap between the footprint of infrastructure, vessel anchor deployments, and jack-up events. The expected footprint of seabed disturbance will be much smaller than this value. Therefore, the magnitude of temporary habitat loss or disturbance during the installation of all infrastructure and placement of vessel anchors on the seabed is considered **Low**.

Significance of Effect

10.11.1.40 Due to the medium sensitivity of sandeel and Atlantic herring, combined with the low magnitude of impact, temporary habitat loss or disturbance during the installation of all infrastructure and placement of vessel anchors on the seabed for these two species has been assessed as having a **Minor** effect. As such, temporary habitat loss or disturbance during the installation of all infrastructure and placement of vessel anchors on the seabed is **Not Significant** in EIA terms.

10.11.1.41 Due to the low sensitivity of elasmobranch, demersal fish, and shellfish receptors, combined with the low magnitude of impact, temporary habitat loss or disturbance during the installation of all infrastructure and placement of vessel anchors on the seabed has been assessed as having a **Negligible** effect. As such, temporary habitat loss or disturbance during the installation of all infrastructure and placement of vessel anchors on the seabed is **Not Significant** in EIA terms.

10.11.1.42 Due to the negligible sensitivity of pelagic fish and diadromous fish receptors, combined with the low magnitude of impact, temporary habitat loss or disturbance during the installation of all infrastructure and placement of vessel anchors on the seabed has been assessed as having a **Negligible** effect. As such, temporary habitat loss or disturbance during the installation of all infrastructure and placement of vessel anchors on the seabed is **Not Significant** in EIA terms.

Further Mitigation

10.11.1.43 No further mitigation is required following the assessment of temporary habitat loss or disturbance during the installation of all infrastructure and placement of vessel anchors on the seabed as having a **Minor or Negligible** effect, which is **Not Significant** in EIA terms.

Temporary increases in Suspended Sediment Concentrations and Potential Sedimentation/ Smothering of Fish and Shellfish

Background

10.11.1.44 Interaction with seabed habitats associated with the Construction Phase of the Offshore Development, such as seabed preparation and the installation of cables and mooring lines/foundations (including trenchless operations at the Landfall), is likely to result in suspension of seabed sediments into the water column. Activities with the greatest potential for suspension of seabed substrates includes the installation and burial of cables, and the installation of anchors/mooring points.

10.11.1.45 The Fish and Shellfish Ecology Study Area is characterised by primarily sand-dominated substrates, with limited mud content. Sand-dominated sediments are likely to settle within a few hundred metres from the source of disturbance. Therefore, the resulting suspended sediment concentrations are expected to be short-term and localised, particularly within the Offshore ECC where sediment composition shifts from sand-dominated to gravel-dominated towards the Landfall. Coarser sediments such as gravels are expected to settle closer to the point of disturbance than finer sediments.

10.11.1.46 It is noted that the nature of this impact is highly specific to the point of disturbance, and therefore will occur during discrete and localised events throughout the Construction Phase, as opposed to continuously throughout the Construction Phase.

Sensitivity of Receptors

10.11.1.47 For all fish and shellfish receptors, increases in suspended sediment concentration have the potential to reduce visibility and result in the smothering of respiratory organs. The sensitivity of receptors is proportionate to the body size of each receptor, their dependence on visual hunting strategies, and the potential for spawning within the Fish and Shellfish Ecology Study Area (Cloern, 1987; Henley *et al.*, 2000).

10.11.1.48 Elasmobranch species are highly mobile and utilise electromagnetic sensory organs, such as Ampullae of Lorenzini, supplemented by visual cues, as the primary sense when hunting. Due to their mobility, and the spatial extent of hunting grounds, elasmobranch species are considered tolerant to increases in suspended sediments, of which they are able to avoid if necessary.

10.11.1.49 Demersal fish species characteristic of the Fish and Shellfish Ecology Study Area include sandeel and flatfish, which are well adapted to direct interaction with the seabed, through burial within the sediment and/or formation of burrows. Benthopelagic species, such as Atlantic cod and haddock, are highly mobile and considered both tolerant and capable of avoiding areas of high suspended sediment concentrations. Pelagic fish and diadromous fish species are also highly mobile, and generally considered tolerant following a similar rationale.

10.11.1.50 Therefore, adult life stages of elasmobranch, demersal, pelagic, and diadromous fish species are considered to have a **Negligible** sensitivity to temporary increases in suspended sediment concentrations and potential sedimentation/smothering.

10.11.1.51 However, both demersal and pelagic species may have spawning areas within the Fish and Shellfish Ecology Study Area. Fish eggs and larvae are known to be susceptible to increases in suspended sediment concentration through smothering of surfaces used for gas exchange and increased pelagic egg sinking rates (Westerberg *et al.*, 1996; Griffin *et al.*, 2009). Despite known tolerance of sandeel and adult Atlantic herring (Messieh *et al.*, 1981; Kiørboe *et al.*, 1981; Utne-Palm, 2004), it is expected that eggs and larvae of these species will be less tolerant of increases in suspended sediment concentration than adults. Whilst Atlantic herring spawning potential within the Fish and Shellfish Ecology Study Area is generally low, there is marginal potential spawning habitat present within the Offshore ECC.

10.11.1.52 Therefore, the eggs and larval stages of demersal and pelagic fish species are considered to have a **Medium** sensitivity to temporary increases in suspended sediment concentrations and potential sedimentation/smothering.

10.11.1.53 Similarly to demersal and pelagic fish, shellfish species have a greater risk of impact associated with suspended sediment concentrations during breeding seasons. Female brown crab and other crustacean species carry eggs whilst berried, which may experience fluctuations in oxygen availability in response to smothering by increases suspended sediment concentrations. Whilst the mobility of crustaceans may mitigate smothering in areas of high suspended sediment concentrations (Neal and Wilson, 2008; Sabatini and Hill, 2008; Gibson-Hall *et al.*, 2020), berried brown crab retreat into pits within the sediment, and are considered less tolerant of smothering during the breeding season. Evidence suggests that scallops are tolerant of smothering by coarse and medium sediment grain sizes, with no observed short-term reduction in survivability during experimental study (Szostek *et al.*, 2013).

10.11.1.54 Filter-feeding shellfish present, but not commercially or ecologically important within the Fish and Shellfish Ecology Study Area, may be at risk of smothering of feeding appendages resulting from increased suspended sediment concentration (Pineda *et al.*, 2017). However, evidence suggests bivalves have a certain degree of tolerance to light smothering by maintaining filtration ability (Essink, 1999; Lummer *et al.*, 2016). Therefore, shellfish species are considered to have a **Medium** sensitivity to temporary increases in suspended sediment concentrations and potential sedimentation/smothering.

Magnitude of Impact

10.11.1.55 Temporary increases in suspended sediment concentrations as a result of the proposed works will be highly localised in the context of the Fish and Shellfish Ecology Study Area, and short term in nature. Therefore, the magnitude of temporary increases in suspended sediment concentrations and potential sedimentation/smothering is considered **Low**.

Significance of Effect

10.11.1.56 Due to the negligible sensitivity of the adult stages of elasmobranchs, demersal, pelagic, and diadromous fish receptors, and the low magnitude of impact; temporary increases in suspended sediment concentrations and potential sedimentation/smothering of fish and shellfish has been assessed as having a **Negligible** effect. As such, temporary increases in suspended sediment concentrations and potential sedimentation/smothering of fish and shellfish are **Not Significant** in EIA terms.

10.11.1.57 Due to the medium sensitivity of the eggs and larval stages of demersal and pelagic fish, and shellfish receptors, and the low magnitude of impact; temporary increases in suspended sediment concentrations and potential sedimentation/smothering of fish and shellfish has been assessed as having a **Minor** effect. As such, temporary increases in suspended sediment concentrations and potential sedimentation/smothering of fish and shellfish are **Not Significant** in EIA terms.

Further Mitigation

10.11.1.58 No further mitigation is required following the assessment of temporary increases in suspended sediment concentrations and potential sedimentation/smothering as having a **Minor** or **Negligible** effect, which is **Not Significant** in EIA terms.

10.11.2 Operation and Maintenance

10.11.2.1 Under the operation and maintenance phase, the following potential impacts have been assessed:

- Disturbance or damage to sensitive species due to underwater noise generated from operation and maintenance activities;
- Habitat loss due to the presence of infrastructure on the seabed and associated scour protection;
- Effects of thermal load and EMFs from subsea and dynamic cables on sensitive species;
- Fish aggregation around the floating substructures and associated infrastructure; and
- Ghost fishing due to lost fishing gear becoming entangled in installed infrastructure.

Disturbance or Damage to Sensitive Species due to Underwater Noise Generated from Operation and Maintenance Activities

Background

10.11.2.2 The generation of underwater noise during the Operation and Maintenance Phase of the Offshore Development will be limited to the transit of service/maintenance vessels, the noise pertaining to the movement/operation of WTGs, and potential 'pinging' of mooring lines. Noise associated with the movement of WTGs is expected to be generated through the transfer of vibration from machinery to the water column and seabed through the turbine tower and/or foundations (Nedwell *et al.*, 2003; Tougaard *et al.*, 2020). In the case of floating WTGs, it is expected that sound associated with the movement of WTGs is not transferred to the seabed via dynamic cables or mooring lines.

10.11.2.3 Pinging has been identified as a potential source of underwater noise specific to mooring lines, where a release in tension due to movement within the floating system produces a 'snap' sound of approximately 160 dB re 1 µPa (SPL_{PEAK}), but rarely exceeding 170 dB re 1 µPa (JASCO, 2011). This source of underwater noise is characterised by discrete events and are unlikely to exceed the TTS SPL_{PEAK} threshold for fish with a swim bladder-inner ear connection at 186 dB re 1 µPa (Popper *et al.*, 2014). The expected rate of pinging has been considered the same as that identified by JASCO (2011) at 0.958 events per hour.

Sensitivity of Receptors

10.11.2.4 The sensitivity of fish and shellfish receptors to underwater noise has been described in detail in **Section 10.11.1**. The resulting consideration of sensitivity for fish and shellfish receptors in response to disturbance or damage to sensitive species due to underwater noise generated from construction and decommissioning activities will be carried forward into the assessment of disturbance or damage to sensitive species due to underwater noise generated from operation and maintenance activities.

10.11.2.5 Fish species with a swim blader-inner ear connection used in hearing are considered to have a **Medium** sensitivity to disturbance or damage to sensitive species due to underwater noise generated from operation and maintenance activities.

10.11.2.6 The remaining fish species lacking the swim bladder-inner ear connection and shellfish receptors are all considered to have a **Low** sensitivity to disturbance or damage to sensitive species due to underwater noise generated from operation and maintenance activities.

Magnitude of Impact

10.11.2.7 The predicted magnitude of underwater noise associated with the 24 h per day operation of large offshore wind turbines is expected to be 145 dB re 1 µPa (SPL_{RMS}) at 10 m and reduces with increasing distance from the turbine (**Volume ER.A.4, Annex 4.1: Underwater Noise Modelling Report**). It is unlikely that sound generated by the operation of the turbines would exceed 145 dB re 1 µPa at 10 m.

10.11.2.8 It is also unlikely that vessel traffic associated with operation and maintenance activities will exceed background levels within the Fish and Shellfish Ecology Study Area, and therefore is unlikely to exceed background levels of underwater noise. This is particularly the case considering the depth of the OAA, and therefore the reduced likelihood of fish being present within close vicinity of vessels. Furthermore, the magnitude of underwater noise associated with mooring line pinging is unlikely to exceed SPL_{PEAK} values produced by UXO detonation or impact piling (**Volume ER.A.4, Annex 4.1: Underwater Noise Modelling Report**).

10.11.2.9 Therefore, the magnitude of disturbance or damage to sensitive species due to underwater noise generated from operation and maintenance activities is considered **Negligible**.

Significance of Effect

10.11.2.10 Due to the medium sensitivity of fish with a swim bladder-inner ear connection used in hearing, combined with the negligible magnitude of impact, disturbance or damage to sensitive species due to underwater noise generated from operation and maintenance activities has been assessed as having a **Negligible** effect. As such, disturbance or damage due to underwater noise generated by operation and maintenance activities is **Not Significant** in EIA terms.

10.11.2.11 Due to the low sensitivity of fish without a swim bladder-inner ear connection used in hearing and shellfish receptors, combined with the negligible magnitude of impact, disturbance or damage to sensitive species due to underwater noise generated from operation and maintenance activities has been assessed as having a **Negligible** effect. As such, disturbance or damage due to underwater noise generated by operation and maintenance activities is **Not Significant** in EIA terms.

Further Mitigation

10.11.2.12 No further mitigation is required following the assessment of disturbance or damage to sensitive species due to underwater noise generated from operation and maintenance activities as having a **Negligible** effect, which is **Not Significant** in EIA terms.

Habitat Loss due to the Presence of Infrastructure on the Seabed and Associated Scour Protection

Background

10.11.2.13 Habitat loss is expected to occur as a result of placement of infrastructure within the water column and on the seabed. Due to the negligible volume of water that is directly replaced by infrastructure, and the generally high mobility of fish and shellfish species within the water column, this impact exclusively refers to the lasting habitat loss resulting from the Construction Phase of the Offshore Development on the seabed that will be present throughout the Operation and Maintenance Phase. It is expected that the footprint of temporary seabed disturbance (e.g. associated with buried cable) will return to baseline conditions during the Operation and Maintenance Phase of the Offshore Development.

10.11.2.14 Therefore, this impact is specific to the presence (including swept area) of catenary chains, cables, tethers, anchors/moorings, scour protection, and cable stabilisation on the seabed, where the seabed cannot return to baseline conditions during the Operation and Maintenance Phase of the Offshore Development. The total seabed footprint (assuming no overlap) of this infrastructure equates to 6,950,460m² (6.95 km²).

Sensitivity of Receptors

10.11.2.15 Many elasmobranch species identified as present within the Fish and Shellfish Ecology Study Area are dependent on the seabed for spawning grounds and prey. The Fish and Shellfish Ecology Study Area is not considered a key spawning ground for elasmobranch species. The mobility and wide ranges of most elasmobranch species within the Fish and Shellfish Ecology Study Area makes elasmobranch species tolerant and adaptable to potential reductions in prey availability associated with habitat loss, as individuals can be displaced into the wider area representing natural ranges. Therefore, elasmobranch species are considered to have a **Low** sensitivity to habitat loss due to the presence of infrastructure on the seabed and associated scour protection.

