Salamander Offshore Wind Farm

Offshore EIA Report

Volume ER.A.3, Chapter 11: Marine Mammals

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 Salamander Project 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 Salamander Project.
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 Salamander Project for Environmental Impact Assessment (EIA) purposes when the exact engineering parameters are not yet known.
Energy Balancing Infrastructure (EBI)	Energy Balancing Infrastructure which will provide services to the electrical grid, such as storing energy to meet periods of peak demand and improving overall reliability, as well as additional services such as system monitoring and computing. EBI will be housed within buildings and / or containers will be co-located with the Onshore Substation.
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 likely 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 Town and Country Planning (EIA) (Scotland) Regulations 2017.

Term	Definition
Impact	An impact is considered to be the change to the baseline as a result of an activity or event related to the Salamander Project. 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 corridor 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, 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 (MHWS).
Permanent Threshold Shift (PTS)	Permanent threshold shift (or PTS) is a permanent increase in the threshold of hearing (minimum intensity needed to hear a sound) at a specific frequency above a previously established reference level.
Project Lifetime Effects	Project lifetime effects are considered to be effects that occur throughout more than one phase of the Salamander Project, (construction, operation, and decommissioning) to interact to potentially create a more significant effect on a receptor, than if just assessed in isolation in the three key project stages (e.g. construction, operation and decommissioning).
Receptor (Offshore)	Any physical, biological or anthropogenic element of the environment that may be affected or impacted by the Offshore Development. Receptors can include

Term	Definition
	natural features such as the seabed and wildlife habitats as well as man-made features like fishing vessels and cultural heritage sites.
Receptor-led Effects	Receptor-led effects involve spatially or temporal interaction of effects, to create inter related effects on a receptor or receptor group. Receptor-led effects might be short term, temporary or transient effects, or incorporate longer term effects.
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 impacts 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.
Sound Exposure Level (SEL)	The decibel level of the time integral (summation) of the squared pressure over the duration of a sound event; units of dB re 1 μPa^2/s.
Sound Pressure Level (SPL)	A means of characterising the amplitude of a sound. There are several ways sound pressure can be measured. The most common of these are the root-mean-square (RMS) pressure, the peak pressure, and the peak-to-peak pressure.
Temporary Threshold Shift (TTS)	Temporary threshold shift (or TTS) is a temporary increase in the threshold of hearing (minimum intensity needed to hear a sound) at a specific frequency above a previously established reference level.
Threshold of Hearing	The minimum intensity at which a sound of a specific frequency is reliably detected i.e., by marine mammals, in absolute quiet conditions. The intensity level (of the sound detected, measured in decibels (dB)) varies with frequency.
Wind Turbine Generator	All the components of a wind turbine, including the tower, nacelle, and rotor.

Acronyms

Term	Definition
ADD	Acoustic Deterrent Device

Term	Definition
BND	Bottlenose dolphin
CEA	Cumulative Effect Assessment
CES MU	Coastal East Scotland Management Unit
DEB	Dynamic Energy Budget
DEFRA	Department for Environment, Food and Rural Affairs
DEPONS	Disturbance Effect on Harbour Porpoise in the North Sea
DP	Dynamic Positioning
ECC	Export Cable Corridor
EDR	Effective Deterrence Range
EEA	European Economic Area
EEZ	Exclusive Economic Zone
EIA	Environment Impact Assessment
EIAR	Environment Impact Assessment Report
EMF	Electromagnetic Field
EPS	European Protected Species
EQT	Effective Quiet Threshold
GNS MU	Greater North Sea Management Unit
GS	Grey Seal
HF	High Frequency
HP	Harbour Porpoise
HRA	Habitats Regulations Appraisal
HS	Harbour Seal
IAMMWG	Inter-Agency Marine Mammal Working Group

Term	Definition
iPCoD	Interim Population Consequences of Disturbance Model
JNCC	Joint Nature Conservation Committee
JV	Joint Venture
kJ	Kilojoules
km	Kilometres
LF	Low Frequency
MHWS	Mean High Water Spring
MMMP	Marine Mammal Mitigation Protocol
MPA	Marine Protected Area
MU	Management Unit
MW	Mega Watt
NMFS	National Marine Fisheries Centre
OAA	Offshore Array Area
OWF	Offshore Wind Farm
PCW	Phocid Carnivore in Water
PEIR	Preliminary Environmental Information Report
PTS	Permanent Threshold Shift
SAC	Special Area of Conservation
SCANS	Small Cetaceans in European Atlantic waters and the North Sea
SCOS	Special Committee on Seals
SEL	Sound Exposure Level
SMRU	Sea Mammal Research Unit

Term	Definition
SMU	Seal Management Unit
SPL	Sound Pressure Level
SWPC	Salamander Wind Project Company Limited (formerly called SBES)
TTS	Temporary Threshold Shift
UXO	Unexploded Ordnance
VHF	Very High Frequency
VMP	Vessel Management Plan
WTG	Wind Turbine Generator

11 Marine Mammals

11.1 Introduction

11.1.1.1 The Applicant, Salamander Wind Project Company Limited (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 kilometres (km) east of Peterhead. It will consist of both offshore and onshore infrastructure, including an offshore generating station (wind farm), export cables to landfall, and connection to the electricity transmission network (please see **Volume ER.A.2, Chapter 4: Project Description** for full details on the Salamander Project Design).

11.1.1.2 This chapter of the Environmental Impact Assessment Report (EIAR) presents the results of the EIA of potential effects of the Salamander Project on Marine Mammals. Specifically, this chapter considers the potential impact of the 'Offshore Development' associated with the Salamander Project, which includes all offshore components (i.e. seaward of Mean High Water Springs, MHWS) of the Salamander Project (wind turbine generators (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.

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

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

- Marine Mammal Baseline Characterisation: **Volume ER.A.4, Annex 11.1: Marine Mammal Baseline Report**
- Underwater Noise Assessment: **Volume ER.A.4, Annex 4.1: Underwater Noise Modelling Report**
- Digital video aerial surveys of seabirds and marine mammals at Salamander: **Volume ER.A.4, Annex 12.1: Offshore Ornithology Baseline Data Report**

11.1.1.5 This chapter has been authored by SMRU Consulting Ltd. Subacoustech Environmental Ltd have supplied the underwater noise modelling data to this chapter. Further competency details of the authors of this chapter are outlined in **Volume ER.A.4, Annex 1.1: Project Team Annex.**

11.2 Purpose

11.2.1.1 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.

11.2.1.2 The EIAR has been finalised following the completion of the pre-application consultation **Volume RP.A.4, Report 1: 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.

11.2.1.3 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 Offshore Development on Marine Mammal 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.

11.3 Planning and Policy Context

11.3.1.1 The preparation of the Marine Mammal Chapter has been informed by the following policy, legislation, and guidance outlined in **Table 11-1**.

Table 11-1 Relevant policy, legislation and guidance relevant to the Marine Mammal assessment

Relevant policy, legislation, and guidance
Policy
Scotland's Biodiversity: a route map to 2020 (Scottish Government 2015b)
Scottish Biodiversity Strategy (Scottish Government 2022)
Scotland's National Marine Plan (Scottish Government 2015a)
National Planning Framework 4 (NPF4) (Scottish Government 2023)
Legislation
The Marine Works (Environmental Impact Assessment) (Scotland) Regulations 2017
Marine (Scotland) Act 2010
Marine and Coastal Access Act 2009
Wildlife and Countryside Act 1981 (WCA)
Nature Conservation (Scotland) Act 2004
Protection of Seals (Designation of Haul-out Sites) (Scotland) Order 2014 and Amendment Order 2017
Wildlife and Natural Environment (Scotland) Act 2011
The Conservation of Habitats and Species Regulations 2017
The Conservation of Offshore Marine Habitats and Species Regulations 2017
The Conservation (Natural Habitats &c.) Regulations 1994

Relevant policy, legislation, and guidance
The Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019
Guidance
Scottish Priority Marine Features (PMFs), as described in Scottish Natural Heritage (now NatureScot) Commissioned Report 406 (Tyler-Walters *et al.* 2016)
The UK Post-2010 Biodiversity Framework and the Scottish Biodiversity Strategy: Revised Implementation Plan (2018-2020) (JNCC 2018)
Marine environment: unexploded ordnance clearance joint interim position statement (DEFRA *et al.* 2021)
Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects (Southall *et al.* 2019)
Environmental Impact Assessment Handbook (NatureScot 2018)
Scottish Marine Wildlife Watching Code (NatureScot (formerly Scottish Natural Heritgate (SNH), (2017)
The protection of Marine European Protected Species from injury and disturbance: Guidance for Inshore Waters (July 2020 Version) (Marine Scotland (now Marine Directorate), 2020)
JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys (seismic survey guidelines) (JNCC 2017)
JNCC guidelines for minimising the risk of disturbance and injury to marine mammals whilst using explosives (JNCC 2010a)
Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise (JNCC 2010b)
Guidance on the Offence of Harassment at Seal Haul-out Sites (Marine Scotland (now Marine Directorate), 2014)

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

11.4 Consultation

11.4.1.1 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.

11.4.1.2 An overview of the Salamander Project consultation process is outlined in **Volume ER.A.2, Chapter 5: Stakeholder Consultation**. Consultation regarding Marine Mammals has been conducted through the EIA scoping process and associated Scoping Workshops.

11.4.1.3 The issues raised during consultation specific to Marine Mammals are outlined in **Table 11-2**, including consideration of where the issues have been addressed within the EIAR.