10.11.2.16 Most demersal and pelagic fish species present within the Fish and Shellfish Ecology Study Area have a relatively high degree of mobility and are therefore capable of avoiding areas of temporary disturbance, but crucially returning following cessation of the activity. Species with demersal spawning strategies within the Fish and Shellfish Ecology Study area, including sandeel and Atlantic herring, are not tolerant to habitat loss during the breeding season at a highly localised scale, but have a degree of flexibility at a population scale due to the expansive area of potential spawning grounds within the wider central North Sea region. As such, demersal and pelagic fish are initially considered to have a **Low** sensitivity to Habitat loss due to the presence of infrastructure on the seabed and associated scour protection.

10.11.2.17 Due to the presence of High potential supporting habitat for sandeel, but limited vector for population-level effects in the context of the habitat available to sandeel within the Fish and Shellfish Ecology Study Area and the wider central North Sea. Therefore, for sandeel, sensitivity to temporary habitat loss or disturbance during the installation of all infrastructure and placement of vessel anchors on the seabed is considered **Medium** as a precaution. Sensitivity for all other demersal fish and pelagic fish receptors will remain as **Low**.

10.11.2.18 Diadromous fish species, including PMFs such as salmonids and lamprey, are not typically associated with the seabed during the marine phase of their lifecycle, due to pelagic predatory and/or parasitic feeding strategies (Hansen and Quinn, 1998; O'Reilly *et al.*, 2021; Quintella *et al.*, 2021; Gillson *et al.*, 2022). Therefore, diadromous fish species are considered to have a **Negligible** sensitivity to habitat loss due to the presence of infrastructure on the seabed and associated scour protection.

10.11.2.19 Shellfish species identified within the Fish and Shellfish Ecology Study Area are likely to be directly impacted by habitat loss due to their reliance on seabed habitats post-larval settlement. Shellfish typically have high fecundity and broadcast spawning strategies, which allow populations to recover relatively quickly compared to some demersal fish species. Habitat loss is considered to prevent colonisation and establishment of species previously present at the area, and therefore high fecundity cannot replace these individuals unless population densities increase in surrounding, unaffected areas. Considering the scale of the characteristic habitats of the Offshore Development Area, in the context of the wider region, the potential for population-level effects upon shellfish is highly unlikely. Therefore, shellfish species are considered to have a **Low** sensitivity to habitat loss due to the presence of infrastructure on the seabed and associated scour protection.

Magnitude of Impact

10.11.2.20 The predicted magnitude of habitat loss due to the presence of infrastructure on the seabed and associated scour protection is based upon the worst-case scenario of permanent seabed footprint loss associated with the Offshore Development. This represents the seabed lost during the Operation and Maintenance Phase as a result of the presence of infrastructure on the seabed and replacements of infrastructure made during the Operation and Maintenance Phase, which equates to 6,950,460 m² (approximately 6.95 km²). This footprint represents approximately 8.6% of the footprint of the OAA and the Offshore ECC combined (80,650,000 m² or 80.65 km²), and 1.3% of the Fish and Shellfish Ecology Study Area (514,485,600 m² or 514.49 km²).

10.11.2.21 Therefore, the magnitude of habitat loss due to the presence of infrastructure on the seabed and associated scour protection is considered **Low**.

Significance of Effect

10.11.2.22 Due to the medium sensitivity of sandeel, combined with the low magnitude of impact, habitat loss due to the presence of infrastructure on the seabed and associated scour protection has been assessed as having a **Minor** effect. As such, habitat loss due to the presence of infrastructure on the seabed and associated scour protection is **Not Significant** in EIA terms.

10.11.2.23 Due to the low or negligible sensitivity of elasmobranch, pelagic fish, demersal fish, diadromous fish, and shellfish, combined with the low magnitude of impact, habitat loss due to the presence of infrastructure on the seabed and associated scour protection has been assessed as having a **Negligible** effect. As such, habitat loss due to the presence of infrastructure on the seabed and associated scour protection is **Not Significant** in EIA terms.

Further Mitigation

10.11.2.24 No further mitigation is required following the assessment of habitat loss due to the presence of infrastructure on the seabed and associated scour protection as having a **Minor** or **Negligible** effect, which is **Not Significant** in EIA terms.

Effects of Thermal Load and Electromagnetic Fields from Subsea and Dynamic Cables on Sensitive Species

Background

10.11.2.25 The transmission of electricity along conductors, such as transmission cables, creates both an electric field (E field) and a magnetic field (B-field), collectively termed an electromagnetic field (EMF), around the cable. Subsea cables are insulated and prevent transmitted E-fields from interacting with the environment; however, conductive materials, such as organisms or salt water, form induced E-fields (iE-fields) when

moving through B-fields, a phenomenon exploited by electrosensitive organisms to target prey (Gill *et al.*, 2005). iE-fields are dependent on the extent of B-fields created by active subsea cables and numerous factors regarding the mobile conductive material (e.g. speed of movement, conductivity, distance from B-field, etc). Gill *et al*. (2005) predicted an iE-field of 2.5 μVm^{-1} for 33 kV subsea cables buried at 1.5 m, producing B-fields of 0.04 µT. Whilst this iE-field can be detected by sensitive species, the B-field produced equates to ~0.1% of the Earth's magnetic field (approximately 36 µT as stated in the Gill *et al*. (2005) study).

10.11.2.26 This assessment therefore considers the B-field component of EMF within the marine environment, as iE-fields are unlikely to be substantial outside of natural variation associated with Earth's magnetic field. EMF strength is dependent on the electric current strength through the cable and reduces rapidly with distance from the cable. Therefore, interactions between organisms and EMFs are largely dependent on the proximity of an individual to a live cable. Generally, B-field strength is not altered by the medium through which it flows. Therefore, whilst depth of lowering does not reduce B-field strength, it reduces the volume of seawater within which B-field levels are elevated above baseline.

10.11.2.27 As described within **Volume ER.A.2, Chapter 4: Project Description**, the EMF output of array and export cables associated with the Offshore Development have been shown to reduce to <0.01 µT at a distance of 2.75 m from the surface of a dynamic cable in the water column, and also for static cable buried at a minimum target depth of 0.6 m below the seabed or cable protection/stabilisation where technically feasible; with decreasing radius of effect as depth of lowering increases. At the surface of the dynamic cable, the magnitude of EMF is modelled at 850 µT, which is expected to dissipate to 55 µT at 25 cm from the cable centre to <1 µT within <1.25 m from the surface of dynamic cables. For context, Earth's natural magnetic field varies between approximately 25-65 µT (Hutchinson *et al.*, 2020).

10.11.2.28 EMF has the potential to cause localised heating of solids such as seabed sediments, however this effect is likely to be of a small magnitude (<6°C) at the outer sheathing of buried cables and dissipated within tens of centimetres from the surface of the cable. Given that this increase is limited to the immediate vicinity of these buried cables, it is highly unlikely that there will be any temperature increase above the surface. Therefore, thermal load is unlikely to result in any additional impact upon fish and shellfish receptors (Boehlert and Gill, 2010; National Grid and Energinet, 2017; Moray Offshore Windfarm Ltd, 2018).

Sensitivity of Receptors

10.11.2.29 Elasmobranch species have acute sensitivity to changes in EMF given off by prey species, detected by specialist organs such as Ampullae of Lorenzini. It is therefore considered that elasmobranchs represent the most sensitive receptor group to EMF. Effects primarily involve attraction of predatory species to subsea cables, with shifts in foraging behaviour on the seabed as a response to B-field exposure of >10 µT noted in available literature (Gill, 2009; Anderson *et al*., 2017). Whilst evidence suggests that EMFs may attract large elasmobranchs, the magnitude of effect is currently unknown (Sims and Quale, 1998; Kempster and Collin, 2011). Although the elasmobranch receptor group is understood to be highly perceptive to changes in EMF, effects at the levels indicated for the Offshore Development are limited to behavioural responses. The receptor group is also highly mobile, and able to roam across large distances, with any behavioural response only likely to occur within meters of the cable where B field strength is observable above background. Elasmobranchs are therefore considered to have a **Low** sensitivity to effects of thermal load and EMFs from subsea and dynamic cables on sensitive species.

10.11.2.30 Sensitivity to EMF in demersal and pelagic species is limited. Whilst some species are known to contain biogenic magnetite to aid in orientation (Formicki *et al.*, 2019), significant effects on adult life stages have not been observed within available literature (Bochert and Zettler, 2004; Bochert and Zettler, 2006; Cresci

et al., 2022a; Kilfoyle *et al.*, 2018; Woodruff *et al.*, 2012), with the exception of a single learned response observed in yellow fin tuna *Thunnus albacares* (Walker, 1984). Behavioural changes in juveniles have been observed in a single study, with Cresci *et al.* (2022b), noting a decrease in swimming speed of haddock larvae resulting from exposure to B fields of 150 µT under laboratory conditions.

10.11.2.31 Sensitivity to EMF amongst diadromous species is noted within current literature. The development and behaviour of juvenile Atlantic salmon and brown trout has been found to be impacted by EMF at high field strengths (13,000 µT, Formicki and Winnicki, 1998; and 70,000 µT, Formicki, 1992). However, it should be noted that these are significantly higher than those magnetic fields that will be associated with the Offshore Development. No behavioural changes in adult salmon were identified at B field strengths as low as 38 µT (Rommel and McCleave, 1973). A reduction in the swimming speed of European eel has been observed as individuals cross a marine power cable (Westerberg and Lagenfelt, 2008). Whilst other studies on B field effect on catadromous species have been conducted, none show significant effect at B-field strengths as high as 2,000 µT (Rommel and McCleave, 1973; McCleave and Power, 1978).

10.11.2.32 Findings within published literature indicate that in many cases, no significant effect is observed following the exposure of demersal, pelagic, and diadromous fish species to EMF associated with FLOW projects (ERM, 2023). Where significant effects have been identified, these are often present only where B-field strength is significantly greater than levels relevant to the Offshore Development, in contact with the cable itself, or are limited to behavioural changes concurrent with exposure. The benthic, pelagic, and diadromous receptor groups are therefore considered to have a **Negligible** sensitivity to effects of thermal load and EMFs from subsea and dynamic cables on sensitive species.

10.11.2.33 The response of shellfish species to EMF are well documented within the literature. In laboratory conditions, observations of both brown crab and American lobster *Homarus americanus* indicated increased exploratory behaviours in regions of seabed with an artificial B-field of 65 µT (Hutchinson *et al.*, 2018). However, this attraction effect has not been made consistently across shellfish species, with no significant change in behaviour observed in European lobster or velvet crab *Necora puber* under similar experimental conditions and exposure to B-fields of 200-500 µT (Chapman *et al.*, 2023; Taormina *et al.*, 2020). Significantly higher B-field strengths of 1,000-2,000 µT have been observed to cause changes in the development of brown crab, however these levels are orders of magnitude greater than any B fields modelled to be associated with the Offshore Development (Scott *et al.*, 2018; Scott *et al.*, 2021). Therefore, shellfish are considered to have a **Negligible** sensitivity to effects of thermal load and EMFs from subsea and dynamic cables on sensitive species.

Magnitude of Impact

10.11.2.34 For the purposes of this assessment, a 2.75 m radius of EMF surrounding a dynamic cable in open water has been assumed to present a variation in B field strength detectable by certain fish and shellfish receptors above baseline. Based on the Project Design Envelope in **Table 10-9**, and assuming a 2.75 m radius around all dynamic/suspended cables (with an outer diameter of 0.32 m) associated with the Offshore Development, the maximum volume of water containing detectable EMF is 93,064 m^3, or 0.000093 km^3. The remaining export and array cable is expected to be buried at a minimum target depth of 0.6 m where technically feasible. Cable protection/stabilisation will be placed above static array and/or export cables in areas where the 0.6 m minimum target depth cannot be achieved. For the purposes of this assessment, it is assumed that the volume of water exposed to detectable EMF surrounding cable protection/stabilisation is equal to that of buried cable. As a result, the volume of water containing measurable EMF from static cables (assuming a 0.32 m diameter) is 1,290,078 m^3, and for all dynamic and static cables combined equals 1,383,143 m^3.

10.11.2.35 It is thought that elasmobranch species are capable of detecting EMF magnitudes of <1 µT, and therefore the 2.75 m radius of effect is deemed an appropriate assumption for detection of EMF by elasmobranch species, in the absence of specific study on species present within the Fish and Shellfish Ecology Study Area. For context, elasmobranchs are considered capable of detecting iE-fields of 0.5-100 µV per m (Gill *et al.*, 2005).

10.11.2.36 Therefore, as a precaution, the magnitude of effects of thermal load and EMFs from subsea and dynamic cables on sensitive species is considered **Low**, due to the presence of dynamic array cables within the water column and the potential for array and/or export cables to result in measurable EMF within the water column.

Significance of Effect

10.11.2.37 Due to the low sensitivity of elasmobranchs, combined with the low magnitude of impact, effects of thermal load and EMFs from subsea and dynamic cables on sensitive species has been assessed as having a **Negligible** effect. As such, effects of thermal load and EMFs from subsea and dynamic cables on sensitive species is **Not Significant** in EIA terms.

10.11.2.38 Due to the negligible sensitivity of demersal fish, pelagic fish, diadromous fish, and shellfish receptors, combined with the low magnitude of impact, effects of thermal load and EMFs from subsea and dynamic cables on sensitive species has been assessed as having a **Negligible** effect. As such, effects of thermal load and EMFs from subsea and dynamic cables on sensitive species is **Not Significant** in EIA terms.

Further Mitigation

10.11.2.39 No further mitigation is required following the assessment of effects of thermal load and EMFs from subsea and dynamic cables on sensitive species as having a **Negligible** effect, which is **Not Significant** in EIA terms.

Fish Aggregation around the Floating Substructures and Associated Infrastructure

Background

10.11.2.40 The introduction of offshore wind farm substructures in the water column are expected to result in fish aggregation effects and serve as a foundation for settling invertebrates to colonise (see **Volume ER.A.3, Chapter 9: Benthic and Intertidal Ecology**; Wilhelmsson *et al.*, 2006; Raoux *et al.*, 2017). This effect supports the ecosystems associated with an artificial reef via the 'bottom-up' control of productivity, where colonising primary producers and secondary consumers provide ecosystem functions and allow tertiary consumers to colonise/utilise the artificial habitat.

10.11.2.41 Fish aggregation effects have the potential to affect the health of offshore ecosystems. Additional settling opportunities provided by anthropogenic structures will result in an increase in local biomass. This may lead to increases in local nutrient load beyond natural variation, potentially resulting in the aggregation of fringe populations leading to reduced biomass within surrounding habitats. Additional settling opportunities also have the potential to allow for the establishment of non-native species via an increase in available habitat.

10.11.2.42 Anthropogenic structures in the marine environment increase habitat complexity creating additional opportunities for shelter, and diversifying microhabitat availability. Fish aggregation effects have been recorded in various offshore sectors, including WTG arrays (see **Volume ER.A.3, Chapter 9: Benthic and Intertidal Ecology;** Raoux *et al.*, 2017; Rouse *et al.*, 2017). As floating wind farms typically have a reduced number of large structures which extend throughout the entire water column (from surface to seabed), the scale of the fish aggregation effect is expected to be lower than other offshore industries with foundations on the seabed (Linley *et al.*, 2007).

10.11.2.43 For fish aggregation, the worst-case scenario during the Operation and Maintenance Phase of the Offshore Development is based on the assumption that fish aggregation will occur within an equal volume of water surrounding submerged infrastructure as the submerged infrastructure itself, in the absence of large/massive infrastructure (e.g. monopiles) that extend through the water column to the seabed. It is also assumed that interstitial spaces within Offshore Development infrastructure provides potential opportunities for habitation as shelter. Combined, the volume of potential effect is 7,489,965 m^3.

Sensitivity of Receptors

10.11.2.44 Elasmobranch species interact with marine structures in varying ways, with most species within the Fish and Shellfish Ecology Study Area having the capability of swimming through and around infrastructure with a minor energy burden. As such, elasmobranch species are tolerant and adaptable to fish aggregation effects. The increase in prey availability due to fish aggregation effects may benefit piscivorous and demersal feeding elasmobranch species although, this is likely to be limited due to the small spatial scale of the Offshore Development. As a result, the sensitivity of elasmobranch species to fish aggregation effects is considered to be **Negligible**.

10.11.2.45 Generally, pelagic, demersal and diadromous fish species have a high degree of mobility and agility, as such they are likely to aggregate in areas of high productivity or habitat quality. For example, small and juvenile pelagic fish are likely to aggregate around surface debris for shelter, whereas demersal fish are likely to aggregate around complex structures for both shelter and increased hunting opportunities (Wilhelmsson *et al.*, 2006). Diadromous fish species are likely to, at most, transit through the Offshore Development Area; and therefore are not likely to aggregate in and/or around structures. For well-established artificial reef structures, aggregation of predatory species may have a localised negative impact upon small prey species (Leitão *et al.*, 2008). It is therefore difficult to determine the sensitivity of species to fish aggregation, and this varies with numerous factors relating to the size, complexity, material, location, and age of the artificial structure, in addition to seasonal distributions driven by abiotic conditions (Glarou *et al.*, 2020; Wright *et al.*, 2020). In sand-dominated environments, fish aggregation around hard substrate and structures is likely to boost biodiversity and have positive impacts upon populations of key fish species such as Atlantic cod and pouting (Reubens *et al.*, 2013). In the context of the central North Sea, the positive and negative impacts of fish aggregation as a result of the Offshore Development are not expected to have population-level effects. Therefore, demersal, pelagic, and diadromous fish species are considered to have a **Low** sensitivity to fish aggregation effects as a precautionary measure.

10.11.2.46 Shellfish species have limited mobility and are confined to the immediate area where settlement occurred. However, placing structures in the water column creates the opportunity for encrusting species including blue mussel to settle (Wilhelmsson *et al.*, 2006). As most shellfish species are suspension feeders or detritivores they will benefit as a result of nutrient accumulation due to fish aggregation effects. Whilst there is potential for localised reduction in population density associated with predation halos by tertiary consumers aggregating around/within hard substrates/structures, population-level effects within the Fish and Shellfish Ecology Study Area are unlikely. As such, shellfish are considered to have a **Low** sensitivity to fish aggregation effects as a precautionary measure.

Magnitude of Impact

10.11.2.47 The magnitude of impact associated with fish aggregation is based on the assumption that fish aggregate within a volume of water surrounding the infrastructure that is equal to the volume of water column loss by infrastructure itself. For infrastructure with interstitial spaces for fish to shelter in (e.g. semi-submersible platforms), it is assumed that the volume of water in which fish aggregate within the structure is equal to

the volume of the structure itself (assuming the structure is a solid object). This represents a precautionary volume based upon the maximum area of substructures multiplied by the maximum draught in the water column. For semi-submersible substructures, it is assumed that the volume of water within which fish aggregate is twice the maximum area of substructures multiplied by the maximum draught, which is equal to 6,585,600 m³ as identified in **Table 10-9**.

10.11.2.48 The worst-case scenario volume is associated with the semi-submersible platform and all other infrastructure within the water column (including that protruding from the seabed), equalling approximately 0.0075 km³. The total volume of water contained within the OAA is equal to 3.13 km³ assuming an area of 3.325 km² multiplied by the average water depth of 94.05 m. Fish aggregating effects are therefore possible across approximately 0.24% of the volume of water contained within the OAA.

10.11.2.49 In addition, **Volume ER.A.3, Chapter 9: Benthic and Intertidal Ecology** assessed the colonisation potential of the Offshore Development infrastructure as **Minor** (Not Significant in EIA terms) due to the limited scale if submerged infrastructure. Therefore, fish aggregation is unlikely to be enhanced by colonising benthic organisms on substructures.

10.11.2.50 Due to the small scale and low number of substructures near the surface, and limited interstitial volumes of infrastructure on the seabed, the potential for fish aggregation effects is likely to be limited to isolated schools of small pelagic species and individual pelagic juveniles. This is unlikely to represent an acute attraction/residency of large predatory fish around infrastructure associated with the Offshore Development, and as such population-level effects are considered unlikely. Therefore, the magnitude of fish aggregation around the floating substructures and associated infrastructure is considered **Negligible**.

Significance of Effect

10.11.2.51 The negligible magnitude of impact, combined with low sensitivity of demersal fish, pelagic fish, diadromous fish, and shellfish receptor groups, results in the impact of fish aggregation around the floating substructures and associated infrastructure having a **Negligible** effect, and is therefore **Not Significant** in EIA terms.

10.11.2.52 The negligible magnitude of impact, combined with the negligible sensitivity of elasmobranch receptors, results in the impact of fish aggregation around the floating substructures and associated infrastructure having a **Negligible** effect, and is therefore **Not Significant** in EIA terms.

Further Mitigation

10.11.2.53 No further mitigation is required following the assessment of effects of fish aggregation around the floating substructures and associated infrastructure as having a **Negligible** effect, which is **Not Significant** in EIA terms.

Ghost Fishing due to Lost Fishing Gear becoming Entangled in Installed Infrastructure

Background

10.11.2.54 Ghost fishing is the entrapment or entanglement of marine species within anthropogenic debris, most commonly abandoned, lost, or discarded fishing gear (ALDFG) (Richardson *et al.*, 2019). ALDFG is a well-known cause of mortality in all fish and shellfish receptor groups and identified as responsible for 74% of entanglement observations within published literature (Parton *et al.*, 2019).

10.11.2.55 Within the context of the Offshore Development, ALDFG may become entangled with mooring lines, dynamic cables or seabed infrastructure such as anchors. However, the degree of impact is dependent on the size and location of ALDFG. For example, ALDFG present on the seabed (such as pots and traps) as well as nets caught on structures (including anchors, moorings, cable protection, and surface-laid cables) will

most likely impact demersal and shellfish species. Lost static gear including traps and pots are considered to have a low impact because of the potential for captured species to escape as well as the relatively high retrieval rate which can reduce mortality (Brown and Macfadyen, 2007). Elasmobranchs and pelagic fish are expected to be at a greater risk of being impacted by ghost netting and hooks suspended within the water column or ensnared on marine infrastructure.

10.11.2.56 When compared to targeted fishing, ghost fishing has a substantially lower impact on fish populations, as nets are often tangled and will thereby have a lower area of coverage compared to when they are used normally. Risk may be exacerbated due to the passive nature of ALDFG including trawling nets and a fish aggregating effect, especially if predatory species are attracted to trapped carcasses which could result in them becoming trapped or entangled.

10.11.2.57 As the location of lost gear and the likelihood of it entering the OAA at any point in time is difficult to determine, a worst-case scenario for this impact is difficult to establish. Data from sources including fisheries data (Piet *et al.*, 2021) and citizen science charities can be used to make estimations, however this is not likely to be sufficient representation within the OAA. As such, throughout the lifetime of the Offshore Development, remotely operated vehicles (ROVs) will be used to periodically monitor the dynamic cables, anchors and moorings for ALDFG which may be snagged on the substructures.

Sensitivity of Receptors

10.11.2.58 ALDFG associated with ghost fishing can cause entanglement, and mortality of all entangled individuals, for all receptor groups. As such, elasmobranch, pelagic fish, demersal fish, diadromous fish, and shellfish species are all considered intolerant to ghost fishing. However, ghost fishing is likely to be highly localised, and therefore individual mortality associated with ghost fishing is likely to be tolerated at a population-level. Therefore, all species within all fish and shellfish receptor groups are considered to have a **Medium** sensitivity to ghost fishing due to lost fishing gear becoming entangled in installed infrastructure.

Magnitude of Impact

10.11.2.59 The magnitude of impact associated with ghost fishing is based on the periodic inspection of the Offshore Development substructures for the presence of ALDFG and other potential entanglement hazards. If identified as a risk to project infrastructure or of sufficient entanglement risk (Co17), these hazards will be removed as part of the maintenance of the Offshore Development's infrastructure during the Operation and Maintenance Phase. Therefore, the magnitude of ghost fishing due to lost fishing gear becoming entangled in installed infrastructure is considered **Negligible**.

Significance of Effect

10.11.2.60 The medium sensitivity of all fish and shellfish receptor groups, combined with negligible magnitude of impact, results in the impact of ghost fishing due to lost fishing gear becoming entangled in installed infrastructure having a **Negligible** effect, and is therefore **Not Significant** in EIA terms.

Further Mitigation

10.11.2.61 No further mitigation is required following the assessment of effects of ghost fishing due to lost fishing gear becoming entangled in installed infrastructure as having a **Minor** effect, which is **Not Significant** in EIA terms, in conjunction with the monitoring and removal of ALDFG proposed to protect project infrastructure and ornithological and marine mammal receptors.

10.11.3 Decommissioning

10.11.3.1 Impacts associated with the Decommissioning Phase of the Offshore Development are expected to reflect the nature of impacts associated with the Construction Phase, however it is likely that potential impacts will be of a lower magnitude. For example, if it is determined that infrastructure is to be left *in situ*, such as cable protection, there will be a notable reduction in the potential for seabed habitat disturbance.

10.11.3.2 Further assessment of potential impacts associated with decommissioning of the Offshore Development will be assessed as part of a Marine Licence application that will be submitted prior to the commencement of any Project-specific decommissioning works. In addition, a Decommissioning Programme will be submitted to MD-LOT for approval by the Scottish Ministers prior to construction. This document will then be reviewed and updated at various points during the lifetime of the Offshore Development prior to the commencement of any Project-specific decommissioning works.

10.11.4 Summary of Impact Assessment

10.11.4.1 A summary of the impacts and effects identified for the Fish and Shellfish Ecology assessment is outlined in **Table 10-16**.

Table 10-16 Summary of Impacts and Effects for Fish and Shellfish Ecology

Salamander Project Activity and Impact	Project Aspect	Embedded Mitigation	Receptor	Sensitivity	Magnitude	Significance of Effect	Further Mitigation	Residual Significance of Effect	Significance of Effect in EIA Terms
Construction and Decommissioning									
Damage or disturbance to sensitive species due to underwater noise generated from construction activities (Separate magnitude and significance scores are provided for UXO, impact piling, and other noise-producing activities)	Offshore Array and Offshore ECC	Co14, Co15	Fish with a swim bladder-inner ear connection used in hearing	Medium	Low (Impact Piling) Negligible (UXO and Other Noise-Producing Activities)	Minor (Impact Piling)	No additional mitigation measures have been identified for this effect above and beyond the embedded mitigation listed in **Table 10-8** as it was concluded that the effect was Not Significant	Minor (Impact Piling)	Not Significant
						Negligible (UXO and Other Noise-Producing Activities)		Negligible (UXO and Other Noise-Producing Activities)	
			Fish with a swim bladder not used in hearing	Low		Negligible		Negligible	Not Significant
			Fish without a swim bladder						
			Eggs and larvae						
			Shellfish						

Salamander Project Activity and Impact	Project Aspect	Embedded Mitigation	Receptor	Sensitivity	Magnitude	Significance of Effect	Further Mitigation	Residual Significance of Effect	Significance of Effect in EIA Terms
Temporary habitat loss or disturbance during the installation of all infrastructure and placement of vessel anchors on the seabed	Offshore Array and Offshore ECC	Co9, Co14	Elasmobranchs	Low	Low	Negligible	No additional mitigation measures have been identified for this effect above and beyond the embedded mitigation listed in **Table 10-8** as it was concluded that the effect was Not Significant	Negligible	Not Significant
			Demersal Fish	Low					
			Sandeel	Medium		Minor		Minor	Not Significant
			Pelagic Fish	Negligible		Negligible		Negligible	Not Significant
			Atlantic herring	Medium		Minor		Minor	Not Significant
			Diadromous Fish	Negligible		Negligible		Negligible	Not Significant
			Shellfish	Low					
Temporary increases in suspended sediment concentrations and potential sedimentation/	Offshore Array and Offshore ECC	Co14	Elasmobranchs	Negligible	Low	Negligible	No additional mitigation measures have been identified for this effect above and beyond the embedded mitigation	Negligible	Not Significant
			Demersal Fish	Medium		Minor		Minor	Not Significant
			Pelagic Fish						
			Diadromous Fish	Negligible		Negligible		Negligible	Not Significant

Salamander Project Activity and Impact	Project Aspect	Embedded Mitigation	Receptor	Sensitivity	Magnitude	Significance of Effect	Further Mitigation	Residual Significance of Effect	Significance of Effect in EIA Terms
smothering of fish and shellfish			Shellfish	Medium		Minor	listed in **Table 10-8** as it was concluded that the effect was Not Significant	Minor	Not Significant
Operation and Maintenance									
Disturbance or damage to sensitive species due to underwater noise generated from operation and maintenance activities	Offshore Array and Offshore ECC	None	Fish with a swim bladder-inner ear connection used in hearing	Medium	Negligible	Negligible	No additional mitigation measures have been identified for this effect above and beyond the embedded mitigation listed in **Table 10-8** as it was concluded that the effect was Not Significant	Negligible	Not Significant
			Fish with a swim bladder not used in hearing	Low					
			Fish without a swim bladder						
			Eggs and larvae						
			Shellfish						
Habitat loss due to the presence of infrastructure		Co14	Elasmobranchs	Low	Low	Negligible	No additional mitigation measures have	Negligible	Not Significant
			Demersal Fish						