Table 11-2 Consultation Responses Specific to Marine Mammals

Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
NatureScot	21 June 2023; comments on EIA Scoping Report	Appendix B – Marine mammal Impact Assessment Marine mammal interests are considered in Section 8.3 of the Scoping Report and we have responded to the questions raised in the Scoping Report within our advice below. Our advice with respect to the Salamander Offshore Wind Farm Habitats Regulations Appraisal (HRA) Stage 1 Screening Report is also provided below.	This is noted.
		Study Area – We are content with the marine mammal Study Area as described in Section 8.3.4 of the Scoping Report.	This is noted.
		Scoping Report Baseline Characterisation – Section 8.3.2 correctly identifies the relevant legislation, policy and guidance for marine mammal interests. Table 8-9 captures most of the relevant baseline datasets, but we note the table mentions Wilson *et al.* (1999) for the bottlenose dolphin estimates (although the link is the correct one) – the reference should be Hammond *et al.* (2021). In addition, (Arso Civil *et al.*) (interim report) should be updated to Arso Civil *et al.* (2021) (final report). As noted in the Scoping Report, the SCANS-IV report is expected in 2023 and we agree this should be considered, if available within the timeframe for application.	References updated as suggested. SCANS IV was not available at the time of writing. See: **Volume ER.A.4, Annex 11.1: Marine Mammal Baseline Report,** and **Section 11.7.**
		Scoping Report Baseline Characterisation – Section 8.3.5.1 lists a number of species to be scoped in to be assessed quantitatively and qualitatively. Due to an increase in sightings of humpback whale on the	Humpback whales are considered in the baseline. See: **Volume .ER.A.4, Annex 11.1: Marine Mammal Baseline Report**. No

Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
		east coast of Scotland in recent years, we advise that this species should also be qualitatively assessed.	abundance or density data are available to include humpback whales quantitatively.
		We broadly agree with the impacts that are proposed to be scoped in and out of the assessment as detailed in Table 8-11 subject to the following advice.	This is noted.
		Potential Impacts – Noise-related impacts have been scoped in for assessment but only for the construction and decommissioning phases. We advise that consideration should also be given to potential impacts from operational noise.	Operational noise has been assessed in **Section 11.14.**
		Potential Impacts – In addition, there is the potential for electromagnetic field (EMF) impacts from dynamic cables, therefore this should be scoped in for assessment. Whilst there is limited information available around the potential interaction between marine mammals, prey species and EMF from buried cables, there is an absence of information on potential interactions from these species and EMF from dynamic cables.	The impact of EMF on marine mammal prey species has been assessed in **Volume ER.A.3, Chapter 10: Fish and Shellfish Ecology**. Subsequent indirect impacts on marine mammals have been assessed in S**ection 11.14, from paragraph 11.14.6.1**.
		Approach to Assessment – We are generally content with the approach to assessment as detailed in Section 8.3.10. The dose-response curve will be used to assess disturbance and we agree with this approach. However, we recommend that Graham *et al.* (2019) should be considered as well as Graham *et al.* (2017b) in relation to this.	The Graham *et al.* (2019) dose-response function is audiogram-weighted for harbour porpoise and therefore is not transferable to other cetacean species. The Graham *et al.* (2017b) dose-response function, being based on the first few piling events at Beatrice Offshore Wind Farm and unweighted SEL noise levels, is considered to be the more precautionary of the two and transferable to other species and is therefore used in this assessment. See **Section 11.13.**

Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
		Approach to Assessment – It is also noted that underwater noise modelling is proposed for unexploded ordnance (UXO) clearance. We would like to highlight the joint interim position statement on UXO (DEFRA *et al.* 2021). Our preference is to see the use of deflagration as a removal technique and there is currently a deflagration campaign ongoing in Scottish waters. However, in the absence of the outcomes of this campaign, we advise that currently, both high order and low order clearance should be modelled to ensure the realistic worst case scenario is assessed.	The assessment of UXO clearance assumes that low-order deflagration is the primary method; however, in line with the joint interim position statement (DEFRA *et al.* 2021), high-order clearance has been presented as a realistic worst case scenario. See **Section 11.13** and **Volume ER.A.2, Chapter 4: Project Description.** It should be noted that 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.
		Cumulative impacts – The cumulative effects assessment approach as detailed in Section 8.3.8 and we recommend and welcome the use of the CEF.	The CEF project had not been completed at the time of authoring this EIA chapter and thus has not been used for the purpose of the cumulative effects assessment.
		Mitigation and monitoring – We are generally content with the embedded mitigation measures as per Table 8.3.6 along with the commitment for additional mitigation measures if required. In relation to the guidance listed in the table for informing the Marine Mammal Mitigation Protocols for pile driving, geophysical surveys and UXO clearance – the JNCC 2010 explosives guidance is incorrectly referenced. This should be the 2021 JNCC guidance – we note this is correctly listed in Section 8.3.2.3.	The Applicant confirms that explosives guidance is the most recent and correct document. It should be noted however, that the JNCC 2021 advice referred to is a UK Gov joint agency interim position statement on UXO clearance, particularly relating to the preference for low-order alternatives, and not guidance on mitigation.

Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
		As detailed in our advice above there is a lack of information on potential impacts of EMF from dynamic cables. Therefore, we encourage consideration of collaborating and contributing to monitoring of EMF impacts from dynamic cables as well as monitoring of entanglement with dynamic cables and mooring systems.	Existing evidence suggests that the levels of EMFs emitted by offshore renewable energy export cables are at a level low enough that there is no potential for direct significant impacts on marine mammals (Copping and Hemery, 2020). Given that marine mammals are known to closely associate with offshore wind farm structures (Scheidat *et al.*, 2011, Russell *et al.*, 2014), it is predicted that the magnitude and vulnerability score for this impact would be negligible. However, potential EMF impacts on prey species may impact foraging success for marine mammals. The scale of the indirect impact to marine mammals will be informed by the assessment presented in **Volume ER.A.3, Chapter 10: Fish and Shellfish Ecology** for impacts of EMF on fish species. 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 marine mammal and ornithological entanglement risk and appropriate actions to remove will be taken if deemed necessary (see **Section 11.11**).
		Transboundary / cross border impacts – Consideration may need to be given to transboundary and cross border impacts for certain cetacean species, but not for seal species due to existing marine mammal management units. Once initial impact assessment has been carried out we can provide further advice on this aspect.	Transboundary effects have been assessed in **Section 11.20.**

Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
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.	As noted in the Salamander EIA Scoping Report (SBES, 2023), basking shark and turtles are scoped out of the assessment due to a lack of occurrence in the Offshore Development Area. It is noted that certain embedded mitigation associated with entanglement risk and vessel collisions is of universal benefit to marine megafauna such as basking sharks and turtles. With regard to procedures for minimising risk of injury to marine mammals from UXO clearance, piling or geophysical survey, and their possible extension to any basking sharks or sea turtles present, NatureScot's comments are noted and will be considered through subsequent wildlife licensing processes and development of mitigation plans for UXO clearance and piling.
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 the	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, a SWPC project owner is an official member of the TS-FLOW UK-North Joint Industry Project (JIP) exploring the challenges of wet storage

Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
		intention to seek a separate marine licence application for any requirements for wet storage outwith the array area.	and identifying the opportunities and potentially suitable locations for these 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.
MD-LOT	21 June 2023; Scoping Opinion	The Scottish Ministers are content with the Study Area described in Section 8.3.4 of the Scoping Report.	This is noted.
		With regard to the baseline information included in Table 8-9, the Scottish Ministers highlight the NatureScot representation regarding the dataset references and advise that the recommendation must be fully implemented. The Scottish Ministers also agree with NatureScot that humpback whale should be qualitatively assessed as part of the scoping report and advise this must be included.	References updated as suggested by NatureScot. Humpback whales have been considered in the baseline. See: **Volume ER.A.4, Annex 11.1: Marine Mammal Baseline Report.** No abundance or density data are available to include humpback whales quantitatively.
		The Scottish Ministers broadly agree with the impacts to be scoped in and out as detailed in Table 8-11, however the NatureScot representation with regard to both operational noise and EMF impacts from dynamic cables must be fully addressed and included in the EIA Report.	Operational noise has been assessed in **Section 11.14**. The impact of EMF on marine mammal prey species has been assessed in **Volume ER.A.3, Chapter 10: Fish and Shellfish Ecology**. Subsequent indirect impacts on marine mammals have been assessed in S**ection 11.14, from paragraph 11.14.6.1.**
		The Scottish Ministers are generally content with the approach to assessment as detailed in Section 8.3.10, however highlight the NatureScot comments regarding dose-response curve information sources used and the joint interim position statement on UXO. Scottish	"The Graham et al. (2019) dose-response function is audiogram-weighted for harbour porpoise and therefore is not transferable to other cetacean species. The Graham et al. (2017b) dose-response function, being based on the first few piling events at Beatrice and unweighted SEL noise levels, is considered to be the

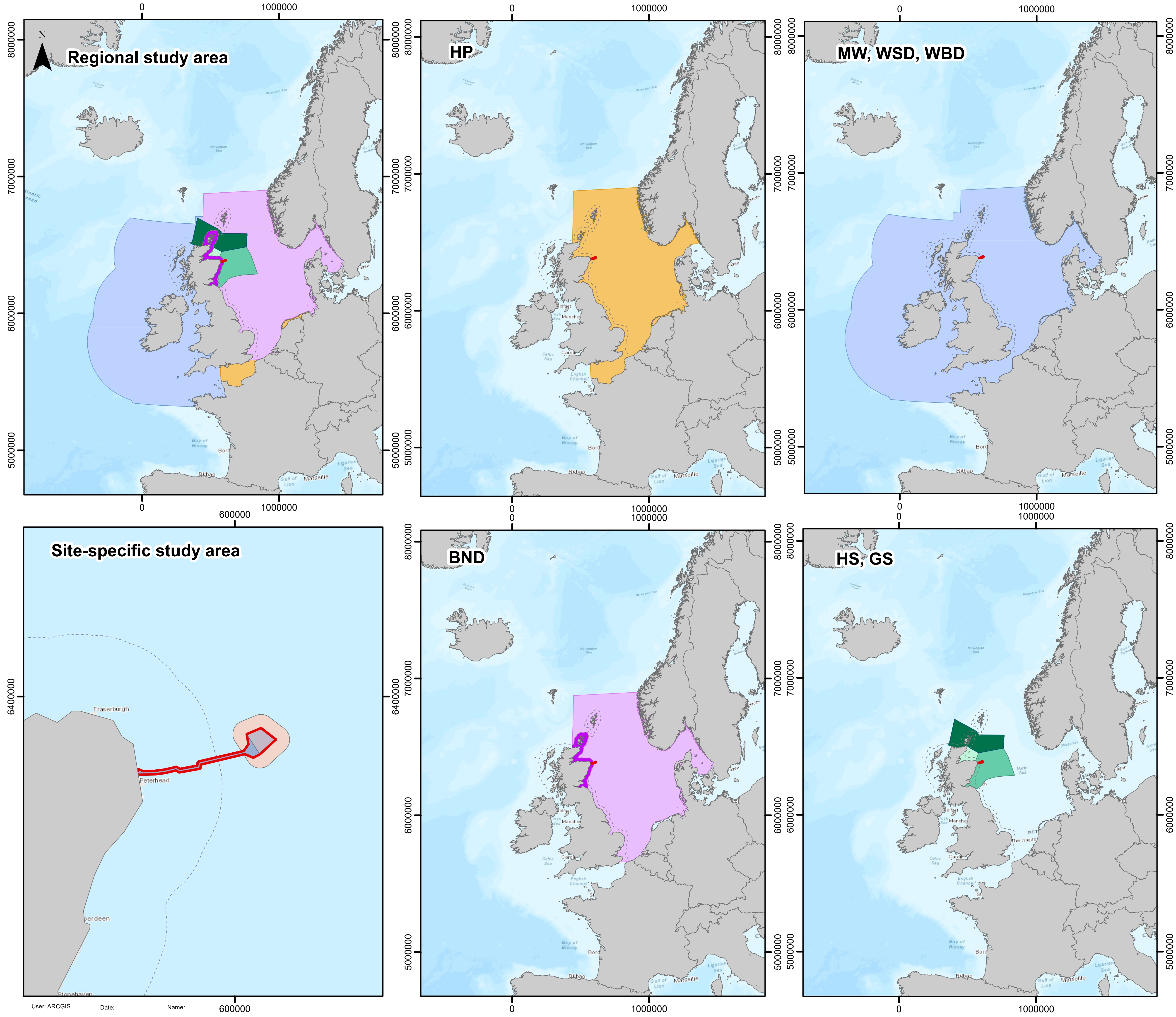
Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
		Ministers advise that the NatureScot representation on this should be fully considered and implemented.	more precautionary of the two and transferable to other species and is therefore used in this assessment. The assessment of UXO clearance assumes that low-order deflagration is the primary method, however in line with the joint interim position statement (DEFRA et al. 2021), high-order clearance has been presented as a realistic worst case scenario. See **Section 11.13: Impact Assessment**
		The Scottish Ministers are content with the embedded mitigation measures included in Table 8.3.6 and the commitment for additional mitigation measures if required. The Scottish Ministers do however highlight NatureScot representation with regard to the guidance listed and also collaboration and contributing to monitoring of EMF impacts from dynamic cables as well as monitoring of entanglement with dynamic cables and mooring systems and advise this should be fully considered by the developer.	See responses to NatureScot comments above relating to guidance. See **Volume ER.A.3, Chapter 10: Fish and Shellfish Ecology** for impacts of EMF on fish species. 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 (see **Section 11.11**).
		In relation to transboundary impacts, the Scottish Ministers agree with NatureScot representation regarding consideration for cross border impacts for certain cetacean species and advise the details of the NatureScot representation should be fully considered in the EIA Report.	Transboundary effects are assessed in **Section 11.20.**
		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	See responses to NatureScot comments above relating to basking sharks and turtles.

Consultee	Date and Forum	Comment	Where it is addressed within this EIAR
		report. The Scottish Ministers are content with this approach however advise that NatureScot recommendations regarding mitigation must be fully implemented as required.	

11.5 Study Area

11.5.1.1 The Marine Mammal Study Area varies depending on the species, considering individual species ecology and behaviour. For all species, the Study Area covers the Offshore Array Area and Offshore ECC (together referred to as the 'Offshore Development Area') and is extended over an appropriate area considering the scale of movement and population structure for each species. For each species, the area considered in the assessment is largely defined by the appropriate Management Unit (MU) (IAMMWG 2023). The Study Area for marine mammals has been defined at two spatial scales; the MU scale for species-specific population units and the marine mammal site-specific survey area (**Figure 11-1**) (see **Volume ER.A.4, Annex 11.1: Marine Mammals Baseline Report** for more details). In **Figure 11-1**, the following species are represented: harbour porpoise (HP), minke whale (MW), white-beaked dolphin (WBD), white-sided dolphin (WSD), bottlenose dolphin (BD), harbour seal (HS), and grey seal (GS). The inset shows detail of Offshore Development Area relative to Coastal East Scotland MU for bottlenose dolphin.

11.5.1.2 Details specifically on the Marine Mammal site-specific survey are provided in **Section 11.6.1**

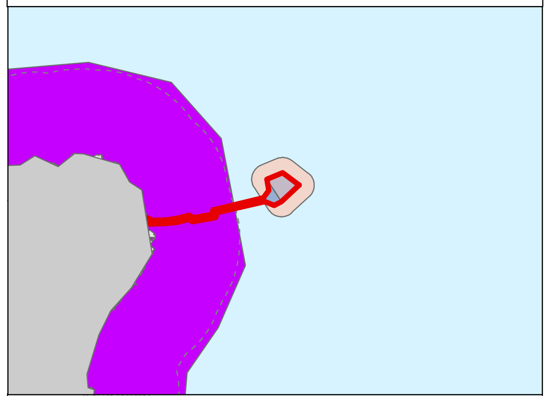


Salamander

Figure 11-1
Marine mammal study area and management units

Legend

- Offshore Development Area
- Offshore Array Area
- Offshore Export Cable Corridor
- Indicative Onshore development area
- 12 nm limit
- 4 km DAS buffer
- North Coast and Orkney MU
- East Coast Scotland MU
- Moray Firth MU
- Coastal East Scotland MU
- Greater North Sea MU
- North Sea MU
- Celtic and Greater North Sea MU



Coordinate System: WGS 1984 UTM Zone 30N

Scale @ A4 : 2,000,000

0 275 550 1,100 Kilometers

0 140 280 560 Nautical Miles

Rev	Description	Date
01	Final	03/04/2024
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Doc. Title : ER.A.3.11-Marine Mammals (08435483_A)
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Created by : JC
Checked by : AB
Approved by : AB

11.6 Methodology to Inform Baseline

11.6.1 Site-specific Surveys

11.6.1.1 The site-specific baseline characterisation surveys for the Offshore Development Area consisted of monthly digital video aerial surveys conducted by HiDef Aerial Surveying Limited (HiDef) from March 2021 to February 2023. The aim of the surveys was to collect data on the abundance and distribution of birds and marine mammals to characterise the baseline environment.

11.6.1.2 The digital ariel survey (DAS) design consisted of 2 km-spaced transects across the original Salamander Area of Search (AoS), from which the OAA[1] was selected, and a 4 km buffer. The original AoS (133.38 km²) and 4 km buffer, together referred to as the 'DAS Area', had a total area of 371.93 km² (**Figure 11-1**). Therefore, the spatial extent of the DAS Area is larger than the OAA. Aircraft were flown at a height of 550 m along transects of variable length with 2 km spacing. The survey design consisted of 13 strip transects providing a coverage of approximately 25% of the survey area across the total of four cameras deployed on the aircraft, of which two were analysed to provide 12.5% analysed coverage of the survey area. Data collected were 2 cm Ground Sampling Distance (GSD) digital video with a combined sampled width of 500 m within a 575 m overall strip width. Relative density estimates were reported for most marine mammal species sighted, with absolute density estimates reported for harbour porpoise using the availability correction estimates presented in Teilmann *et al.* (2013) (see **Volume ER.A.4, Annex 11.1: Marine Mammal Baseline Report**).

11.6.2 Data Sources

11.6.2.1 The data sources that have been used to inform this Marine Mammal chapter of the EIAR are presented within **Table 11-3**.

Table 11-3 Summary of key available datasets for Marine Mammals

Source	Year	Spatial Coverage	Summary
Regional Baselines for Marine Mammal Knowledge Across the North Sea and Atlantic Areas of Scottish Waters	Hague *et al.* (2020)	Report covers the entirety of Scotland and thus, includes the Proposed Offshore Development Area.	Collation of up-to-date information on the distribution and abundance of marine mammal species in the Scottish Northern North Sea region and Scottish Atlantic waters. This report covers the whole of Scotland, inclusive of the Salamander Offshore Development Area.
Various bottlenose dolphin surveys	(Cheney *et al.* 2012, Cheney *et al.* 2013, Cheney *et al.* 2014a, Cheney *et al.* 2014b, Quick *et al.* 2014, Graham *et al.* 2015, Graham *et al.* 2016,	East Coast of Scotland.	NatureScot report on the condition of bottlenose dolphins within the Moray Firth SAC in six-year intervals. These are inclusive of reports from photo-ID surveys and PAM surveys. A Marine Mammal Monitoring Programme (MMMP) was developed for the Moray Firth in 2014. This includes yearly reports on the results of studies of reproduction,

[1] This is the same area as the Exclusivity Agreement awarded to Simply Blue Energy (Scotland) by Crown Estate Scotland within the Innovation and Targeted Oil & Gas (INTOG) seabed leasing round.

Source	Year	Spatial Coverage	Summary
	Graham *et al.* 2017a, Cheney *et al.* 2018, Arso Civil *et al.* 2019, Arso Civil *et al.* 2021)		survival rates, assessments of trends in abundance and patterns of distribution. Further information is reported on the wider East coast of Scotland population inclusive of photo-ID data in the Firth of Forth and Firth of Tay, to provide the most up to date estimates on the proportion of the Moray Firth population which utilise areas further South.
Small Cetaceans in the European Atlantic and North Sea (SCANS III & IV)	Hammond *et al.* (2017), Hammond *et al.* (2021), (Gilles *et al.* 2023)	European Atlantic waters (not including south, west and north Ireland). The Proposed Development area is located within SCANS III Block R and SCANS IV Block NS-D.	Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS III and summer 2022 from the SCANS IV aerial and shipboard surveys.
Modelled density surfaces of cetaceans in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys	Lacey *et al.* (2022)	Modelled density surfaces cover the entire SCANS III survey area.	Modelled density surfaces of cetaceans in European Atlantic waters in summer 2016 using the SCANS III data.
Scientific Advice on Matters Related to the Management of Seal Populations	SCOS (2023)	The SMUs relevant to the Proposed Development area are the East Scotland, Moray Firth and North Coast & Orkney SMUs.	Under the Conservation of Seals Act 1970 and the Marine (Scotland) Act 2010, the Natural Environment Research Council (NERC) has a duty to provide scientific advice to government on matters related to the management of UK seal populations. NERC has appointed a SCOS to formulate this advice. This document outlines the current status of both harbour and grey seal populations in the UK. Populations of seals are characterised within management units.
Updated abundance estimates for cetacean Management Units in UK waters (Inter-Agency Marine Mammal Working Group (IAMMWG)	IAMMWG (2023)	European North Atlantic.	The IAMMWG defined Mus for the seven most common cetacean species found in UK waters. Abundance estimates were calculated for each species within their respective Mus.

Source	Year	Spatial Coverage	Summary
Designated haul-out sites for grey and harbour seals (Protection of Seals Orders	Marine Scotland (now Marine Directorate), (2017)	The closest designated seal haul-out site is ES-003 Ythan River Mouth (55 km away) protects seals year round while they are on land within the site.	Seal haul-out sites are designated under section 117 of Marine (Scotland) Act 2010. Seal haul-outs are locations on land where seals come ashore to rest, moult or breed. There are a total of 194 seal haul-out sites across Scotland which have been mapped on the National Marine Plan interactive (NMPi) system.
Atlas of cetacean distribution in north-west European waters	Reid *et al.* (2003)	The Atlas includes waters within the regional Study Area for harbour porpoise, bottlenose dolphin, white-sided dolphin, white-beaked dolphin and minke whale.	This Atlas aims to provide an account and snapshot of the distribution of all 28 cetacean species that are known certainly to have occurred in the waters off north-west Europe in the last 25 years (at time of publication).
Revised Phase III Data Analysis of Joint Cetacean Protocol (JCP) Data Resource	Paxton *et al.* (2016)	Covers cetacean trends in the North Sea and includes the Proposed Development area.	The Joint Cetacean Protocol (JCP) has been set up with the aim of delivering information on the distribution, abundance and population trends of cetacean species occurring in the North Sea and adjacent sea regions. Effort-linked sightings data contained within the JCP data resource have been used to estimate spatio-temporal patterns of abundance for seven species of cetacean over a 17-year period from 1994–2010 over a 1.09 million km^2 prediction region from 48° N to c. 64° N and from the continental shelf edge west of Ireland to the Kattegat in the east.
Distribution Maps of Cetacean and Seabird Populations in the North-East Atlantic	Waggitt *et al.* (2020)	Covers cetacean trends in the North Sea and includes the Proposed Development area.	This study provides the largest ever collation and standardisation of diverse survey data for cetaceans and seabirds, and the most comprehensive distribution maps of these taxa in the North-East Atlantic. Aerial and vessel survey data were collated between 1980 and 2018. Distributional maps for 12 cetacean species were produced at 10 km resolution.
The Identification of Discrete and Persistent Areas of Relatively High Harbour Porpoise Density in the Wider UK Marine Area	Heinänen and Skov (2015)	UK harbour porpoise Mus were used for presentation of results, thus, any data used from this report shall be	This report provides the results of detailed analyses of 18 years of survey data in the JCP undertaken to inform the identification of discrete and persistent areas of relatively high harbour porpoise density in