Salamander Project Activity and Impact	Project Aspect	Embedded Mitigation	Receptor	Sensitivity	Magnitude	Significance of Effect	Further Mitigation	Residual Significance of Effect	Significance of Effect in EIA Terms
on the seabed and associated scour protection	Offshore Array and Offshore ECC		Sandeel	Medium		Minor	been identified for this effect above and beyond the embedded mitigation listed in **Table 10-8** as it was concluded that the effect was Not Significant	Minor	Not Significant
			Pelagic Fish	Low		Negligible		Negligible	Not Significant
			Atlantic herring	Medium		Minor		Minor	Not Significant
			Diadromous Fish	Low		Negligible		Negligible	Not Significant
			Shellfish						
Effects of thermal load and EMFs from subsea and dynamic cables on sensitive species	Offshore Array and Offshore ECC	No further mitigation is proposed to reduce the effects of EMF. However, it is noted that cable route selection and burial is expected to have a beneficial secondary effect by reducing the volume of water or the likelihood of sensitive species from	Elasmobranchs	Low	Low	Negligible	No additional mitigation measures have been identified for this effect above and beyond the embedded mitigation listed in **Table 10-8** as it was concluded that	Negligible	Not Significant
			Demersal Fish	Negligible					
			Pelagic Fish						
			Diadromous Fish						
			Shellfish						

Salamander Project Activity and Impact	Project Aspect	Embedded Mitigation	Receptor	Sensitivity	Magnitude	Significance of Effect	Further Mitigation	Residual Significance of Effect	Significance of Effect in EIA Terms
		being exposed to EMF.					the effect was Not Significant		
Fish aggregation around the floating substructures and associated infrastructure	Offshore Array	None	Elasmobranchs	Negligible	Negligible	Negligible	No additional mitigation measures have been identified for this effect above and beyond the embedded mitigation listed in **Table 10-8** as it was concluded that the effect was Not Significant	Negligible	Not Significant
			Demersal Fish	Low					
			Pelagic Fish						
			Diadromous Fish						
			Shellfish						
Ghost fishing due to lost fishing gear becoming entangled in installed infrastructure	Offshore Array	Co10	Elasmobranchs	Medium	Negligible	Negligible	No additional mitigation measures have been identified for this effect above and beyond the embedded mitigation	Negligible	Not Significant
			Demersal Fish						
			Pelagic Fish						
			Diadromous Fish						
			Shellfish						

Salamander Project Activity and Impact	Project Aspect	Embedded Mitigation	Receptor	Sensitivity	Magnitude	Significance of Effect	Further Mitigation	Residual Significance of Effect	Significance of Effect in EIA Terms
							listed in **Table 10-8** as it was concluded that the effect was Not Significant		

10.12 Mitigation and Monitoring

10.12.1.1 No further mitigation or monitoring is required, as none of the impacts assessed alone were deemed not significant in EIA terms.

10.13 Cumulative Effect Assessment

10.13.1.1 A Cumulative Effects Assessment (CEA) has been made based on existing and proposed developments in the Study Area, identified within **Volume ER.A.4, Annex 6.1: Cumulative Effects Assessment Technical Annex**. The approach to the CEA is described in **Volume ER.A.2, Chapter 6: EIA Methodology**. Cumulative effects are defined as those effects on a receptor that may arise when the development is considered together with other projects. Therefore, projects to be included in the CEA are located within the Offshore Development zone of influence, specific to effects identified within this Fish and Shellfish Ecology Chapter. Projects are only included in the CEA if an EIA is/was required.

10.13.1.2 As noted above, the cut-off date for cumulative assessment of new projects submitting consent and scoping applications was up to six months before the Salamander Project's offshore application submission; six months prior is the end of October 2023. Projects submitting an application or scoping report between six and two months before submission will be acknowledged but not assessed in the EIAR. A review of projects was undertaken in early March (i.e. less than two months prior to submission) and the projects that have submitted a scoping report between October and March are Stromar Offshore Wind Farm and the Broadshore Hub (Broadshore, Sinclair and Scaraben Projects) in January 2024.

10.13.1.3 The maximum spatial extent of potential effects identified within this Fish and Shellfish Ecology Chapter is defined as either:

- the 57 km maximum spatial extent of underwater noise that exceeds the TTS threshold (186 dB SEL_{CUM}) for sensitive receptors during the Construction Phase of the Offshore Development; or
- the 17 km tidal ellipse, representing the maximum extent of increased SSC (as identified in **Volume ER.A.3, Chapter 7: Marine Physical Processes**).

10.13.1.4 Receptors beyond this range are unlikely to experience any significant effect as a result of the Offshore Development alone, as described in the alone assessment. However, underwater noise below the TTS threshold may interact with noise produced by other projects to extend the Offshore Development's zone of influence. As such, plans or projects with potential to overlap spatially or temporally within a 100 km radius of the OAA, or 17 km radius of the Offshore Export Cable Route will be included in the cumulative assessment. 100 km was chosen as a buffer to encompass projects with potential to result in underwater noise.

10.13.1.5 On this basis, the projects considered for cumulative assessment have been presented in **Table 10-17**.

Table 10-17 External projects identified within a 100 km radius of the Offshore Development

Development	Type	Project Phase	Closest distance from the Offshore **Array Area**		Closest distance from the Offshore **ECC**		Reasons for inclusion
			Project Array	*Project ECC/Other*	*Project Array*	*Project ECC/Other*	
Hywind Scotland Pilot Park	Floating Offshore Wind Farm	Operational	11.7 km	14.3 km	8.1 km	0.1 km	The Hywind Scotland Pilot Park Project's array is located 11.7 km and 8.1 km from the Offshore Array and Offshore ECC respectively. The Hywind Scotland Pilot Park Project's ECC is located 14.3 km and 0.1 km from the Offshore Array and Offshore ECC respectively.
NorthConnect	Interconnector	Consented	NA (Subsea cable project)	0 km	NA (Subsea cable project)	0 km	The NorthConnect Project overlaps the Offshore Array and Offshore ECC respectively.
Eastern Green Link 2 (EGL2)	Interconnector	Consented	NA (Subsea cable project)	26.78 km	NA (Subsea cable project)	2.86 km	There is potential for temporal overlap of construction timelines and the EGL2 project is 26.78 km and 2.86 km of the Offshore Array and Offshore ECC.
Green Volt Floating Offshore Windfarm	Floating Offshore Wind Farm	Consent Application Submitted	33.6 km	0.3 km	38.9 km	0 km	The Green Volt Project is included as it is scheduled to be operational by 2027. The Green Volt array is 33.6 km and 38.9 km from the Offshore Array and Offshore ECC respectively. The Green Volt export cable is 0.3 km from the Offshore Array and overlaps the Offshore ECC.

Development	Type	Project Phase	Closest distance from the Offshore **Array Area**		Closest distance from the Offshore **ECC**		Reasons for inclusion
			Project Array	*Project ECC/Other*	*Project Array*	*Project ECC/Other*	
MarramWind Offshore Wind Farm[6]	Floating Offshore Wind Farm	Scoping Submitted	47 km	59 km	1.5 km	0 km	The MarramWind Project was included as the MarramWind ECC search area is 1.5 km from the Offshore Array and overlaps with the Offshore ECC.
Muir Mhòr Offshore Wind Farm	Floating Offshore Wind Farm	Scoping Submitted	28.4 km	5.53 km	30.9 km	0 km	The Muir Mhòr Project is included as the construction period could overlap with Salamander. The Muir Mhòr project's array is 28.4 km and 30.9 km from the Offshore Array and Offshore ECC respectively. The Muir Mhòr project's ECC is 5.53 km from the Offshore Array and overlaps the Offshore ECC.
Cenos Floating Offshore Wind Farm Export Cable	Floating Offshore Wind Farm	Scoping Submitted	154 km	0 km	157.4 km	0 km	The Cenos Project is included as it is scheduled to be operational by 2028 and its ECC overlaps the Offshore Array and Offshore ECC.
Central North Sea Electrification (CNSE) Project	Platform Electrification	Scoping Submitted	NA (Subsea cable project)	18.1 km	NA (Subsea cable project)	4.6 km	The CNSE Project is included as it is scheduled to be operational by 2028. The CNSE Project's cable route is 18.1 and 4.6 km from the Offshore Array and Offshore ECC respectively.

[6] Distances provided for MaramWind are based on the ECC area of search, and should not be considered necessarily indicative of the route that will subsequently be proposed.

Development	Type	Project Phase	Closest distance from the Offshore **Array Area**		Closest distance from the Offshore **ECC**		Reasons for inclusion
			Project Array	*Project ECC/Other*	*Project Array*	*Project ECC/Other*	
Ossian Offshore Wind Farm	Floating Offshore Wind Farm	Scoping Submitted	79.5 km	Unknown	79.5 km	Unknown	The Ossian Project's array is 79.5 km from both the Offshore Array and Offshore ECC respectively.
Caledonia Offshore Wind Farm	Offshore Wind Farm	Scoping Submitted	80.3 km	70.16 km	62.9 km	40.51 km	The Caledonia Project's array is 80.3 km and 62.9 km from the Offshore Array and Offshore ECC respectively.
Buchan Floating Offshore Wind Farm	Floating Offshore Wind Farm	Scoping Submitted	66.3 km	1.44 km	69.3 km	0 km	The Buchan Project's array is 66.3 km and 69.3 km from the Offshore Array and Offshore ECC respectively. The Buchan Project's ECC Area of Search is 1.44 km from the Offshore Array and overlaps with the Offshore ECC.
Morven Offshore Wind Farm	Offshore Wind Farm	Scoping Submitted	74.9 km	Unknown	74.2 km	Unknown	The Morven Project's array is 74.9 km and 74.2 km from the Offshore Array and Offshore ECC respectively.
Peterhead (CR070)	Dredge Spoil Disposal	Operational	NA (Aggregate extraction project)	3.1 km	NA (Aggregate extraction project)	33.9 km	Disposal ground located 3.1 km and 33.9 km from the Offshore Array and Offshore ECC respectively.

Development	Type	Project Phase	Closest distance from the Offshore **Array Area**		Closest distance from the Offshore **ECC**		Reasons for inclusion
			Project Array	*Project ECC/Other*	*Project Array*	*Project ECC/Other*	
North Buchan Ness (CR080)	Dredge Spoil Disposal	Operational	NA (Aggregate extraction project)	1.7 km	NA (Aggregate extraction project)	29.9 km	Disposal ground located 1.7 km and 29.9 km from the Offshore Array and Offshore ECC respectively.

Table 10-18 Expected overlap of piling activities for projects scoped in for the Fish and Shellfish Ecology Cumulative Impact Assessment. Blue cells denote expected years in which piling activities may occur. Overlap in piling activities with the Salamander Project may occur in 2028. Projects outside of 1 year either side of the indicative piling year for the Salamander Project (i.e. outside of the 2027-2029 period indicated) and/or beyond 100 km from the Offshore Array Area have been scoped out for further assessment due to the low likelihood of overlap with piling activities

Project	Type	Scoped In/Out	2024	2025	2026	2027	2028	2029	2030	2031
Salamander Offshore Wind Farm	Floating Offshore Wind Farm	In								
Green Volt Floating Offshore Wind Farm	Floating Offshore Wind Farm	In								
Muir Mhòr Offshore Wind Farm	Floating Offshore Wind Farm	In								
Caledonia Offshore Wind Farm	Offshore Wind Farm	In								
MarramWind Offshore Wind Farm	Floating Offshore Wind Farm	Out								
Cenos Floating Offshore Wind Farm	Floating Offshore Wind Farm	Out (>100 km)								

10.13.1.6 Further information on these projects is outlined in **Volume ER.A.4, Annex 6.1: Cumulative Effects Assessment Technical Annex**.

10.13.2 Potential Cumulative Effects

10.13.2.1 The first stage of the CEA is to identify the potential for effects assessed alone to have cumulative pathways with other projects. As described within **Table 10-17** and **Volume ER.A.4, Annex 6.1: Cumulative Effects Assessment Technical Annex**, projects which do not have detailed impact data available at scoping or which have not submitted scoping requests or consent applications up to six months before Salamander's application submission will not be considered part of any in-depth cumulative or in-combination assessment. This includes future ScotWind and Innovation and Targeted Oil and Gas (INTOG) projects. These projects will need to include any impacts from the Offshore Development in their cumulative effect assessments when they submit a consent application.

10.13.2.2 The outcome of this stage is presented in **Table 10-19**.

Table 10-19 Potential cumulative effects relating to Fish and Shellfish Ecology

Effect Assessed Alone	Potential for Cumulative Effect	Rationale
Construction		
Disturbance or damage to sensitive species due to underwater noise generated from construction activities: species with a swim bladder-inner ear connection used in hearing	Yes	There is potential for other underwater noise-producing projects within 100 km to coincide, should it be likely that such projects involve impact piling construction methods. Other sources of underwater noise will be considered within a radius of 57 km in alignment with the distance of TTS onset as a result of the Offshore Development alone.
Disturbance or damage to sensitive species due to underwater noise generated from construction activities: species lacking a swim bladder-inner ear connection used in hearing; and shellfish species.	No	These receptor groups are generally considered to have an increased tolerance of elevated underwater noise due to the absence of a swim bladder-inner ear connection used in hearing, or an absence of a swim bladder all together (Popper et al., 2014). Assessment of impact from project activities alone determined Negligible effect for species lacking a swim bladder-inner ear connection used in hearing, and shellfish species. In view of this low sensitivity, these species are not taken forward for assessment of cumulative disturbance or damage effects due to underwater noise generated from construction activities.
Temporary habitat loss or disturbance during the installation of all infrastructure and placement of vessel anchors on the seabed	No	Limited to the footprint of works within the OAA and Offshore ECC and included within the Project Design Envelope assessed alone. Cable crossings installed over existing third-party infrastructure have been included within the Project Design Envelope for impact assessed alone, and therefore no additional cumulative effect is expected based on the distance of projects screened into the CEA for the Offshore Development.
Temporary increases in suspended sediment concentrations and potential sedimentation/smothering of fish and shellfish	Yes	Several projects are located within 17 km of the Offshore Development, and therefore have the potential to overlap with the 17 km tidal excursion buffer.