Source	Year	Spatial Coverage	Summary
		representative of that for the harbour porpoise NS MU. The proposed development area is located within this MU.	the UK marine area within the UK Exclusive Economic Zone (EEZ).
Habitat-based predictions of at- sea distribution for grey and harbour seals in the British Isles	Carter *et al.* (2020)	Report covers the entirety of Scotland and thus, includes the Proposed Development area.	Habitat modelling was used, matching seal telemetry data to habitat variables, to understand the species-environment relationships that drive seal distribution. Haul-out count data were then used to generate predictions of seal distribution at sea from all known haul-out sites. This resulted in predicted distribution maps on a 5x5 km grid. The estimated density surface gives the percentage of the British Isles at sea population (17xclude-out animals) estimated to be present in each grid cell at any one time during the main foraging season.
Sympatric Seals, Satellite Tracking and Protected Areas: Habitat-Based Distribution Estimates for Conservation and Management	Carter *et al.* (2022)	Report covers the entirety of Scotland and thus, includes the Proposed Development area	The United Kingdom (UK) and Ireland represents an important population centre for both species, and Special Area of Conservation (SACs) are designated for their monitoring and protection. The study uses an extensive high-resolution GPS tracking dataset, unprecedented in both size (114 grey and 239 harbour seals) and spatial coverage, to model habitat preference and generate at-sea distribution estimates for the entire UK and Ireland populations of both species. The study also provides SAC-specific estimates of at-sea distribution for use in marine spatial planning, demonstrating that hotspots of at-sea density in UK and Ireland-wide maps cannot always be apportioned to the nearest SAC.
Seal telemetry data (1988 – 2019)	Data provided by SMRU.	Data encompasses the entirety of Scotland and thus, includes the Proposed Development area.	Data collated by multiple authors and gathered through a consortium of funders. Used to assess connectivity and habitat associations of seal species with at-sea and on-land locations.
Seal August haul-out data	Data provided by SMRU.	UK wide	August haul-out surveys of harbour and grey seals.

Source	Year	Spatial Coverage	Summary
Grey seal pup production database	Data provided by SMRU.	UK wide	Grey seal pup production estimates at various breeding colonies around the UK. Includes data collated between 1989 and 2022 (depending on site).
East Coast Scotland Marine Mammal Acoustic Array (ECOMMAS)	Data provided by Marine Directorate	Two sites are in proximity to the Salamander Offshore development: Cruden Bay and Fraserburgh.	The ECOMMAS project uses acoustic recorders, known as CPODs, at 30 locations off the east coast of Scotland, to detect echolocation clicks. At 10 of these locations, a broadband acoustic recorder has also been deployed, to record ambient noise levels, as well as other animal vocalisations.
Site-specific aerial surveys for the proposed development	HiDef Aerial Surveying Limited (2022)	Salamander OAA plus 4 km buffer.	Site-specific baseline characterisation digital aerial surveys (24 between March 2021 and February 2023).
Statistical approaches to aid the identification of Marine Protected Areas (MPA) for minke whale, Risso's dolphin, white-beaked dolphin and basking shark	Paxton *et al.* (2014)	Generated estimated densities per area surveyed which includes the North Sea and includes the Proposed Development area.	Effort-linked sightings data contained within the JCP plus additional data sourced by NatureScot (formerly Scottish Natural Heritage) were used to generate estimated densities per area surveyed (corrected for detection/availability) for minke whale (2000 – 2012), Risso's dolphin (1994 – 2012) and white-beaked dolphin (1994 – 2012). A further relative density per area surveyed index was obtained for basking shark (2000 – 2012). There were up to 23 distinct data sources used for each analysis (25 used in total) with data from at least 172 distinct survey platforms (ships and aircraft) representing up to 180,300 km of effort depending on the species considered.

11.7 Baseline Environment

11.7.1.1 A comprehensive characterisation of the baseline environment to understand the range of species and the abundance and the density of marine mammals that could be potentially impacted by the Offshore Development are provided in the **Volume ER.A.4, Annex 11.1: Marine Mammal Baseline Report**. A summary is provided here.

11.7.2 Summary of Existing Baseline

11.7.2.1 The key marine mammal species that are common in the Study Area (see **Volume ER.A.4, Annex 11.1: Marine Mammal Baseline Report**) and considered for quantitative assessment in this EIA are harbour porpoise (*Phocoena phocoena*), bottlenose dolphin (*Tursiops truncatus*), white beaked dolphin (*Lagenorhynchus albirostris*), minke whale (*Balaenoptera acutorostrata*), harbour seal (*Phoca vitulina*) and grey seal (*Halichoerus grypus*).

11.7.2.2 Consideration of humpback whales (*Megaptera noveangliae*) in this impact assessment is qualitative only, since no density or MU information is available for this species. In addition, as killer whales (*Orcinus orca*) were opportunistically sighted during a site visit in February 2023 they have also been included in this impact assessment qualitatively as no density or MU information is available for this species.

11.7.2.3 As both the site-specific data and the wider literature review provided no evidence of white sided dolphin (*Lagenorhynchus acutus*) this species was scoped out of the assessment.

11.7.2.4 Basking sharks and marine turtles were also considered in the marine mammals chapter of the Salamander EIA Scoping Report (SBES, 2023), but scoped out of the assessment due to a lack of evidence of occurrence in the Offshore Development Area.

11.7.2.5 From all the available data sources, the most robust and relevant density estimates for each of the above species, and within each marine mammal MU, were selected and are presented in **Table 11-4**.

11.7.2.6 Where possible, density estimates derived from Salamander site-specific DAS have been used; however, it is important to note that the site-specific density estimates are not representative of animal densities across the full spatial scale of potentially wide-ranging impacts such as disturbance from pile-driven anchors. As such, grid cell specific density estimates at a regional scale (Carter *et al.* 2022, Lacey *et al.* 2022) have been used to inform the impacts from piling for each species wherever possible. For certain impacts, spatially-explicit density surfaces are not appropriate for the assessment (e.g. UXO clearance where the location of UXOs are unknown); in these instances the SCANS III or MU uniform density estimates have been used instead. The impact assessment results tables clearly denote which density estimate has been used in each case.

Table 11-4 Species, abundance of species within the Management Unit (and the United Kingdom portion of the Management Unit) and density estimate recommended for use in the Offshore Development quantitative impact assessment

Species	MU	MU Abundance	Abundance UK Portion	Density (animals/km2)
Harbour porpoise	North Sea	346,601 (IAMMWG 2023)	159,632 (IAMMWG 2023)	Grid cell specific (Lacey *et al.* 2022) (0.482-0.526/km^2 in the OAA)
				0.71 DAS
				0.599 SCANS III Block R
				0.5985 SCANS IV Block NS-D
Bottlenose dolphin	Coastal East Scotland	224 (IAMMWG 2023)	NA	0.01 (CES MU)
	Greater North Sea	2,022 (IAMMWG 2023)	1,885 (IAMMWG 2023)	0.003 (GNS MU)
	Combined Mus	2,246 (IAMMWG 2023)	2,109	0.110 within 2 km of the coast 0.003 beyond

Species	MU	MU Abundance	Abundance UK Portion	Density (animals/km2)
White-beaked dolphin	Celtic and Greater North Seas	43,951 (IAMMWG 2023)	34,025 (IAMMWG 2023)	Grid cell specific (Lacey *et al.* 2022) (0.208-0.385/km^2 in OAA)
				0.243 SCANS III Block R
				0.0799 SCANS IV Block NS-D
Minke whale	Celtic and Greater North Seas	20,118 (IAMMWG 2023)	10,288 (IAMMWG 2023)	Grid cell specific (Lacey *et al.* 2022) (0.017-0.021/km^2 in OAA)
				0.0387 SCANS III Block R
				0.0419 SCANS IV Block NS-D
Harbour seal	East Scotland	364 (scaled counts) (SCOS 2023)	NA	Grid cell specific (Carter *et al.* 2022) (max 0.003/km^2 in OAA and Offshore ECC)
Grey seal	East Scotland Moray Firth North Coast & Orkney	10,783 (scaled counts) (SCOS 2023) 7,380 (scaled counts) (SCOS 2023) 34,191 (scaled counts) (SCOS 2023)	NA	Grid cell specific (Carter *et al.* 2022) (max 0.89/km^2 in OAA, max 0.11/km^2 in Offshore ECC)

11.8 Project Design Envelope Parameters

11.8.1.1 **Volume ER.A.2, Chapter 6: EIA Assessment Methodology** sets out the general approach to the assessment of potential significant effects that may arise from the Salamander Project.

11.8.1.2 The realistic worst-case scenario is based on the design option (or combination of options) that represents the greatest potential for change to baseline conditions, as set out in **Volume ER.A.2, Chapter 4: Project Description;** therefore, it can be reasonably assumed that development of any alternative options within the Offshore Development Design Envelope parameters will give rise to no effects greater or worse than those assessed in this impact assessment. The Offshore Development Design Envelope parameters relevant to the Marine Mammal assessment, and which have been used to establish the maximum potential impact associated with the Offshore Development, are outlined in **Table 11-5**.

Table 11-5 Design Envelope parameters for Marine Mammals

Potential Impact and Effect	Project Design Envelope Parameters
Construction	
PTS from geophysical surveys	Pre-construction and construction geophysical equipment could include any or all of the following: sub-bottom profiling (SBP); multibeam echosounder (MBES); Side Scan Sonar (SSS) with piggybacked magnetometer. The SSS/magnetometer would be towed behind the vessel (tow fish), to avoid disturbance from the vessel, and could use ultra-short baseline (USBL) positioning systems. NOTE: geophysical surveys will be licenced under a separate Marine Licence, but are included in this EIAR chapter impact assessment for illustrative purposes.
Disturbance from pre-construction geophysical surveys	
PTS from UXO clearance	As the detailed pre-construction surveys have not yet been completed, it is not possible at this time to determine how many items of UXO will require clearance. Primary method will be low-order deflagration, but high-order clearance is assessed as the realistic worst-case scenario. Assumed maximum charge weight is 698 kg (TNT equivalent). NOTE: UXO clearance will be licenced under a separate Marine Licence, but are included in this EIAR chapter impact assessment for illustrative purposes.
Disturbance from UXO clearance	
PTS from piling	WTGs: • Maximum of 7 WTGs. • Maximum pile diameter shall be 3 m. • 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. • Maximum 8 piled anchors per WTG = 56 piled anchors for WTGs in total. • No concurrent piling shall occur. Sub-sea hubs: • Maximum of 2 hubs. • Maximum pile diameter shall be 1.5 m. • Maximum hammer energy during piling: 2,500 kJ. • Maximum 12 piled anchors per hub = 24 piled anchors for hubs in total. • No concurrent piling shall occur. Total number of piled anchors = 56 WTG piled anchors + 24 Hub piled anchors = 80 total
Disturbance from piling	
PTS from other construction noise	

Potential Impact and Effect	Project Design Envelope Parameters
Disturbance from other construction noise	• Inter-array cable and export cable installation: Jetting, Vertical Injection, Mass Flow Excavation, Ploughing / Pre-Ploughing, Trenching / Pre-Trenching (incl. dredging, cutting, with or without backfill) / Rock Placement may all be required • Landfall shall be trenchless. • Construction shall be within an 18-month period.
Disturbance from vessels	Overall construction period has a window of 2.5 years, with construction activities taking place over a period of up to 18 months, specifically:: • ≤18 months mooring/anchors • ≤18 months cable installation • ≤8 months substructure/WTG Number of simultaneous vessels on-site: • Jack-up vessels: ≤1 • Heavy lift crane vessels: ≤1 mooring/anchoring, ≤1 substructure/WTG • Cable laying vessel: ≤1 • Cable burial/jointing vessels: ≤1 • Shallow water cable barge: ≤1 • Anchor handling vessels: ≤2 mooring/anchors, ≤6 cable installation, ≤3 substructure/WTG • Offshore Construction Vessel: ≤1 mooring/anchoring, ≤1 substructure/WTG • Support vessels (includes light construction vessels such as SOVs, guard vessels, diving vessels and survey vessels): ≤2 mooring/anchors, ≤12 cable installation, ≤2 substructure/WTG • Crew transfer vessels: ≤2 cable installation, ≤2 substructure/WTG Vessel trips (round trip): • Jack-up vessels: ≤2 • Heavy lift crane vessels: ≤14 mooring/anchoring, ≤7 substructure/WTG • Cable laying vessel: ≤14 • Cable burial/jointing vessels: ≤14 • Shallow water cable barge: ≤2 • Anchor handling vessels: ≤56 mooring/anchors, ≤84 cable installation, ≤21 substructure/WTG • Offshore Construction Vessel: ≤7 mooring/anchoring, ≤7 substructure/WTG • Support vessels includes light construction vessels such as SOVs, guard vessels, diving vessels and survey vessels: ≤56 mooring/anchors, ≤168 cable installation, ≤14 substructure/WTG • Crew transfer vessels: ≤14 cable installation, ≤180 substructure/WTG

<table>
<tr><th>Potential Impact and Effect</th><th>Project Design Envelope Parameters</th></tr>
<tr><td></td><td>Total time on site:
Jack-up vessels: ≤120 days
Heavy lift crane vessels: ≤84 days mooring/anchoring, ≤42 days substructure/WTG
Cable laying vessel: ≤95 days
Cable burial/jointing vessels: ≤95 days
Shallow water cable barge: ≤62 days
Anchor handling vessels: ≤84 days mooring/anchors, ≤95 days cable installation, ≤50 days substructure/WTG
Offshore Construction Vessel: ≤84 days, mooring/anchors, ≤50 days substructure/WTG
Support vessels: ≤84 days mooring/anchors, ≤95 days cable installation, ≤64 days substructure/WTG
Crew transfer vessels: ≤95 days cable installation, ≤90 days substructure/WTG
Vessel transit speeds:
Jack-up vessels: 10 knots
Heavy lift crane vessels: 13 knots
Cable laying vessel: 11 knots
Cable burial/jointing vessels: 11 knots
Shallow water cable barge: 6 knots
Anchor handling vessels: 11 knots
Offshore Construction Vessel: 14 knots
Support vessels: 14 knots
Crew transfer vessels: 25 knots</td></tr>
<tr><td>Indirect impacts on prey availability and distribution</td><td>Impact dependent on the result of the assessment presented in Volume ER.A.3, Chapter 10: Fish and Shellfish</td></tr>
<tr><td colspan="2">Operation and Maintenance</td></tr>
<tr><td>Risk of injury and entanglement with WTG mooring lines and cables</td><td>Max 8 mooring lines per WTG for all mooring arrangement options (7 WTGs, max 56 mooring lines total)
Mooring line radius: ≤ 1,500 m (except for tension mooring lines: 125 m)
Mooring line length: ≤ 1,650 m (except for tension mooring lines: 150 m)
Mooring line diameter: ≤ 300 mm (rope), ≤ 840 mm (chain, based on 4 x chain bar diameter of ≤ 210 mm)
Dynamic cable length suspended in water column (per cable end): ≤ 250 m
Total length of dynamic cable suspended in water column: ≤ 3,500 m</td></tr>
<tr><td>Risk of injury resulting from collision with WTG substructures</td><td>A maximum of 7 WTGs; semi-submersible platform type</td></tr>
<tr><td>Operational noise impacts</td><td>A maximum of 7 WTGs</td></tr>
</table>

Potential Impact and Effect	Project Design Envelope Parameters
Displacement and barrier effects	A maximum of 7 WTGs, each with a maximum of 8 mooring lines (56 total mooring lines)
Indirect impacts on prey availability and distribution	Impact dependent on the result of the assessment presented in **Volume ER.A.3, Chapter 10: Fish and Shellfish.**
Decommissioning	
PTS from decommissioning activities	At this stage, the worst-case scenario envelope during decommissioning is considered equal to the worst-case scenario during construction, with the exception of vessel movements, where more detailed information is available. Noting this, it is assumed that the worst-case scenario will involve full removal of all infrastructure placed during the construction phase. This assumption is subject to best practice methods and technology appropriate at the time of decommissioning.
Disturbance from decommissioning activities (including vessels)	
Indirect impacts on prey availability and distribution	Impact dependent on the result of the assessment presented in **Volume ER.A.3, Chapter 10: Fish and Shellfish Ecology.**

11.8.2 Pile Driving Parameters

11.8.2.1 Two locations have been selected for the assessment of PTS and disturbance from pile driving of anchors: the East location in 89.7 m water depth, and the West location, in 97.1 m water depth. Two piling scenarios are presented for each modelling location within **Volume ER.A.4, Annex 4.1: Underwater Noise Modelling Report**. Assessment within this chapter is based on underwater noise modelling undertaken for the following scenarios:

- Scenario 1: Installation of 1 piled anchor in 1 day, with a maximum of 2,500 kJ hammer energy.
- Scenario 2: Installation of 4 piled anchors in 1 day, with a maximum of 1,500 kJ hammer energy.

11.8.2.2 The piling parameters for each scenario are detailed in **Table 11-6**.

Table 11-6 Piling parameters for both Scenario 1 and Scenario 2

	Soft start	Ramp-up			Maximum	Total	
Scenario 1							
Energy (kJ)	250	250	500	1000	2500	**1 pile**	**4 piles**
# strikes	60	1140	1200	1200	4800	**8,400**	**NA**
Duration (s)	1200	2280	2400	2400	9600	**4.97 hours**	**NA**
Strike rate (bl/min)	3	30	30	30	30	-	-

	Soft start	Ramp-up			Maximum	Total	
Scenario 2							
Energy (kJ)	150	150	300	600	1500	**1 pile**	**4 piles**
# strikes	60	2040	2100	2100	2100	**8,400**	**33,600**
Duration (s)	1200	4080	4200	4200	4200	**4.97 hours**	**19.87 hours**
Strike rate (bl/min)	3	30	30	30	30	-	-

11.9 Assessment Methodology

11.9.1.1 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.

11.9.1.2 The approach to the Marine Mammal assessment in this EIA is outlined below.

11.9.2 Sensitivity

11.9.2.1 The sensitivity of marine mammal receptors is defined by their potential vulnerability to an impact from the proposed development, their recoverability, and the value or importance of the receptor.

11.9.2.2 The criteria for defining marine mammal sensitivity in this chapter are outlined in **Table 11-7**.

11.9.2.3 Please note, the value of the receptor is not included in the definition of sensitivity as all marine mammals are considered to have a high value, since all marine mammals are either listed under Annex IV of the Habitats Directive as EPS of Community Interest and in need of strict protection and/or are listed in the under Annex II of the Habitats Directive as species of Community Interest.

Table 11-7 Impact sensitivity definitions for Marine Mammals

Receptor Sensitivity	Definition
High	**Adaptability**: No ability to adapt behaviour so that individual survival and reproduction rates are affected. **Tolerance**: No tolerance – Effect will cause a change in both individual reproduction and survival rates. **Recoverability**: No ability for the animal to recover from any impact on vital rates (reproduction and survival rates).
Medium	**Adaptability**: Limited ability to adapt behaviour so that individual survival and reproduction rates may be affected. **Tolerance**: Limited tolerance – Effect may cause a change in both individual reproduction and survival of individuals.

Receptor Sensitivity	Definition
	Recoverability: Limited ability for the animal to recover from any impact on vital rates (reproduction and survival rates).
Low	**Adaptability**: Ability to adapt behaviour so that individual reproduction rates may be affected but survival rates not likely to be affected. **Tolerance**: Some tolerance – Effect unlikely to cause a change in both individual reproduction and survival rates. **Recoverability**: Ability for the animal to recover from any impact on vital rates (reproduction and survival rates)
Negligible	**Adaptability**: Receptor is able to adapt behaviour so that individual survival and reproduction rates are not affected. **Tolerance**: Receptor is able to tolerate the effect without any impact on individual reproduction and survival rates. **Recoverability**: Receptor is able to return to previous behavioural states/activities once the impact has ceased.

11.9.3 Magnitude

11.9.3.1 The magnitude of potential impacts is defined by a series of factors including the spatial extent of any interaction, the likelihood, duration, frequency, and reversibility of a potential impact. The criteria for defining magnitude in this chapter are outlined in **Table 11-8**.

Table 11-8 Magnitude Definitions for Marine Mammals

Magnitude of Impact	Definition
High	**Extent**: Total change or major alteration to key elements/features of the baseline conditions. **Duration**: 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. **Probability**: The impact is very likely to occur and/or will occur at a high frequency or intensity.
Medium	**Extent**: Partial change or alteration to one or more key elements / features of the baseline conditions. **Duration**: 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. **Probability**: The impact is likely to occur and/or will occur at a moderate frequency or intensity.
Low	**Extent**: Minor shift away from the baseline conditions.

Magnitude of Impact	Definition
	Duration: The impact is localised and temporary or short-term, leading to a short-term detectable change in baseline conditions or a noticeable effect on a small proportion of a receptor population. **Probability**: The impact is unlikely to occur or may occur but at low frequency or intensity.
Negligible	**Extent**: Very slight change from baseline conditions. **Duration**: 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. **Probability**: 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.

11.9.4 Significance of Impact

11.9.4.1 The matrix used for the assessment of the significance of potential effects is described in **Table 11-9**. The magnitude of the impact is correlated against the sensitivity of the receptor to provide a level of significance.

11.9.4.2 For the purpose of this assessment any effect that is moderate or major is considered to be significant in EIA terms. Any effect that is minor or below is not significant with respect to the EIA Regulations.