Effect Assessed Alone	Potential for Cumulative Effect	Rationale
Operation and Maintenance		
Disturbance or damage to sensitive species due to underwater noise generated from operation and maintenance activities	Yes	There is potential for other underwater noise-producing projects to coincide with vessel traffic associated with the Offshore Development.
Habitat loss due to the presence of infrastructure on the seabed and associated scour protection	No	Limited to the footprint of works within the OAA and Offshore ECC. Cable crossings installed over existing third-party infrastructure have been included within the Project Design Envelope for impact assessed alone, and therefore no additional cumulative effect is expected based on the distance of projects screened into the CEA for the Offshore Development.
Effects of thermal load and EMFs from subsea and dynamic cables on sensitive species	No	Limited to the footprint of works within the OAA and Offshore ECC and volume of water surrounding dynamic cables. Potential EMF effects associated with cable crossings installed over existing third-party infrastructure have been included within the Project Design Envelope for impact assessed alone, and therefore cable crossings are not assessed separately within the CEA. No significant additional cumulative effect is expected based on the distance of projects that a.) do not overlap with the Offshore ECC and b.) are screened into the CEA for the Offshore Development. This is determined based on the highly localised nature of EMF effect and comparatively large distance between projects.
Fish aggregation around the floating substructures and associated infrastructure	No	Evidence suggests that larger oil rig platforms, which extend from the sea surface to the seabed, have a range of influence upon demersal fish species between 1.5-15 km (average of 5 km) (UKRI, 2024). These structures are able to provide greater ecosystem functions than the infrastructure associated with the Offshore Development, and therefore it is expected that small-scale floating offshore wind projects will have a substantially reduced range of influence in comparison to oil rig platforms.

Effect Assessed Alone	Potential for Cumulative Effect	Rationale
		As such, there is no potential for significant cumulative effect with other projects, due to the small scale of the Offshore Development and the distance between other external projects with potential for fish aggregation effects (the closest is the similar scale Hywind Scotland Pilot Park Project at 11.7 km).
Ghost fishing due to lost fishing gear becoming entangled in installed infrastructure	Yes	There is limited but potential cumulative effect with other projects due to the small scale of the Offshore Development and the distance between other projects with infrastructure in the water column (11.7 km), but the potential for ghost fishing associated with subsea cable projects (including ECCs associated with offshore wind farm projects) that cross, or are within close proximity to, infrastructure associated with the Offshore Development.
Decommissioning		
It is expected that all effects associated with the Decommissioning Phase of the Offshore Development assessed alone, and therefore also cumulatively, are similar and of lower magnitude as those identified within the Construction Phase of the Offshore Development. This assumption is subject to best practice methods and technology appropriate at the time of decommissioning.		

10.13.2.3 The second stage of the CEA is to assess the significance of each potential cumulative effect in relation to relevant external projects considered within the CEA. Please refer to **Volume ER.A.4, Annex 6.1: Cumulative Effects Assessment Technical Annex** for detailed information regarding the external projects with potential for spatial and temporal overlap with the Offshore Development.

10.13.2.4 The following CEA will therefore exclusively assess potential cumulative effects (identified in **Table 10-19**) of the projects identified in **Table 10-17**.

Construction

Cumulative Disturbance or Damage to Sensitive Species due to Underwater Noise Generated from Construction Activities

10.13.2.5 The underwater noise generated during the Construction Phase of the Offshore Development was assessed alone as **Minor**, which is **Not Significant** in EIA terms. When considering the active external projects within 57 km of the Offshore Development, the Construction Phase of the Offshore Development is likely to coincide with underwater noise associated with vessel traffic during routine operation and maintenance works on the external projects. Vessel noise and other low-level noise produced during the construction of subsea cable installation projects are unlikely to produce a significant increase in underwater noise than that produced by potential pile driving activity during the Construction Phase of the Offshore Development. In the instance that piling is not selected as the anchoring method, vessel noise associated with the installation of other anchorage types (e.g. drag embedment) would be additive to noise produced by cable installation projects. It is unlikely that the additive effect of vessel noise would exceed the magnitude of effect associated with piling activities undertaken for the Offshore Development alone, and therefore the likelihood of significant cumulative effect with existing operational projects is considered low.

10.13.2.6 There is potential for underwater noise associated with pile driving activity during the construction of other projects to occur simultaneously with the Construction Phase of the Offshore Development. Such projects are limited to those with arrays located within 100 km of the OAA, and likely to have scoped in pile driving activity within one year either side of the proposed piling activity in the OAA (see **Table 10-18**). These projects include:

- Green Volt;
- Muir Mhòr; and
- Caledonia.

10.13.2.7 Piling activity undertaken by the MarramWind project is unlikely to overlap with the Offshore Development (**Table 10-18**), and there is uncertainty in the piling timelines for the Ossian, Buchan, and Morven projects. The Cenos project's array is > 100 km from the OAA, and is subsequently scoped out of cumulative assessment.

10.13.2.8 In the instance that piling schedules of the Offshore Development and other projects overlap, it is likely that the output underwater noise model for the project alone assessment in **Section 10.11.1** will not reflect the true extent of TTS experienced by the receptor (as the SEL_{CUM} parameter may be influenced by the additional project(s)). As a precautionary measure, it is expected that the extent of TTS would be increased above that assessed alone in **Section 10.11.1** for any other project in which piling may occur, and therefore it is likely that a significant cumulative effect with proposed projects may occur.

Significance of Cumulative Effect

10.13.2.9 Due to the small scale of the Offshore Development, and the potential overlap of piling activity with other projects, the cumulative disturbance or damage to sensitive species due to underwater noise generated from temporary construction activities is considered **Moderate**, and therefore **Significant** in EIA terms. This determination accounts for any tertiary mitigation commitments by other projects with potential for pile driving activities during their construction.

Further Mitigation

10.13.2.10 In order to mitigate this potential cumulative impact to a level that is non-significant in EIA terms, i.e. minor or less, further mitigation is proposed. This will entail the Salamander Project working closely with the other developers active in this region construction to avoid, where reasonably practicable, potential overlap of piling activities between projects in order to minimise cumulative disturbance or damage to sensitive species due to underwater noise generated from temporary construction activities (Co58).

10.13.2.11 Successful implementation of this further mitigation measure is considered to reduce this impact to **Minor**, which is **Not Significant** in EIA terms.

Cumulative Temporary Increases in Suspended Sediment Concentrations and Potential Sedimentation/Smothering of Fish and Shellfish

10.13.2.12 Several projects have the potential to overlap with increased suspended sediment within the 17 km tidal excursion buffer, and therefore have the potential to have overlapping sediment plumes that could increase beyond the 17 km buffer. These projects include:

- Eastern Green Link 2 (EGL2);
- Green Volt Floating Offshore Wind Farm Export Cable;
- MarramWind Offshore Wind Farm Export Cable;
- Muir Mhòr Offshore Wind Farm Export Cable;
- Cenos Floating Offshore Wind Farm Export Cable;
- Buchan Floating Offshore Wind Farm Export Cable;
- Central North Sea Electrification (CNSE) Project Export Cable;
- NorthConnect;
- Peterhead (CR070); and
- North Buchan Ness (CR080).

10.13.2.13 These projects are expected to result in localised seabed disturbance, and are therefore expected to produce temporary suspended sediment plumes of similar magnitude to the Offshore Development. However, due to the small scale of all these projects (most are limited to export cables making landfall in/around Peterhead) and the natural variability in SSCs within the 17 km tidal excursion buffer, it is unlikely that cumulative temporary increases in suspended sediment concentrations and potential sedimentation/smothering of fish and shellfish would substantially increase in significance over that assessed alone.

Significance of Cumulative Effect

10.13.2.14 Due to the temporary nature of effect, and small scale of the extents of the subsea cable projects within the area of cumulative effect with the Offshore Development, cumulative temporary increases in suspended sediment concentrations and potential sedimentation/smothering of fish and shellfish are considered **Minor**, and therefore **Not Significant** in EIA terms.

Further Mitigation

10.13.2.15 No further mitigation is required following the assessment of cumulative temporary increases in suspended sediment concentrations and potential sedimentation/smothering of fish and shellfish as having a **Minor** effect, which is **Not Significant** in EIA terms.

Operation and Maintenance

<u>Cumulative Disturbance or Damage to Sensitive Species due to Underwater Noise Generated from Operation and Maintenance Activities</u>

10.13.2.16 The Operation and Maintenance Phase of the Offshore Development is likely to coincide with construction of projects that have submitted scoping reports, and the operation and maintenance activities of active projects (e.g. the Hywind Scotland Pilot Park Project). As stated in the alone assessment, the generation of underwater noise during the Operation and Maintenance Phase of the Offshore Development will be limited to the transit of service/maintenance vessels, the noise pertaining to the movement/operation of WTGs, and potential pinging of mooring lines.

10.13.2.17 Due to the reduced magnitude of underwater noise associated with vessel trips and operation of the Offshore Development, the radius of effect for underwater noise will be significantly reduced in comparison to the worst-case radius of effect assessed during the alone assessment or the Construction section of the CEA. As the magnitude of vessel noise resulting in TTS is localised around vessels (within a few hundred metres), there is limited potential for significant cumulative effect between projects, even if such projects utillise piling activities. Potential cumulative effects may arise if vessels are in transit from common ports, however this will not exceed the background variation in vessel noise.

Significance of Cumulative Effect

10.13.2.18 Due to the generation of underwater noise associated with vessel trips, cable laying activity, and the operation of the Offshore Development, the cumulative disturbance or damage to sensitive species due to underwater noise generated from operation and maintenance activities is considered **Negligible**, and therefore **Not Significant** in EIA terms.

Further Mitigation

10.13.2.19 No further mitigation is required following the assessment of cumulative disturbance or damage to sensitive species due to underwater noise generated from operation and maintenance activities as having a **Negligible** effect, which is **Not Significant** in EIA terms.

<u>Cumulative Ghost Fishing due to Lost Fishing Gear becoming Entangled in Installed Infrastructure</u>

10.13.2.20 Due to the high sensitivity of fish species to this effect and the proximity of future OWFs within established fisheries within the region, there is potential for cumulative ghost fishing due to lost fishing gear becoming entangled in installed infrastructure.

10.13.2.21 Due to their small scale, the combined infrastructure for all projects is unlikely to represent a substantial increase in entanglement risk for fish and shellfish receptors within ghost fishing gear in the context of the wider fishing grounds in the region. It is expected that most projects will undertake periodic survey of installed infrastructure and subsequently removal of gear if identified as a risk to infrastructure integrity.

Significance of Cumulative Effect

10.13.2.22 Due to the limited scale of the Offshore Development, the distance to other OWF projects, and the low risk of entanglement of gear within the Offshore ECC, cumulative ghost fishing due to lost fishing gear becoming entangled in installed infrastructure is considered **Minor** as a precaution, and therefore **Not Significant** in EIA terms.

Further Mitigation

10.13.2.23 No further mitigation is required following the assessment of cumulative effects of ghost fishing due to lost fishing gear becoming entangled in installed infrastructure as having a **Minor** effect, which is **Not Significant** in EIA terms.

Decommissioning

10.13.2.24 Cumulative effects associated with the Decommissioning Phase of the Offshore Development are expected to reflect the nature of effects associated with the Construction Phase, however it is likely that potential cumulative effects are of a lower magnitude. For example, if it is determined that infrastructure is to be left *in situ*, such as cable protection, there will be a notable reduction in the potential for seabed habitat disturbance.

10.13.2.25 Any potential differences in cumulative effects associated with the Decommissioning Phase of the Offshore Development will be considered prior to the commencement of any decommissioning works relating to the Offshore Development.

10.14 Assessment of Impacts Cumulatively with the Onshore Development

10.14.1.1 The Onshore Development components are summarised in **Volume ER.A.2, Chapter 4: Project Description**. These project aspects have been considered in relation to the impacts assessed within this chapter.

10.14.1.2 The main components of the Onshore Development which have the potential to disturb receptors of Fish and Shellfish Ecology are the trenchless operations at the Landfall.

10.14.1.3 Receptors detailed within the impact assessment of this chapter primarily at risk of interactions with the Onshore Development include the demersal fish and shellfish receptor groups.

10.14.1.4 The impacts associated with trenchless operations at the Landfall with potential to impact Fish and Shellfish Ecology receptors (i.e. below MHWS) have been assessed in **Section 10.11**.

10.14.1.5 It is not anticipated that there will be any additional impacts from the Onshore Development on Fish and Shellfish Ecology receptors as all other activities from the Onshore Development are fully terrestrial.

10.15 Transboundary Effects

10.15.1.1 Transboundary effects are defined as effects that extend into other European Economic Area (EEA) states. These may occur from the Offshore Development alone, or cumulatively with other plans or projects. Due to the small, localised effects on Fish and Shellfish Ecology, the assessment of transboundary effects would focus solely on the transboundary effects of underwater noise.

10.15.1.2 Due to the location of the Offshore Development on the east coast of Scotland, and the maximum extent of TTS from the OAA not overlapping with EEA state boundaries, no transboundary effects are expected with non-UK EEA states.

10.15.1.3 Therefore, in line with the Scoping Report, transboundary effects have been scoped out from further assessment.

10.16 Inter-related Effects

10.16.1.1 The potential inter-related effects associated with the Offshore Development exist between fish and shellfish ecology and:

- **Volume ER.A.3, Chapter 7: Marine Physical Processes**: impacts on marine physical processes may result in impacts on fish and shellfish ecology;
- **Volume ER.A.3, Chapter 8: Water and Sediment Quality**: impacts on water quality may result in impacts on fish and shellfish ecology;
- **Volume ER.A.3, Chapter 9: Benthic and Intertidal Ecology**: impacts to benthic ecology may affect the food resource available to fish and shellfish;
- **Volume ER.A.3, Chapter 11: Marine Mammals**: impacts to fish and shellfish ecology may affect the food resource available to mammal populations;
- **Volume ER.A.3, Chapter 12: Offshore and Intertidal Ornithology**: impacts to fish and shellfish ecology may affect the food resource available to bird populations; and
- **Volume ER.A.3, Chapter 13: Commercial Fisheries**: impacts on fish communities may impact on catch and effort of commercial fisheries.

10.16.1.2 The worst-case effects assessed within this Fish and Shellfish Ecology Chapter account for such interactions and are considered conservative and robust. As such, both project lifetime and receptor-led inter-related effects are not considered of greater significance than those assessed alone. For clarity, the areas of interaction between effects are listed in **Table 10-20**.

Table 10-20 Summary of the potential project lifetime inter-related effects for Fish and Shellfish Ecology

Impacts	Residual Effects			Inter-related Effects
	Construction *18 months*	*Operation and Maintenance* *35 years*	*Decommissioning* *18 months*	
Damage or disturbance to sensitive species due to underwater noise generated from construction activities, and, Disturbance or damage to sensitive species due to underwater noise generated from operation and maintenance activities	Minor	Negligible	Minor	Underwater noise associated with the Offshore Development is short-term and primarily occurs during the Construction Phase. Under the assumption that the Decommissioning Phase will result in equivalent impacts and effects, it is assumed that underwater noise would also have a **Minor** effect. Realistically, no piling activity would be expected during the Decommissioning Phase, and therefore underwater noise will likely be a result of vessel activity and less intrusive noise-producing activities. Therefore, there is highly limited potential for project lifetime inter-related effects associated with underwater noise.
Temporary habitat loss or disturbance during the installation of all seabed infrastructure and placement of vessel anchors on the seabed, and Habitat loss due to the presence of infrastructure on the seabed and associated scour protection	Minor	Minor	Minor	Temporary and prolonged habitat loss is likely to occur throughout the Offshore Development's lifetime, as a result of dynamic cable movement, seabed infrastructure, cable protection, and scour protection on the seabed. However, given the small scale of the Offshore Development and limited spatial extent of impact in the context of available habitats, there is limited potential for significant project lifetime inter-related effects associated with habitat loss.

Impacts	Residual Effects			Inter-related Effects
	Construction *18 months*	*Operation and Maintenance* *35 years*	*Decommissioning* *18 months*	
Temporary increases in suspended sediment concentrations and potential sedimentation/smothering of fish and shellfish	Minor	NA	Minor	Temporary increases in suspended sediment are most likely to occur during the Construction Phase, however a similar or lower magnitude of increased SSC is expected during the Decommissioning Phase. The Construction and Decommissioning Phases of the Offshore Development are separated by a period of 35 years, which is sufficient for full recovery of fish and shellfish receptors that may have experienced an effect. Whilst both the Construction and Decommissioning Phases occur during the Offshore Development's lifetime, it is unlikely that the Offshore Development's lifetime inter-related effects exist above those identified for the Construction or Decommissioning Phases alone.
Effects of thermal load and EMFs from subsea and dynamic cables on sensitive species	NA	Negligible	NA	Cable EMFs will only be produced at the time of energy transmission. As such, this will be limited to the Operation and Maintenance Phase, and there is no potential for the Offshore Development's lifetime inter-related effects associated with EMF.
Fish aggregation around the floating substructures and associated infrastructure	NA	Negligible	NA	Fish aggregation is only likely to occur during prolonged infrastructure presence in the water column and on the seabed. As such, this will be limited to the Operation and Maintenance Phase, and there is no potential for the Offshore Development's lifetime inter-related effects associated with fish aggregation.
Ghost fishing due to lost fishing gear becoming entangled in installed infrastructure	NA	Negligible	NA	Ghost fishing is only likely to occur during prolonged infrastructure presence in the water column and on the seabed. As such, this will be limited to the Operation and Maintenance Phase, and there is no potential for the Offshore Development's lifetime inter-related effects associated with ghost fishing.

Impacts	Residual Effects			Inter-related Effects
	Construction *18 months*	*Operation and Maintenance* *35 years*	*Decommissioning* *18 months*	
	Receptor Based Effects			
There is potential for interactions between the effects of habitat loss/disturbance/alteration, and effects on fish and shellfish receptors from sediment deposition associated with elevated SSC. It is considered that there is greatest risk of inter-related effects from the combined effects of direct (both temporary and long-term) habitat loss/disturbance (from placement of anchors from vessels and jack-up events, seabed levelling and boulder clearance), indirect habitat disturbance (from cable installation/burial and due to sediment deposition), and indirect effects of changes in physical processes due to the presence of Offshore Development infrastructure within the marine environment. Receptors at most risk of inter-related effects are spawning populations of Atlantic herring and sandeel populations. Given the limited spatial extent of the Offshore Development, the extent of potential habitat available for both Atlantic herring and sandeel in the region, and the recoverability of spawning habitats over time, it is unlikely that the Offshore Development would have a significant potential for lifetime inter-related effects associated with these receptor groups.			

10.17 Conclusion and Summary

10.17.1.1 This chapter provides a baseline characterisation of the Fish and Shellfish Ecology within the Offshore Development Area, and investigates the potential effects of the Construction, Operation and Maintenance, and Decommissioning Phases of the Offshore Development. The range of potential effects considered within this chapter has been informed by existing policy and guidance, the Scoping Opinion, and stakeholder consultation workshops.

10.17.1.2 The Offshore Development and the associated Fish and Shellfish Ecology Study Area is located in the Central North Sea, approximately 35 km east of Peterhead. The Fish and Shellfish Ecology Study Area is characterised by ecologically and commercially valuable elasmobranch, demersal, pelagic, and diadromous fish species, and shellfish species. Some species utilise the Fish and Shellfish Ecology Study Area as spawning and/or nursery grounds or migrate through the Fish and Shellfish Ecology Study Area to reach key habitats further offshore.

10.17.1.3 These receptor groups were used to assess the potential effects associated with the Offshore Development, with the exception of the underwater noise assessment which categorised adult fish into receptor groups dependent on the presence of a swim bladder-inner ear connection used in hearing. A full summary of the results of the impact assessment is presented in **Table 10-16**, including the requirement for mitigation and consequent residual effects. All effects associated with the Offshore Development were assessed as having **Negligible** to **Minor** residual effects, which are considered not significant in EIA terms.

10.17.1.4 The CEA identified that cumulative effects of underwater noise due to impact piling were considered **Moderate** and therefore a potential significant cumulative effect would be expected. In order to mitigate this potential cumulative impact to a level that is non-significant in EIA terms, the Salamander Project will seek to coordinate with the other developers active in this region post-consent closer to the time of construction to develop a coordinated approach to timing of piling activities in order to minimise disruption to sensitive species, where possible. All other cumulative effects assessed were considered **Minor**, and that no potential significant cumulative effects are expected.

10.17.1.5 No transboundary effects specific to Fish and Shellfish Ecology were identified, however it is noted that transboundary effects may be present with reference to the effects upon fishing vessels of other nationalities. As this would be related to commercial fisheries, as opposed to the environment specific to Fish and Shellfish Ecology, this is addressed within **Volume ER.A.3, Chapter 13: Commercial Fisheries**.

10.17.1.6 The inter-related effects are not likely to result in a greater effect significance above that assessed for effects alone due to the small scale of the Offshore Development.

10.18 References

Aires, C., González-Irusta, J.M., and Watret, R. (2014). Updating fisheries sensitivity maps in British waters. *Scottish Marine and Freshwater Science*, 5(10): 88 pp.

Anderson, J. M., Clegg, T. M., Véras, L. V. M. V. Q., & Holland, K. N. (2017). Insight into shark magnetic field perception from empirical observations. *Scientific Reports*, 7(1).

Aprahamian, M.W., Lester, S.M. & Aprahamian, C.D. (1998). *Shad Conservation in England and Wales*. R&D technical report W110. Environment Agency.

Armstrong, J.D., Gauld, N.R., Gilbey, J., and Morris, D.J. (2018). Application of acoustic tagging, satellite tracking and genetics to assess the mixed stock nature of coastal net fisheries. *Scottish Marine and Freshwater Science*, 9(5): 27 pp.

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

Bochert, R., & Zettler, M. L. (2006). Effect of Electromagnetic Fields on Marine Organisms.

Boehlert, G.W., and Gill, A.B. (2010). Environmental and ecological effects of ocean renewable energy development: a current synthesis. *Oceanography*, 23: pp. 68-81.

Boyle, G., and New, P. (2018). *ORJIP Impacts from Piling on Fish at Offshore Wind Sites: Collating Population Information, Gap Analysis and Appraisal of Mitigation Options. A report for The Carbon Trust*. 247 pp.

Brown, J., and Macfadyen, G. (2007). Ghost fishing in European waters: Impacts and management responses. *Marine Policy*, 31: pp. 488-504.

Burrows, M.T., Bates, A.E., Costello, M.J., Edwards, M., Edgar, G.J., Fox, C.J., Halpern, B.S., Hiddink, J.G., Pinsky, M.L., Batt, R.D., and García Molinos, J. (2019). Ocean community warming responses explained by thermal affinities and temperature gradients. *Nature Climate Change*, 9(12): pp. 959-963.

Casper, B.M., and Mann, D.A. (2006). Evoked potential audiograms of the nurse shark (*Ginglymostoma cirratum*) and the yellow stingray (*Urobatis jamaicensis*). *Environmental Biology of Fishes*, 76: pp. 101-108.

Cauwelier, E., Gilbey, J., and Middlemas, S.J. (2014). Genetic assignment of marine-caught adult salmon at Armadale to region of origin. *Scottish Marine and Freshwater Science*, 6(16): 17 pp.

Chapman, E. C. N., Rochas, C. M. V., Piper, A. J. R., Vad, J., & Kazanidis, G. (2023). Effect of electromagnetic fields from renewable energy subsea power cables on righting reflex and physiological response of coastal invertebrates. *Marine Pollution Bulletin*, 193, 115250.

Coull, K.A., Johnstone, R., and Rogers, S.I., 1998. *Fisheries Sensitivity Maps in British Waters. Published and distributed by UKOOA Ltd*.

Cloern, J.E., 1987. Turbidity as a control on phytoplankton biomass and productivity in estuaries. *Continental Shelf Research*, 7(11-12): pp. 1367-1381.

Cresci, A., Sandvik, A.D., Sævik, P.N., Ådlandsvik, B., Olascoaga, M.J., Miron, P., Durif, C.M., Skiftesvik, A.B., Browman, H.I., and Vikebø, F. (2021). The lunar compass of European glass eels (*Anguilla anguilla*) increases the probability that they recruit to North Sea coasts. *Fisheries Oceanography*, 30(3): pp. 315-330.

Cresci, A., Perrichon, P., Durif, C. M. F., Sørhus, E., Johnsen, E., Bjelland, R., Larsen, T., Skiftesvik, A. B., & Browman, H. I. (2022a). Magnetic fields generated by the DC cables of offshore wind farms have no effect on spatial distribution or swimming behavior of lesser sandeel larvae (*Ammodytes marinus*). *Marine Environmental Research*, 176.

Cresci, A., Durif, C. M. F., Larsen, T., Bjelland, R., Skiftesvik, A. B., & Browman, H. I. (2022b). Magnetic fields produced by subsea high-voltage direct current cables reduce swimming activity of haddock larvae (*Melanogrammus aeglefinus*). *PNAS Nexus*, 1(4).

Davidsen, J.G., Plantalech Manel-la, N., Økland, F., Diserud, O.H., Thorstad, E.B., Finstad, B., Sivertsgård, R., McKinley, R.S., and Rikardsen, A.H. (2008). Changes in swimming depths of Atlantic salmon *Salmo salar* post-smolts relative to light intensity. *Journal of Fish Biology*, 73(4): pp. 1065-1074.

Di Franco, E., Pierson, P., Di Iorio, L., Calò, A., Cottalorda, J.M., Derijard, B., Di Franco, A., Galvé, A., Guibbolini, M., Lebrun, J., and Micheli, F. (2020). Effects of marine noise pollution on Mediterranean fishes and invertebrates: A review. *Marine Pollution Bulletin*, 159: p. 111450.

Downie, H., Hanson, N., Smith, G.W., Middlemas, S.J., Anderson, J., Tulett, D., and Anderson, H. (2018). Using historic tag data to infer the geographic range of salmon river stocks likely to be taken by a coastal fishery. *Scottish Marine and Freshwater Science*, 9(20): 20 pp.

Eden Environment Ltd. (2017). *Allt Easach hydropower scheme: Potential interactions between electromagnetic fields (EMF) and migratory fish. Commissioned report to Green Highland Renewables Limited*.

Ellis, J., Dulvy, N., and Walls, R. (2015a). *Leucoraja naevus*. The IUCN Red List of Threatened Species 2015: e.T161626A48949434. Available at: https://dx.doi.org/10.2305/IUCN.UK.2015-1.RLTS.T161626A48949434.en. [Accessed April 2023].

Ellis, J., Dulvy, N., Walls, R., and Serena, F. (2016). *Raja clavata* (Europe assessment). The IUCN Red List of Threatened Species 2016: e.T39399A103111648. Available at: https://www.iucnredlist.org/species/39399/103111648. [Accessed April 2023].

Ellis, J., Farrell, E., Jung, A., McCully, S., Sims, D., and Soldo, A. (2015c). *Lamna nasus* (Europe assessment). The IUCN Red List of Threatened Species 2015: e.T11200A48916453. Available at: https://www.iucnredlist.org/species/11200/48916453. [Accessed April 2023].

Ellis, J., Ferretti, F., Soldo, A., and Walls, R. (2015f). *Alopias vulpinus* (Europe assessment). The IUCN Red List of Threatened Species 2015: e.T39339A48936583. Available at: https://www.iucnredlist.org/species/39339/48936583. [Accessed April 2023].

Ellis, J., McCully-Philipps, S.R., Sims, D., Derrick, D., Cheok, J., and Dulvy, N.K. (2021a). *Dipturus batis*. The IUCN Red List of Threatened Species 2021: e.T203364219A203375487. Available at: https://dx.doi.org/10.2305/IUCN.UK.2021-2.RLTS.T203364219A203375487.en. [Accessed: April 2023].

Ellis, J.R., McCully-Philipps, S.R., Sims, D., Walls, R.H.L., Cheok, J., Derrick, D., and Dulvy, N.K. (2021b). *Dipturus intermedius*. The IUCN Red List of Threatened Species 2021: e.T18903491A68783461. Available at: https://dx.doi.org/10.2305/IUCN.UK.2021-2.RLTS.T18903491A68783461.en. [Accessed April 2023].

Ellis, J.R., Milligan, S.P., Readdy, L., Taylor, N., and Brown, M.J. (2012). *Spawning and nursery grounds of selected fish species in UK waters. Science series Technical Report 147: 56 pp., Cefas, Lowestoft*.

Ellis, J., Serena, F., Mancusi, C., Haka, F., Morey, G., Guallart, J., and Schembri, T. (2015b). *Scyliorhinus stellaris* (Europe assessment). The IUCN Red List of Threatened Species 2015: e.T161484A48923567. Available at: https://www.iucnredlist.org/species/161484/48923567. [Accessed April 2023].

Ellis, J., Soldo, A., Dureuil, M., and Fordham, S. (2015e). *Squalus acanthias* (Europe assessment). The IUCN Red List of Threatened Species 2015: e.T91209505A48910866. Available at: https://www.iucnredlist.org/species/91209505/48910866. [Accessed April 2023].

Ellis, J.R., Walls, R.H.L., Serena, F., and Dulvy, N.K. (2015d). *Raja montagui* (Europe assessment). The IUCN Red List of Threatened Species 2015: e.T63146A48919726. Available at: https://www.iucnredlist.org/species/63146/48919726. [Accessed April 2023].

ERM, 2023. Dynamic cable EMF study for floating offshore wind programme, Environmental impacts of EMF. A report produced for Ørsted. Available upon request.