Table 11-9 Significance of Effect Matrix

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

11.9.5 Auditory Injury (Temporary Threshold Shift and Permanent Threshold Shift)

11.9.5.1 For marine mammals, the main impact from the Offshore Development will be as a result of underwater noise produced during construction. Therefore, a detailed assessment has been provided for this impact pathway.

11.9.5.2 Exposure to loud sounds can lead to a reduction in hearing sensitivity (a shift in hearing threshold). This threshold shift results from physical injury to the auditory system and may be temporary (TTS) or permanent (PTS). The point at which threshold shifts occur in marine mammals is species-specific (i.e., functional hearing group dependent, see **Table 11-10**).

11.9.5.3 The PTS-onset thresholds used in this assessment to calculate PTS-onset impact ranges are those presented in Southall *et al.* (2019), which are detailed in **Table 11-10**. These include two different thresholds covering 'instantaneous' PTS (SPL_{peak}, sound pressure from a single noise pulse), and 'cumulative' PTS (SEL_{cum}, accumulated sound energy over 24 hours), with the latter thresholds being frequency-weighted to marine mammal functional hearing groups.

Table 11-10 Permanent Threshold Shift – onset thresholds for impulsive noise (Southall et al., 2019)

Functional hearing group	Species relevant to this assessment	Cumulative PTS (SEL_{cum} dB re 1 µPa²s weighted)	Instantaneous PTS (SPL_{peak} dB re 1 µPa unweighted)
Very High Frequency (VHF) Cetacean	Harbour porpoise	155	202
High Frequency (HF) Cetacean	Bottlenose dolphin, white-beaked dolphin and killer whale	185	230
Low Frequency (LF) Cetacean	Minke whale and humpback whale	183	219
Phocid carnivores (seals) in water (PCW)	Grey and harbour seal	185	218

11.9.5.4 In calculating the received noise level that animals are likely to receive during the whole piling sequence, constant animal swimming speeds were used and based upon the marine mammal swimming speeds previously recommended by Scottish Natural Heritage (now NatureScot) (2016). Scottish Natural Heritage (now NatureScot) (2016) recommend that a minimum fleeing speed of 1.4 m/s is used for harbour porpoise, which is based on the average descent and ascent routine speed rates from tagged porpoise (Westgate *et al.* 1995). These values are recommended despite Kastelein *et al.* (2018) finding that routine swimming speeds of ~7 km/h (1.94 m/s) are sustainable for harbour porpoise (throughout a 30 min test period). Although the speeds recommended to be used are likely slower than a routine swimming speed or typical fleeing response of harbour porpoise, the modelling is conservative as it uses recommended fleeing speeds lower than this. In addition, Scottish Natural Heritage (now NatureScot) (2016) recommend a fleeing speed of 2.1 m/s for minke whales based on Williams (2009). This recommendation is made despite the fact that Williams (2009) states that the routine speeds for mysticete whales is 2.1 – 2.6 m/s. Therefore, the recommended fleeing speed to be used in any modelling for mysticete species is slower than the expected routine or fleeing speeds and ensures a conservative assessment. Similarly, for seals species, Scottish Natural Heritage (now NatureScot)(2016) recommend a swimming speed of 1.8 m/s, based on the finding of Thompson (2015), which estimated routine swimming speeds for grey seals were in the range of 1.8 – 2.0 m/s.

11.9.5.5 The calculated PTS-onset impact ranges therefore represent the minimum safe starting distances from the piling location for fleeing animals to avoid a dose higher than the threshold. Southall *et al.* (2019) propose the SPL_{peak} (being either unweighted or flat weighted across the entire frequency band of a hearing group). This is because the direct mechanical damage to the auditory system that is associated with high peak sound pressures is not frequency dependent (i.e., restricted to the audible frequency range of a species).

11.9.5.6 The physiological damage that sound energy can cause is mainly restricted to energy occurring in the frequency range of a species' hearing range. Therefore, for the cumulative sound exposure level (SELcum), sound has been weighted based on species group specific weighting curves given in Southall et al. (2019) (**Figure 11-2**).

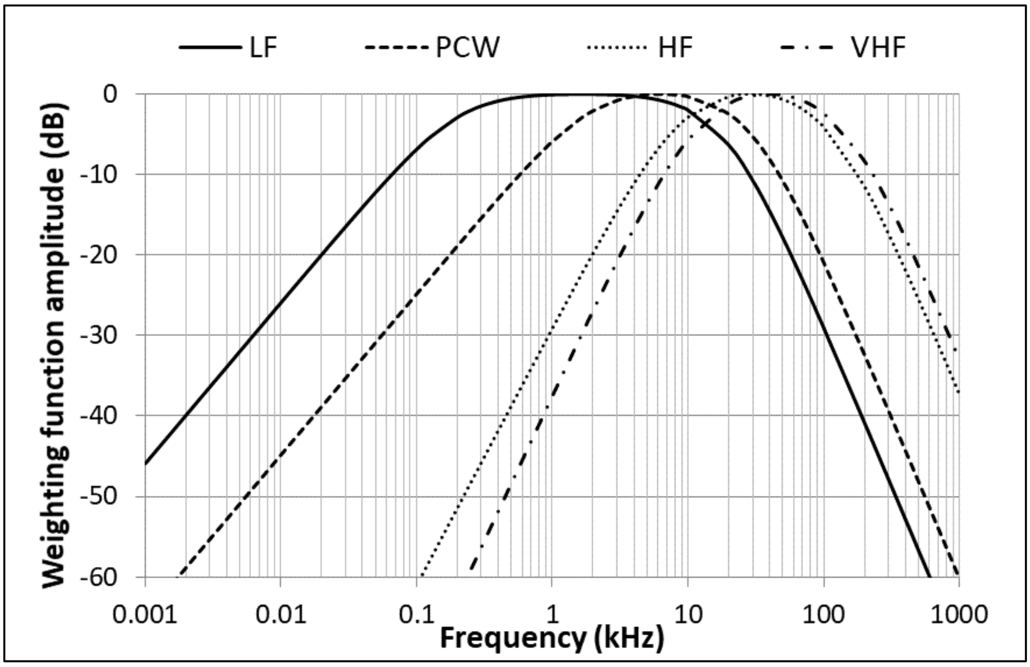


Figure 11-2 Auditory weighting functions for low frequency (LF), high frequency (HF) and very high frequency (VHF) cetaceans as well as phocid carnivores (seals) in water (PCW) taken from Southall et al. (2019

11.9.5.7 The impact assessment presented here focusses on PTS and disturbance. TTS is not assessed as an auditory injury. The reasoning for this is provided in **Appendix 1: TTS Limitations and Assumptions**. The exception to this is where TTS-onset has been used a proxy for disturbance when assessing UXO clearance (see **Section 11.9.6.25**).

Auditory Injury (Permanent Threshold Shift) – Pile Driving

11.9.5.8 To quantify the impact of noise with regard to PTS, the PTS-onset impact range (the area around the piling location within which the noise levels exceed the PTS-onset threshold) will be determined using the recent threshold presented by Southall *et al.* (2019).

11.9.5.9 Based on agreed density estimates for each species presented in **Volume ER.A.4, Annex 11.1: Marine Mammals Baseline Report**, the number of animals expected within the PTS onset impact range has been calculated and presented as a proportion of the relevant (estimated) population size.

11.9.5.10 The SEL_{cum} threshold for PTS-onset considers the sound exposure level received by an animal and the duration of exposure, accounting for the accumulated exposure over the duration of an activity within a 24-hour period. Southall *et al.* (2019) recommends the application of SEL_{cum} for the individual activity alone (i.e., not for multiple activities occurring within the same area or over the same time). To inform this impact assessment, sound modelling has considered the SEL_{cum} over a piling event.

Auditory Injury (Permanent Threshold Shift) – Unexploded Ordnance Clearance

11.9.5.11 Current practice is that Southall *et al.* (2019) should be used for assessing the impacts from UXO detonation on marine mammals. However, the suitability of these criteria for UXO is under discussion due to the lack of empirical evidence from UXO detonations using these metrics, in particular the range-dependent characteristics of the peak sounds, and whether current propagation models can accurately predict the range at which these thresholds are reached.

11.9.5.12 Full details of the underwater noise modelling and the resulting PTS-onset impact areas and ranges are detailed in **Volume ER.A.4, Annex 4.1: Underwater Noise Modelling Report**. A selection of charge weights has been considered based on what has been found at other sites in North Sea waters and, in each case, it has been assumed that the maximum explosive charge in each device is present and undergoes a full explosive detonation (a "high-order" event).

11.9.5.13 For high-order clearance, the maximum assumed charge weight is 698 kg (TNT equivalent). In addition to this a range of smaller charge weights have been estimated as 25, 55, 120, 240, and 525 kg. In each case, an additional donor weight of 0.5 kg has been included to initiate detonation. Additionally, a low-order clearance scenario has been modelled, assuming a donor charge of 0.25 kg. Estimation of the source noise level for each charge weight has been carried out in accordance with the methodology of Soloway and Dahl (2014), which follows Arons (1954) and the Marine Technical Directorate (Barett 1996).

11.9.5.14 This approach does not consider any degradation of explosive material over time, despite most historic UXOs having laid on the seabed exposed to saltwater for over 70 years. Therefore, these results are considered to be a conservative estimate of the true noise output from each charge weight and, as such, likely an overestimate of PTS-onset impact ranges, especially for larger charge weights.

11.9.5.15 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 risk assessments) will be submitted for the detonation of any UXO which may be identified as requiring clearance in pre-construction surveys.

Auditory Injury (Permanent Threshold Shift) – Other Construction Activities

11.9.5.16 While impact piling will be the loudest noise source during the construction phase, there will also be several other construction activities that will produce underwater noise. These include dredging, cable laying, rock placement and trenching, drilling, as well as noise generated by the presence of construction vessels.

11.9.5.17 A simple assessment of the noise impacts from other construction (i.e. excluding impact piling and UXO clearance) is presented in **Volume ER.A.4, Annex 4.1: Underwater Noise Modelling Report.** This includes an assessment of the potential PTS and TTS-onset impact ranges for:

- Cable laying: Noise from the cable laying vessel and any other associated noise during the offshore cable installation;
- Dredging: Dredging may be required on site for seabed preparation work for certain foundation options, as well as for the export cable, array cables and interconnector cable installation. Suction dredging has been assumed as a realistic worst-case;
- Rock placement: Potentially required on site for installation of offshore cables (cable crossings and cable protection) and scour protection around foundation structures;
- Trenching: Plough trenching may be required during offshore cable installation;

- Vessel noise: Vessel noise from large and medium sized vessels; and
- Drilling noise.

11.9.6 Assessment of Disturbance

Disturbance from Piling

11.9.6.1 The assessment of disturbance from pile-driven anchors was based on the current best practice methodology, making use of the best available scientific evidence. This incorporates the application of a species-specific dose-response approach rather than a fixed behavioural threshold approach.

11.9.6.2 For example, the National Marine Fisheries Service (NMFS) uses the Level B harassment (fixed) threshold to predict marine mammal behavioural harassment (i.e., disturbance). This threshold predicts that Level B harassment[2] will occur when an animal is exposed to received levels above 160 dB re 1 µPa (rms) for non-explosive impulsive (e.g., impact pile driving) or intermittent (e.g. scientific, non-tactical sonar) sound sources (Guan and Brookens 2021, NMFS 2022). The Level B harassment threshold originates from a study on a grey whale mother and calf, which were shown to exhibit avoidance responses when exposed to air gun playback signals at levels above 160 dB re 1µPa rms (Malme *et al.* 1984). The use of this criterion can be applied to all marine mammals, although it assumes that no animals exposed below 160 dB re 1 µPa are impacted and that all animals exposed above 160 dB re 1 µPa are impacted (Tyack and Thomas 2019). Similarly, the use of Effective Deterrent Ranges (EDRs) has been recommended by the JNCC (2020), informed by the published ranges where the bulk of the effect (reduction in porpoise vocal activity or sightings) had been detected. For floating OWF projects, the EDR proposed for pile driven anchors is 15 km, whereby an effective area of 707 km^2 is expected to be disturbed and assuming that all animals within this area shall be subject to disturbance. However, the JNCC (2020) 31ecognize that EDRs *"are not equivalent to 100% deterrence/disturbance in the associated area (i.e. some animals show greater reaction than others) […], nor do they represent the limit range at which effects have been detected. […] In addition, the full spectrum of animals' response to the noise has not been or cannot yet be recorded (e.g. physiological changes) and so it is possible that those studies observed only the most visible of effects".* It is important to note that the EDRs provided in the JNCC (2020) guidance are for harbour porpoise only. No EDRs are available for other marine mammal species.

11.9.6.3 Compared with the EDRs and fixed noise threshold approaches, the application of a dose-response function allows for more realistic assumptions about animal response varying with dose, which is supported by a growing number of studies (Miller *et al.* 2014, Graham *et al.* 2017b, Dunlop *et al.* 2018, Tyack and Thomas 2019). A dose-response function was used to quantify the probability of a response from an animal to a dose of a certain stimulus or stressor (Dunlop *et al.* 2017) and is based on the assumption that not all animals in an impact zone will respond. The dose can either be determined using the distance from the sound source or the received weighted or unweighted sound level at the receiver (Sinclair *et al.* 2023).

11.9.6.4 Using a species-specific dose-response function rather than a fixed behavioural threshold to assess disturbance is currently considered to be the best practice methodology and the latest guidance provided in Southall *et al.* (2019) is that: *"Apparent patterns in response as a function of received noise level (sound pressure level) highlighted a number of potential errors in using all-or-nothing "thresholds" to predict*

[2] Level B harassment refers to acts that have the potential to disturb (but not injure) a marine mammal or marine mammal stock in the wild by disrupting behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering.

whether animals will respond. Tyack and Thomas (2019) subsequently and substantially expanded upon these observations. The clearly evident variability in response is likely attributable to a host of contextual factors, which emphasizes the importance of estimating not only a dose-response function but also characterizing response variability at any dosage".

11.9.6.5 Noise contours at 5 dB intervals were generated by noise modelling and were overlain on species density surfaces to predict the number of animals potentially disturbed. This allowed for the quantification of the number of animals that will potentially respond.

Harbour Porpoise Dose-Response Function

11.9.6.6 To estimate the number of porpoise predicted to experience behavioural disturbance as a result of pile driving, this impact assessment uses the porpoise dose-response function presented in Graham *et al.* (2017b) (**Figure 11-3**)

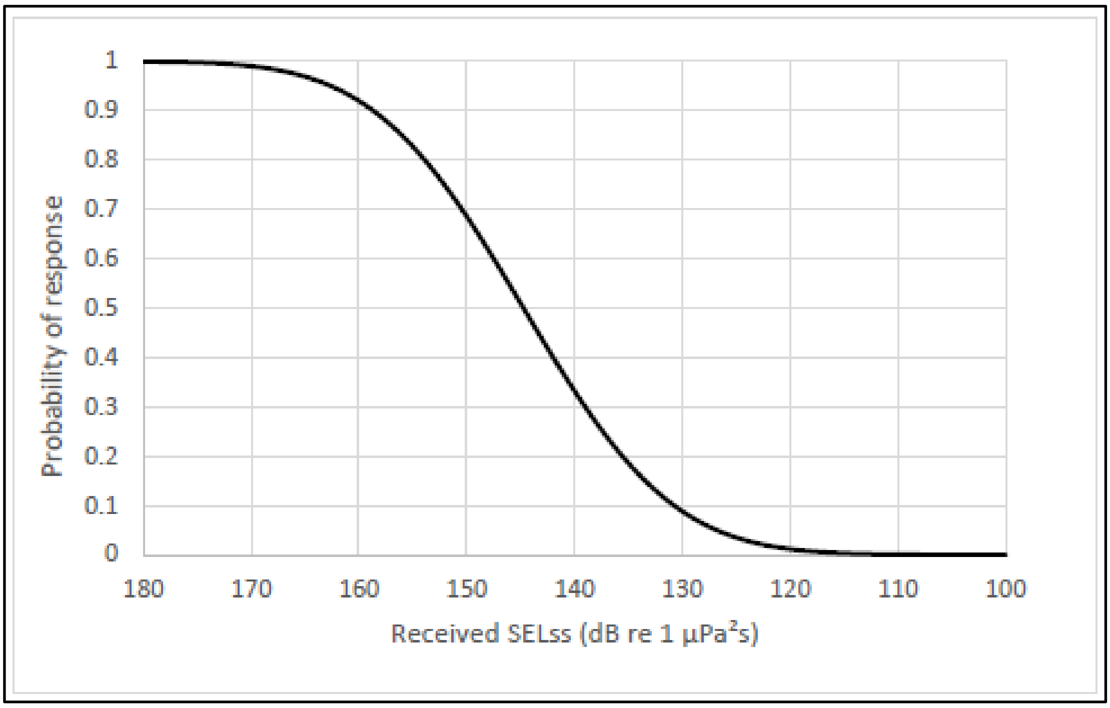


Figure 11-3 Relationship between the proportion of porpoise responding and the received single strike SEL (SEL_{ss}) (Graham *et al.* 2017b)

11.9.6.7 The Graham *et al.* (2017b) dose-response function was developed using data on harbour porpoise collected during the first six weeks of piling during Phase 1 of the Beatrice Offshore Wind Farm monitoring program. Changes in porpoise occurrence (detection positive hours per day) were estimated using 47 CPODs[3] placed

[3] CPODs monitor the presence and activity of toothed cetaceans by the detection within the CPOD app of the trains of echolocation clicks that they make. See https://www.chelonia.co.uk/index.html

around the wind farm site during piling and compared with baseline data from 12 sites outside of the wind farm area prior to the commencement of operations, to characterise this variation in occurrence. Porpoise were considered to have exhibited a behavioural response to piling when the proportional decrease in occurrence was greater than 0.5. The probability that porpoise occurrence did or did not show a response to piling was modelled along with the received single-pulse sound exposure levels piling source levels based on the received noise levels (Graham *et al.* 2017b).

11.9.6.8 Since the initial development of the dose-response function in 2017, additional data from the remaining pile driving events at Beatrice Offshore Wind Farm have been processed and are presented in Graham *et al.* (2019). The passive acoustic monitoring showed a 50% probability of porpoise response (a significant reduction in detection relative to baseline) within 7.4 km at the first location piled, with decreasing response levels over the construction period (excluding pre-construction surveys) to a 50% probability of response within 1.3 km by the final piling location (**Figure 11-4**) (Graham *et al.* 2019). Using the dose-response function derived from the initial piling events for all piling events in the impact assessment is precautionary, as evidence shows that porpoise response is likely to diminish over the construction period (excluding pre-construction surveys).

11.9.6.9 It is noted that Graham *et al.* (2019) presents an updated dose-response function for harbour porpoise, however this function is audiogram weighted specific to VHF-cetaceans and as such cannot be used as a proxy for other species. Therefore, the assessment uses the Graham *et al.* (2017b) dose-response function as it is a) more precautionary (predicts higher responses) than the Graham *et al.* (2019) dose-response function and b) can be used across other cetacean species since the curve is not audiogram weighted.

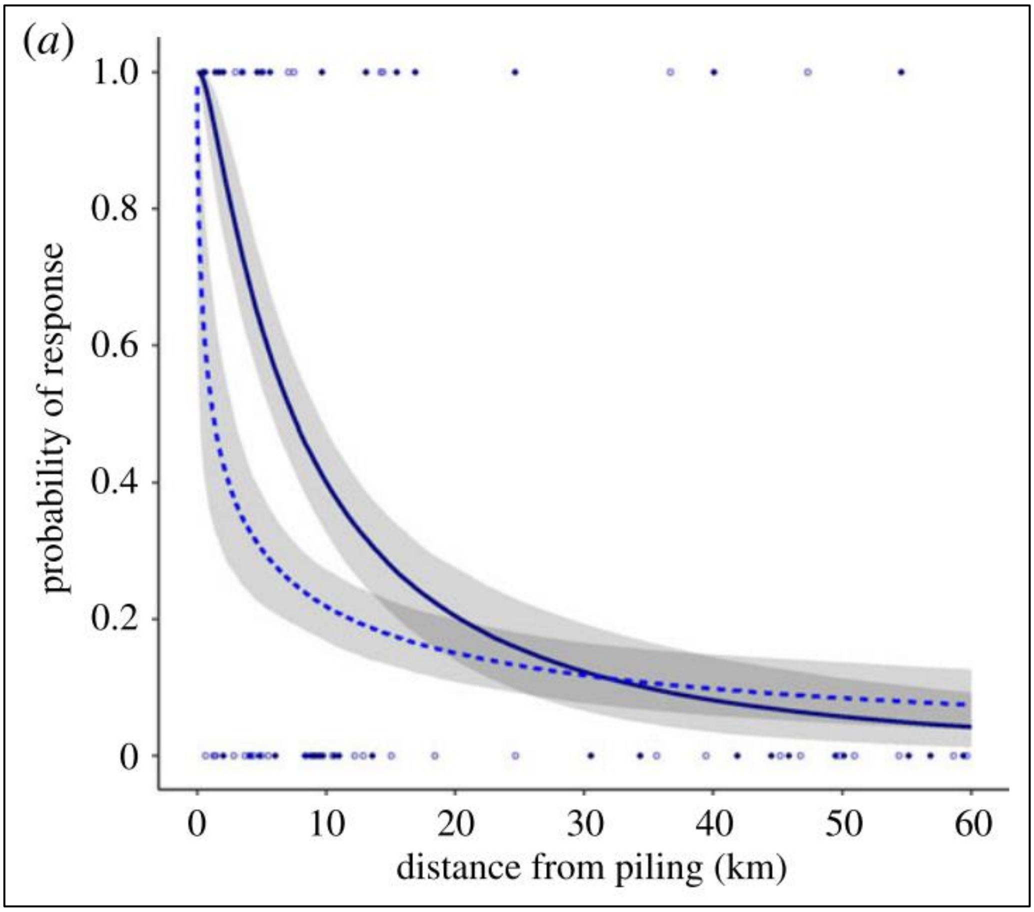


Figure 11-4 The probability of a harbour porpoise response (24 h) in relation to the partial contribution of distance from piling for the first location piled (solid navy line) and the final location piled (dashed blue line). Obtained from Graham *et al.* (2019).