Essink, K. (1999). Ecological effects of dumping of dredged sediments; options for management. *Journal of Coastal Conservation*, 5: pp. 69-80.

Farrell, E.D., Dulvy, N.K., and Walls, R.H.L. (2015a). *Mustelus mustelus* (Europe assessment). The IUCN Red List of Threatened Species 2015: e.T39358A48940145. Available at: https://www.iucnredlist.org/species/39358/48940145. [Accessed April 2023].

Farrell, E., McCully, S., Dulvy, N., Mancusi, C., and Ellis, J. (2015b). *Mustelus asterias* (Europe assessment). The IUCN Red List of Threatened Species 2015: e.T39357A48940630. Available at: https://www.iucnredlist.org/species/39357/48940630. [Accessed April 2023].

Ferretti, F., and Buscher, E. (2015). *Echinorhinus brucus* (Europe assessment). The IUCN Red List of Threatened Species 2015: e.T41801A48909148. Available at: https://www.iucnredlist.org/species/41801/48909148. [Accessed April 2023].

Folk, R.L. (1954). The distinction between grain size and mineral composition in sedimentary-rock nomenclature. *The Journal of Geology*, 62(4): pp. 344-359.

Formicki, K. (1992). Respiratory Movements Of Trout (*Salmo trutta* L.) Larvae During Exposure To Magnetic Field. *Acta Ichthyologica et Piscatoria*.

Formicki, K., Korzelecka-Orkisz, A., & Tański, A. (2019). Magnetoreception in fish. *Journal of Fish Biology* (Vol. 95, Issue 1, pp. 73–91).

Formicki, K., and Winnicki, A. (1998). Reactions of fish embryos and larvae to constant magnetic fields. *Italian Journal of Zoology*, 65: pp. 479–482.

Franco, A., Smyth, K., and Thomson, S. (2023). Developing Essential Fish Habitat maps for fish and shellfish species in Scotland. *Report to the Scottish Government*.

Frost, M., and Diele, K. (2022). Essential spawning grounds of Scottish herring: current knowledge and future challenges. *Reviews in Fish Biology and Fisheries*, 32: pp. 721–744.

Gibson-Hall, E., Jackson, A., and Marshall, C. (2020). *Palinurus elephas* European spiny lobster. In Tyler-Walters, H., and Hiscock, K., (eds.) Marine Life Information Network: Biology and Sensitivity Key Information Reviews [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available at: https://www.marlin.ac.uk/species/detail/1145. [Accessed: June 2023].

Gill, A.B., Gloyne-Phillips, I., Neal, K.J. and Kimber, J.A., 2005. *The potential effects of electromagnetic fields generated by sub-sea power cables associated with offshore wind farm developments on electrically and magnetically sensitive marine organisms–a review*. COWRIE.

Gill, A.B. (2009). *EMF-sensitive fish response to EM emissions from sub-sea, electricity cables of the type used by the offshore renewable energy industry*. COWRIE.

Gillson, J.P., Bašić, T., Davison, P.I., Riley, W.D., Talks, L., Walker, A.M., and Russell, I.C. (2022). A review of marine stressors impacting Atlantic salmon *Salmo salar*, with an assessment of the major threats to English stocks. *Reviews in Fish Biology and Fisheries*, 32(3): pp. 879-919.

Glarou, M., Zrust, M., and Svendsen, J.C. (2020). Using artificial-reef knowledge to enhance the ecological function of offshore wind turbine foundations: Implications for fish abundance and diversity. *Journal of Marine Science and Engineering*, 8(5): p 332.

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

Gonzalez-Irusta, J.M., and Wright, P.J. (2016). Spawning grounds of Atlantic cod (*Gadus morhua*) in the North Sea. ICES Journal of Marine Science, 73(2): pp. 304-315.

Gonzalez-Irusta, J.M., and Wright, P.J. (2017a). Spawning grounds of haddock (*Melanogrammus aeglefinus*) in the North Sea and West of Scotland. *Fisheries Research*, 183: pp. 180-191.

Gonzalez-Irusta, J.M., and Wright, P.J. (2017b). Spawning grounds of whiting (*Merlangius merlangus*). Fisheries Research, 195: pp. 141-151.

Griffin, F.J., Smith, E.H., Vines, C.A., and Cherr, G.N. (2009). Impacts of suspended sediments on fertilization, embryonic development, and early larval life stages of the Pacific herring, *Clupea pallasi*. *The Biological Bulletin*, 216(2): pp. 175-187.

Griffiths, A.M., Sims, D.W., Cotterell, S.P., El Nagar, A., Ellis, J.R., Lynghammar, A., McHugh, M., Neat, F.C., Pade, N.G., Queiroz, N., Serra-Pereira, B., Rapp, T., Wearmouth, V.J., and Genner, M.J. (2010). Molecular markers reveal spatially segregated cryptic species in a critically endangered fish, the common skate (*Dipturus batis*). *Proceedings of the Royal Society B: Biological Sciences*, 277(1687): pp. 1497–1503.

Hansen, L.P., and Quinn, T.P., 1998. The marine phase of the Atlantic salmon (*Salmo salar*) life cycle, with comparisons to Pacific salmon. *Canadian Journal of Fisheries and Aquatic Sciences*, 55(S1): pp. 104-118.

Harding, H., Bruintjes, R., Radford, A.N., and Simpson, S.D. (2016). *Measurement of hearing in the Atlantic salmon (Salmo salar) using auditory evoked potentials, and effects of pile driving playback on salmon behaviour and physiology. A report for Marine Scotland Science*.

Hawkins, A.D., and Popper, A.N. (2017). A sound approach to assessing the impact of underwater noise on marine fishes and invertebrates. *ICES Journal of Marine Science*, 74(3): pp. 635-651.

Henley, W.F., Patterson, M.A., Neves, R.J., and Lemly, A.D. (2010). Effects of sedimentation and turbidity on lotic food webs: A concise review for natural resource managers. *Reviews in Fisheries Science*, 8: pp. 125-139.

Holm, M., Chr. Holst, J., Hansen, L.P. (2000). Spatial and temporal distribution of post-smolts of Atlantic salmon (*Salmo salar* L.) in the Norwegian Sea and adjacent areas. *ICES Journal of Marine Science*, 57(4): pp. 955-964.

Hutchison, Z., Sigray, P., & King, J. (2018). Electromagnetic Field (EMF) Impacts on Elasmobranch (shark, rays, and skates) and American Lobster Movement and Migration from Direct Current Cables. *BOEM*.

Hutchinson, Z.L., Gill, A.B., Sigray, P., He, H., and King, J.W. (2020). Anthropogenic electromagnetic fields (EMF) influence the behaviour of bottom-dwelling marine species. *Scientific Reports*, 10(1): p. 4219.

ICES Data Portal, 2023. *Dataset on bottom trawl surveys*. Available at: https://data.ices.dk [Accessed: August 2023]

Iglésias, S.P., Toulhoat, L., and Sellos, D.Y. (2010). Taxonomic confusion and market mislabelling of threatened skates: Important consequences for their conservation status. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 20(3): pp. 319–333.

JASCO. (2011). *HYWIND Acoustic Measurement Report, Jasco Report NO 00229*.

Kempster, R.M., and Collin, S.P. (2011). Electrosensory pore distribution and feeding in the basking shark *Cetorhinus maximus* (Lamniformes: Cetorhinidae). *Aquatic Biology*, 12(1): pp. 33-36.

Kilfoyle, A. K., Jermain, R. F., Dhanak, M. R., Huston, J. P., & Spieler, R. E. (2018). Effects of EMF emissions from undersea electric cables on coral reef fish. *Bioelectromagnetics*, 39(1), 35–52.

Kiørboe, T., Frantsen, E., Jensen, C., and Sørensen, G. (1981). Effects of suspended sediment on development and hatching of herring (*Clupea harengus*) eggs. *Estuarine, Coastal and Shelf Science*, 13(1): pp. 107-111.

Kulka, D.W., Sulikowski, J., Gedamke, J., Pasolini, P., and Endicott, M. (2015). *Amblyraja radiata* (Europe assessment). The IUCN Red List of Threatened Species 2015: e.T161542A48945123. Available at: https://www.iucnredlist.org/species/161542/48945123. [Accessed April 2023].

Langton, R., Boulcott, P., and Wright, P.J. (2021). A verified distribution model for the lesser sandeel *Ammodytes marinus*. *Marine Ecology Progress Series*, 667: pp. 145-159.

Leitão, F., Santos, M.N., Erzini, K., and Monteiro, C.C. (2008). The effect of predation in artificial reef juvenile demersal fish species, *Marine Biology*, 153: pp. 1233-1244.

Linley, E., Wilding, T., Black, K., Hawkins, S., and Mangi, S. (2007). *Review of the reef effects of offshore wind farm structures and their potential for enhancement and mitigation. Report from PML Applications Ltd and the Scottish Association from Marine Science to the Department for Business, Enterprise and Regulatory Reform (BERR), Contract No.: RFC/005/0029P.* Available at: http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk/files/file43528.pdf. [Accessed August 2023].

Lummer, E. M., Auerswald, K., and Geist, J. (2016). Fine sediment as environmental stressor affecting freshwater mussel behavior and ecosystem services. *Science of the Total Environment*, 571: pp. 1340-1348.

Malcolm, I.A., Godfrey, J., and Youngson, A.F. (2010). Review of migratory routes and behaviour of Atlantic salmon, sea trout and European eel in Scotland's coastal environment: Implications for the development of marine renewables. *Scottish marine and Freshwater Science*, 1(14): 72 pp.

McCully, S., Dureuil, M., and Farrell, E. (2015d). *Galeorhinus galeus* (Europe assessment). The IUCN Red List of Threatened Species 2015: e.T39352A48938136. Available at: https://www.iucnredlist.org/species/39352/48938136. [Accessed April 2023].

McCully, S., Ellis, J., Walls, R., and Fordham, S. (2015b). *Leucoraja circularis*. The IUCN Red List of Threatened Species 2015: e.T161464A48938919. Available at: https://dx.doi.org/10.2305/IUCN.UK.2015-1.RLTS.T161464A48938919.en. [Accessed April 2023].

McCully, S., Serena, F., Walls, R.H.L., Morey, G., and Ellis, J.R. (2015a). *Raja brachyura* (Europe assessment). The IUCN Red List of Threatened Species 2015: e.T161691A48907330. Available at: https://www.iucnredlist.org/species/161691/48907330. [Accessed April 2023].

McCully, S., and Walls, R. (2015c). *Leucoraja fullonica*. The IUCN Red List of Threatened Species 2015: e.T161461A48938639. Available at: https://dx.doi.org/10.2305/IUCN.UK.2015-1.RLTS.T161461A48938639.en. [Accessed April 2023].

McGeady, R., Loca, S.L., and McGonigle, C. (2022). Spatio-temporal dynamics of the common skate species complex: Evidence of increasing abundance. *Diversity and Distributions*, 28(11): pp. 2403-2415.

Mcilvenny, J., Youngson, A., Williamson, B.J., Gauld, N.R., Goddijn-Murphy, L., Del Villar-Guerra, D. (2021). Combining acoustic tracking and hydrodynamic modelling to study migratory behaviour of Atlantic salmon (*Salmo salar*) smolts on entry into high-energy coastal waters. *ICES Journal of Marine Science*, 78(7): pp. 2409-2419.

Marine Directorate. (2023). *Scotland's Marine Assessment 2020 Portal*. Available at: https://marine.gov.scot/sma/. [Accessed: June 2023].

Marine Directorate Maps NMPI. (2023). Available at: https://marinescotland.atkinsgeospatial.com/nmpi/default.aspx?availablelayers=1900. [Accessed August 2023].

MD-LOT (Marine Directorate - Licensing Operations Team), (2023). Scoping Opinion for Salamander Offshore Wind Farm.

Messieh, S.N., Wildish, D.J., and Peterson, R.H. (1981). Possible Impact from dredging and spoil disposal on the Miramichi Bay herring fishery. *Canadian Technical Report of Fisheries and Aquatic Sciences*, 1008: pp. 1-33.

Mickle, M.F., Miehls, S.M., Johnson, N.S., and Higgs, D.M. (2019). Hearing capabilities and behavioural response of sea lamprey (*Petromyzon marinus*) to low-frequency sounds. *Canadian Journal of Fisheries and Aquatic Sciences*, 76(9): pp. 1541-1548.

Marine Management Organisation (MMO). (2021). *UK fleet landings by rectangle and estimated EEZ 2016 2020*. Available at: https://www.gov.uk/government/statistics/uk-sea-fisheries-annual-statistics-report-2020. [Accessed: April 2023].

Marine Management Organisation (MMO). (2022). *UK Sea Fisheries Annual Statistics Report 2021*. Available at: https://www.gov.uk/government/statistics/uk-sea-fisheries-annual-statistics-report-2021. [Accessed: April 2023].

Moray Offshore Windfarm (West) Limited (Ltd). (2018). *Moray West Offshore Windfarm Offshore EIA Report, Chapter 1 Introduction*. Available at: https://marine.gov.scot/sites/default/files/00538033.pdf. [Accessed: July 2023].

Myrberg, A.A. (2001). *The acoustical biology of elasmobranchs. The behavior and sensory biology of elasmobranch fishes: an anthology in memory of Donald Richard Nelson*, pp. 31-46.

National Grid and Energinet. (2017). *Appendix I – Cable Heating Effects – Marine Ecological Report, Viking Link. Document No VKL-07-30-J800-016*.

NatureScot. (2023a). *SiteLink Map Search*. Available at: https://sitelink.nature.scot/map. [Accessed June 2023].

NatureScot. (2023b). *Flapper skate*. Available at: https://www.nature.scot/plants-animals-and-fungi/fish/sea-fish/flapper-skate. [Accessed: August 2023].

Neal, K.J., and Wilson, E. (2008). *Cancer pagurus* Edible crab. In Tyler-Walters, H., and Hiscock, K., (eds.) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available at: https://www.marlin.ac.uk/species/detail/1179. [Accessed: June 2023].

Nedwell, J.R., Langworthy, J., and Howell, D. (2003). *Assessment of subsea noise and vibration from offshore wind turbines and its impact on marine wildlife. Initial measurements of underwater noise during construction of offshore wind farms, and comparisons with background noise. Subacoustech Report No. 544R0423, published by COWRIE, May 2003.*

Ocean Infinity. (2022a). Salamander Offshore Floating Wind: Geophysical & environmental survey. Document ref. 104052-SBE-OI-SUR-REP-ENVSURRE.

Ocean Infinity (2022b). Salamander Offshore Floating Wind: Environmental Baseline Report. Document ref. 104052-SBE-OI-SUR-REP-ENVSURRE.

O'Reilly, M., Boyle, J., Nowacki, S., Elliott, M., and Foster, R. (2021). Monitoring Scotland's transitional water fish communities under the EU Water Framework Directive. *The Glasgow Naturalist*, 27(Part 3): pp. 48-67.

OSPAR. (2008). *OSPAR List of threatened and/or declining species and habitats. OSPAR Agreement 2008-06*. Available at: https://www.ospar.org/work-areas/bdc/species-habitats. [Accessed June 2023].

Ounsley, J.P., Gallego, A., Morris, D.J., and Armstrong, J.D. (2020). Regional variation in directed swimming by Atlantic salmon smolts leaving Scottish waters for their oceanic feeding grounds – A modelling study. *ICES Journal of Marine Science*, 77(1): pp. 315-325.

Parton, K. J., Galloway, T. S., and Godley, B. J. (2019). Global review of shark and ray entanglement in anthropogenic marine debris. *Endangered Species Research*, 39: pp. 173-190.

Piet, G. J., Tamis, J. E., Volwater, J., de Vries, P., van der Wal, J. T., and Jongbloed, R. H. (2021). A roadmap towards quantitative cumulative impact assessments: Every step of the way. *Science of the Total Environment*, 784: 146847.

Pineda, M.C., Strehlow, B., Sternel, M., Duckworth, A., Jones, R., and Webster, N.S. (2017). Effects of suspended sediments on the sponge holobiont with implications for dredging management. *Scientific Reports*, 7: pp. 4925.

Popper, A.N., Hawkins, A.D., Fay, R.R., Mann, D.A., Bartol, S., Carlson, T.J., Coombs, S., Ellison, W.T., Gentry, R.L., Halvorsen, M.B., Løkkeborg, S., Rogers, P.H., Southall, B.L., Zeddies, D.G., and Tavolga, W.N. (2014). *Sound exposure guidelines for Fishes and Sea Turtles. Springer International Publishing*.

Popper, A.N., and Hawkins, A.D. (2018). The importance of particle motion to fishes and invertebrates. *Journal of the Acoustical Society of America*, 143: pp. 470-488.

Popper, A.N., and Hawkins, A.D. (2019). An overview of fish bioacoustics and the impacts of anthropogenic sounds on fishes. *Journal of Fish Biology*, 94(5): pp. 692-713.

Potts, G.W., and Swaby, S.E. (1993). *Review of the status of estuarine fishes*. English Nature Research Report by the Marine Biological Association. Report 34, English Nature, Peterborough.

Quintella, B.R., Clemens, B.J., Sutton, T., Lança, M.J., Madenjian, C.P., Happel, A., and Harvey, C.J. (2021). At-sea feeding ecology of parasitic lampreys. *Journal of Great Lakes Research*, 47: pp. S72-S89.

Raoux, A., Tecchio, S., Pezy, J.P., Lassalle, G., Degraer, S., Wilhelmsson, D., Cachera, M., Ernande, B., Le Guen, C., Haraldsson, M., and Grangeré, K. (2017). Benthic and fish aggregation inside an offshore wind farm: which effects on the trophic web functioning? *Ecological Indicators*, 72: pp. 33-46.

Reach, I.S., Latto, P., Alexander, D., Armstrong, S., Backstrom, J., Beagley, E., Murphy, K., Piper, R., and Seiderer, L.J. (2013). *Screening spatial interactions between Marine Aggregate Application Areas and Atlantic herring potential spawning areas. A method statement produced for BMAPA*.

Reiss, H., Cunze, S., König, K., Neumann, H., and Kröncke, I. (2011). Species distribution modelling of marine benthos: A North Sea case study. *Marine Ecology Progress Series*, 442: pp. 71-86.

Reubens, J.T., Braeckman, U., Vanaverbeke, J., Van Colen, C., Degraer, S., and Vincx, M. (2013). Aggregation at windmill artificial reefs: CPUE of Atlantic cod (*Gadus morhua*) and pouting (*Trisopterus luscus*) at different habitats in the Belgian part of the North Sea. *Fisheries Research*, 139: pp. 28-34.

Richardson, K., Asmutis-Silvia, R., Drinkwin, J., Gilardi, K.V., Giskes, I., Jones, G., O'Brien, K., Pragnell-Raasch, H., Ludwig, L., Antonelis, K., and Barco, S. (2019). Building evidence around ghost gear: Global trends and analysis for sustainable solutions at scale. *Marine Pollution Bulletin*, 138: pp. 222-229.

Roach, M., Revill, A., and Johnson, M.J. (2022). Co-existence in practice: a collaborative study of the effects of the Westermost Rough offshore wind development on the size distribution and catch rates of a commercially important lobster (*Homarus gammarus*) population. *ICES Journal of Marine Science*, 79(4): pp. 1175-1186.

Rommel, Jr. S. A., & McCleave, J. D. (1973). Sensitivity of American Eels (*Anguilla rostrata*) and Atlantic Salmon (*Salmo salar*) to Weak Electric and Magnetic Fields. *Journal of the Fisheries Research Board of Canada*, 30(5), 657–663.

Rouse, S., Kafas, A., Catarino, R., and Hayes, P. (2017). Commercial fisheries interactions with oil and gas pipelines in the North Sea: considerations for decommissioning. *ICES Journal of Marine Science*, 75: pp. 279-286.

Sabatini, M., and Hill, J.M., 2008. *Nephrops norvegicus* Norway lobster. In Tyler-Walters, H., and Hiscock, K., (eds.) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available at: https://www.marlin.ac.uk/species/detail/1672. [Accessed: June 2023].

Scott, K., Harsanyi, P., & Lyndon, A. R. (2018). Understanding the effects of electromagnetic field emissions from Marine Renewable Energy Devices (MREDs) on the commercially important edible crab, *Cancer pagurus* (L.). *Marine Pollution Bulletin*, 131, 580–588.

Scott, K., Harsanyi, P., Easton, B.A.A., Piper, A.J.R., Rochas, C.M.V, and Lyndon, A.R. (2021). Exposure to electromagnetic fields (EMF) from submarine power cables can trigger strength -dependant behavioural and physiological responses in edible crab, *Cancer pagurus* (L.). *Journal of Marine Science and Engineering*, 9(7): p. 776.

Serena, F., Ellis, J., Abella, A., Mancusi, C., Haka, F., Guallart, J., Ungaro, N., Coelho, R.P., Schembri, T., and Kirsteen, M. (2015). *Scyliorhinus canicula* (Europe assessment). The IUCN Red List of Threatened Species 2015: e.T161307554A201955962. Available at: https://dx.doi.org/10.2305/IUCN.UK.2015-1.RLTS.T161307554A201955962.en. [Accessed April 2023].

Simply Blue Energy (Scotland) Ltd. (2023). Salamander Offshore Wind Farm, Environmental Impact Assessment Scoping Report. Available online at: https://marine.gov.scot/sites/default/files/salamander_offshore_wind_farm_-_scoping_report.pdf

Sims, D.W., and Quayle, V.A. (1998). Selective foraging behaviour of basking sharks on zooplankton in a small-scale front. *Nature*, 393(6684): pp. 460-464.

Szostek, C.L., Davies, A.J., and Hinz, H. (2013). Effects of elevated levels of suspended particulate matter and burial on juvenile king scallops *Pecten maximus*. *Marine Ecology Progress Series*, 474: pp. 155-165.

Taormina, B., di Poi, C., Agnalt, A. L., Carlier, A., Desroy, N., Escobar-Lux, R. H., D'eu, J. F., Freytet, F., & Durif, C. M. F. (2020). Impact of magnetic fields generated by AC/DC submarine power cables on the behavior of juvenile European lobster (*Homarus gammarus*). *Aquatic Toxicology*, 220.

The Shark Trust. (2020a). *Blonde ray ID Guide*. Available at: https://www.sharktrust.org/Handlers/Download.ashx?IDMF=df92967e-b3bc-4885-b26f-9a7479584e7c. [Accessed June 2023].

The Shark Trust. (2020b). *Bluntnose Sixgill Shark ID Guide*. Available at: https://www.sharktrust.org/Handlers/Download.ashx?IDMF=d09467e3-5f23-4dec-9ba3-955271fdb24e. [Accessed June 2023].

The Shark Trust. (2020c). *Bramble Shark ID Guide*. Available at: https://www.sharktrust.org/Handlers/Download.ashx?IDMF=4d13cdbe-1a61-493c-b06a-2b70d1d94f8a. [Accessed June 2023].

The Shark Trust. (2020d). *Cuckoo Ray ID Guide*. Available at: https://www.sharktrust.org/Handlers/Download.ashx?IDMF=d2ca34d3-4481-420f-b620-366719f9d563. [Accessed June 2023].

The Shark Trust. (2020e). *Nursehound ID Guide*. Available at: https://www.sharktrust.org/Handlers/Download.ashx?IDMF=0ecdd887-60c9-4a8f-954d-235338ffa164. [Accessed June 2023].

The Shark Trust. (2020f). *Sandy Ray ID Guide*. Available at: https://www.sharktrust.org/Handlers/Download.ashx?IDMF=8eeb6d3a-7fb5-40d4-8dd3-ba2ccacd1b05. [Accessed June 2023].

The Shark Trust. (2020g). *Shagreen Ray ID Guide*. Available at: https://www.sharktrust.org/Handlers/Download.ashx?IDMF=b5af35ac-99fc-46d0-9b84-b5080f6fef98. [Accessed June 2023].

The Shark Trust. (2020h). *Smallspotted Catshark ID Guide*. Available at: https://www.sharktrust.org/Handlers/Download.ashx?IDMF=cc234aa2-cf8b-4248-873f-79a44fa2ea31. [Accessed June 2023].

The Shark Trust. (2020i). *Common Smoothhound ID Guide*. Available at: https://www.sharktrust.org/Handlers/Download.ashx?IDMF=281e2453-681d-4fe0-9501-fb9bc330c97f. [Accessed June 2023].

The Shark Trust. (2020j). *Spotted Ray ID Guide*. Available at: https://www.sharktrust.org/Handlers/Download.ashx?IDMF=4eb4e625-a810-4bd2-a4c2-7e3952737636. [Accessed June 2023].

The Shark Trust. (2020k). *Spurdog ID Guide*. Available at: https://www.sharktrust.org/Handlers/Download.ashx?IDMF=cce86e24-1b64-4eca-9e0b-9f1965a2f0cf. [Accessed June 2023].

The Shark Trust. (2020l). *Starry Smoothhound ID Guide*. Available at: https://www.sharktrust.org/Handlers/Download.ashx?IDMF=2517625e-dbf8-4a12-a5e5-a14640c31481. [Accessed June 2023].

The Shark Trust. (2020m). *Thornback Ray ID Guide*. Available at: https://www.sharktrust.org/Handlers/Download.ashx?IDMF=4f547cf2-f728-4b4b-83df-adcfcc3b21f1. [Accessed June 2023].

The Shark Trust. (2020n). *Thresher Shark ID Guide*. Available at: https://www.sharktrust.org/Handlers/Download.ashx?IDMF=af4be2e5-2c36-43de-812c-c327d529bf24. [Accessed June 2023].

The Shark Trust. (2020o). *Tope ID Guide*. Available at: https://www.sharktrust.org/Handlers/Download.ashx?IDMF=e9e5cd0c-8b66-49c3-8028-a51db49c2ddb. [Accessed June 2023].

Thorburn, J., Lavender, E., Cole, G., Smout, S., and James, M. (2022). *Movement ecology of the Flapper Skate. A report for the Coastal Resource Management Group, University of St Andrews*.

Tougaard, J., Hermannsen, L., Madsen, P.T. (2020). How loud is the underwater noise from operating offshore wind turbines? *Journal of the Acoustic Society of America*, 148(5): pp. 2885-2893.

Tyler-Walters, H., James, B., Carruthers, M. (eds.), Wilding, C., Durkin, O., Lacey, C., Philpott, E., Adams, L., Chaniotis, P.D., Wilkes, P.T.V., Seeley, R., Neilly, M., Dargie, J., and Crawford-Avis, O.T. (2016). *Descriptions of Scottish Priority Marine Features (PMFs). Scottish Natural Heritage Commissioned Report No. 406*, 140 pp.

Tyler-Walters, H., Tillin, H.M., d'Avack, E.A.S., Perry, F., and Stamp, T., 2018. Marine Evidence-based Sensitivity Assessment (MarESA) – A Guide. Marine Life Information Network (MarLIN). Marine Biological Association of the UK, Plymouth, pp. 91.

UK Research and Innovation (UKRI). (2024). *Aggregation, production and spillover: the cumulative effect of man-made offshore structures on fish*. Available at: https://gtr.ukri.org/projects?ref=NE%2FT010681%2F1. [Accessed January 2024].

Utne-Palm, A.C. (2004). Effects of larvae ontogeny, turbidity, and turbulence on prey attack rate and swimming activity of Atlantic herring larvae. *Journal of Experimental Marine Biology and Ecology*, 310(2): pp. 147-161.

Walker, M. M. (1984). Learned magnetic field discrimination in yellowfin tuna, *Thunnus albacares*.

Walls, R., Soldo, A., Bariche, M., Buscher, E., Cook, S.F., and Compagno, L.J.V. (2015). *Hexanchus griseus* (Europe assessment). The IUCN Red List of Threatened Species 2015: e.T10030A48939463. Available at: https://www.iucnredlist.org/species/152781341/187313779. [Accessed April 2023].

Westerberg, H., Rännbäek, P., and Frimansson, H. (1996). *Effects of suspended sediments on cod egg and larvae and on the behaviour of adult herring and cod. ICES Report: CM 19961/E*, p. 26.

Westerberg, H., and Lagenfelt, I. (2008). Sub-sea power cables and the migration behaviour of the European eel. *Fisheries Management and Ecology*, 15(5-6): pp. 369-375.

Wilhelmsson, D., Malm, T., and Öhman, M.C. (2006). The influence of offshore windpower on demersal fish. *ICES Journal of Marine Science*, 63: pp. 775-784.

Woodruff, D. L., Ward, J. A., Schultz, I. R., Cullinan, V. I., and Marshall, K. E. (2012). PNNL-20813 Final Effects of Electromagnetic Fields on Fish and Invertebrates Task 2.1.3: Effects on Aquatic Organisms Fiscal Year 2011 Progress Report Environmental Effects of Marine and Hydrokinetic Energy.

Wright, S. R., Lynam, C. P., Righton, D. A., Metcalfe, J., Hunter, E., Riley, A., Garcia, L., Posen, P., and Hyder, K. (2020). Structure in a sea of sand: fish abundance in relation to man-made structures in the North Sea. *ICES Journal of Marine Science*, 77: pp. 1206–1218.