11.9.6.10 In the absence of species-specific data on dolphin species or minke whales, this dose-response function has been adopted for all cetaceans, however it is considered that the application of the porpoise dose-response curve to other cetacean species is highly over precautionary.

11.9.6.11 Porpoise are considered to be particularly responsive to anthropogenic disturbance, with playback experiments showing avoidance reactions to very low levels of sound (Tyack 2009) and multiple studies showing that porpoise respond (avoidance and reduced vocalisation) to a variety of anthropogenic noise sources to distances of multiple kilometres (e.g., Brandt *et al.* 2013, Thompson *et al.* 2013, Tougaard *et al.* 2013, Brandt *et al.* 2018, Sarnocińska *et al.* 2020, Thompson *et al.* 2020, Benhemma-Le Gall *et al.* 2021).

11.9.6.12 Various studies have shown that other cetacean species show comparatively less of a disturbance response from underwater noise compared with harbour porpoise. For example, through an analysis of 16 years of marine mammal observer data from seismic survey vessels, Stone *et al.* (2017) found a significant reduction in porpoise detection rates when large seismic airgun arrays were actively firing, but not for bottlenose dolphins. While the strength and significance of responses varied between porpoise and other dolphin species for different measures of effect, the study emphasised the sensitivity of the harbour porpoise (Stone *et al.* 2017).

11.9.6.13 High-frequency cetacean species, such as striped and common dolphins, have been shown to display less of a response to underwater noise signals and construction-related activities compared with harbour porpoise (e.g., Kastelein *et al.* 2006, Culloch *et al.* 2016).

Seal Dose-Response Function

11.9.6.14 For seals, the dose-response function adopted was based on the data presented in Whyte *et al.* (2020) (**Figure 11-5**). The Whyte *et al.* (2020) study updates the initial dose-response information presented in Russell *et al.* (2016b) and Russell and Hastie (2017), where the percentage change in harbour seal density was predicted at the Lincs Offshore Wind Farm. The original study used telemetry data from 25 harbour seals tagged in the Wash between 2003 and 2006, in addition to a further 24 harbour seals tagged in 2012, to assess how seal usage changed in relation to the pile driving activities at the Lincs Offshore Wind farm in 2011-2012.

11.9.6.15 In the Whyte *et al.* (2020) dose-response function it has been assumed that all seals are displaced at sound exposure levels above 180 dB re 1 μPa^2s. This is a conservative assumption since there were no data presented in the study for harbour seal responses at this level. It is also important to note that the percentage decrease in response in the categories 170 ≤ 175 and 175 ≤ 180 dB re 1 μPa^2s is slightly anomalous (higher response at a lower sound exposure level) due to the small number of spatial cells included in the analysis for these categories (n = 2 and 3 respectively). Given the large confidence intervals on the data, this assessment presents the mean number of seals predicted to be disturbed alongside the 95% confidence intervals (CI), for context.

11.9.6.16 There are no corresponding data for grey seals and, as such, the harbour seal dose-response function is applied to the grey seal disturbance assessment. This is considered to be an appropriate proxy for grey seals, since both species are categorised within the same functional hearing group. However, it is likely that this over estimates the grey seal response, since grey seals are considered to be less sensitive to behavioural disturbance than harbour seals and could tolerate more days of disturbance before there is likely to be an effect on vital rates (Booth *et al.* 2019). Recent studies of tagged grey seals have shown that there is vast individual variation in responses to pile driving, with some animals not showing any evidence of a behavioural response (Aarts *et al.* 2018). Likewise, if the impacted area is considered to be a high quality foraging patch, it is likely that some grey seals may show no behavioural response at all, given their motivation to remain in the area for foraging (Hastie *et al.* 2021). Therefore, the adoption of the harbour seal dose-response function for grey seals is considered to be precautionary as it will likely over-estimate the potential for impact on grey seals.

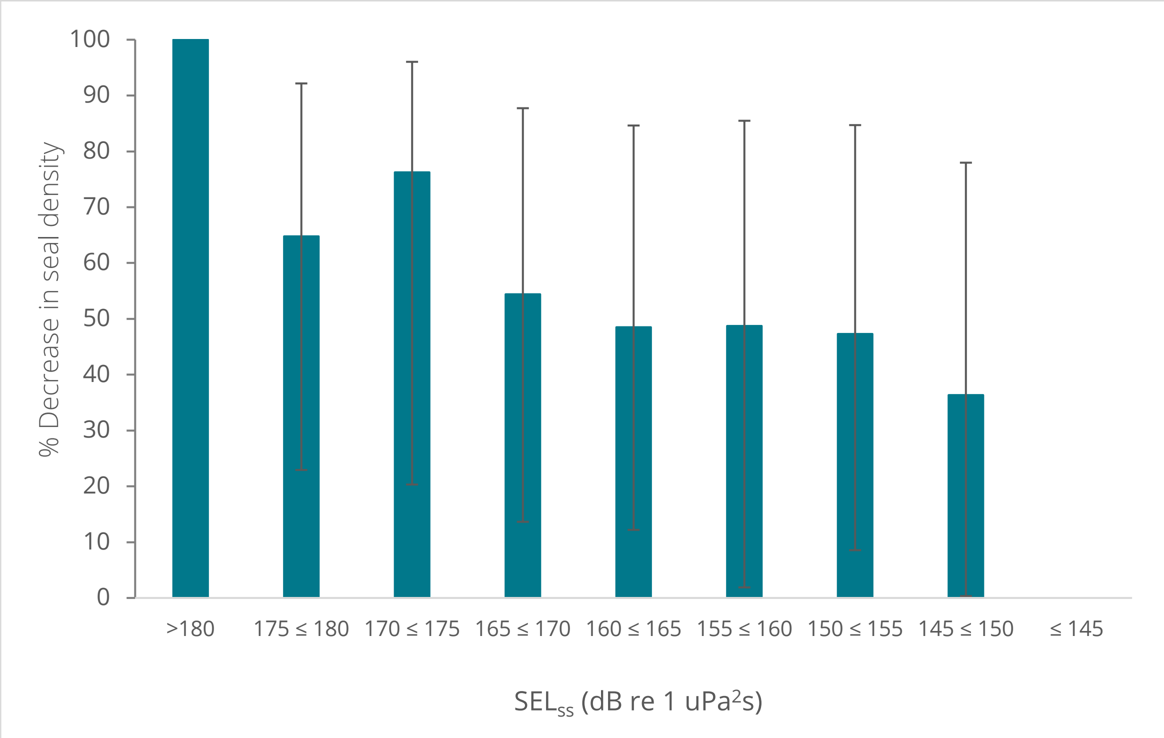


Figure 11-5 Predicted decrease in seal density as a function of estimated sound exposure level, error bars show 95% CI (Whyte *et al.* 2020

Disturbance from Unexploded Ordnance Clearance

11.9.6.17 While there are empirically derived dose-response relationships for pile driving, these are not directly applicable to the assessment of UXO detonation due to the very different nature of the sound emission. While both sound sources (piling and explosives) are categorised as "impulsive", they differ drastically in the number of pulses and the overall duration of the noise emission, both of which will ultimately drive the behavioural response. While one UXO-detonation is anticipated to result in a one-off startle-response or aversive behaviour, the series of pulses emitted during pile driving will more or less continuously drive animals out of the impacted area, giving rise to a measurable and quantifiable dose-response relationship. For UXO clearance, there are no dose-response functions available that describe the magnitude and transient nature of the behavioural impact of UXO detonation on marine mammals.

11.9.6.18 It is important for the impact assessment to acknowledge that our understanding of the effect of disturbance from UXO detonation is very limited, and as such the assessment can only provide an indication of the number of animals potentially at risk of disturbance given the limited evidence available.

11.9.6.19 Since there is no dose-response function available that appropriately reflects the behavioural disturbance from UXO detonation, other behavioural disturbance thresholds have been considered instead. These alternatives are summarised in the sections below.

Effective Deterrent Ranges – 26 km for High Order Unexploded Ordnance Clearance

11.9.6.20 There is guidance available on the EDR that should be applied to assess the significance of noise disturbance against Conservation Objectives of harbour porpoise SACs in England, Wales & Northern Ireland (JNCC 2020).

This guidance advises that an effective deterrence range of 26 km around the source location is used to determine the impact area from high-order UXO detonation (neutralisation of the UXO through full detonation of the original explosive]e content) with respect to disturbance of harbour porpoise in SACs.

11.9.6.21 The recommendation for the 26 km EDR comes from a report by Tougaard *et al*., (2013) which calculates the EDR using data from the Dahne *et al*., (2013) study. The Dahne *et al*., (2013) study was conducted at the first OWF in German waters, where 12 jacket foundations were piled using a Menck MHU500T hydraulic hammer with up to 500 kJ hammer energy to install piles of 2.4 m to 2.6 m diameter up to 30 m penetration depth. The JNCC (2020) guidance itself acknowledges that this EDR is based on the EDR recommended for pile driving of monopiles, since there is no equivalent data for explosives. The guidance states that: *"The 26 km EDR is also to be used for the high order detonation of unexploded ordnance (UXOs) despite there being no empirical evidence of harbour porpoise avoidance."* (JNCC 2020).

11.9.6.22 The guidance also acknowledges that the disturbance resulting from a single explosive detonation would likely not cause the more wide-spread prolonged displacement that has been observed in response to pile driving activities: *"… a one-off explosion would probably only elicit a startle response and would not cause widespread and prolonged displacement…"* (JNCC 2020).

11.9.6.23 It is important to acknowledge that there is no evidence to support the assumption that marine mammal species respond the same way to a high-order UXO clearance as harbour porpoise do to the pile driving of jacket foundations using 500 kJ hammer energy (Dähne *et al*. 2013). Therefore, an alternative approach to the disturbance threshold (TTS-onset as a proxy for disturbance) has been provided alongside the 26km EDR approach.

Effective Deterrent Ranges – 5 km for Low Order Unexploded Ordnance Clearance

11.9.6.24 There are no empirical data upon which to set a threshold for disturbance from low-order UXO clearance. Data have shown that low-order deflagration detonations produce underwater noise that is over 20dB lower than high-order detonation (Robinson *et al*., 2020), which highlights that the EDR for low-order UXO clearance should be significantly lower than that assumed for high-order clearance methods. The JNCC MNR disturbance tool (JNCC, 2023) provides default and realistic worst-case EDRs for various noise sources, and lists the default low-order UXO clearance EDR as 5 km. In the absence of any further data, this 5 km EDR for low-order UXO clearance will be assumed here.

Temporary Threshold Shift as a Proxy for Disturbance

11.9.6.25 Recent assessments of UXO clearance activities have used the TTS-onset threshold to indicate the level at which a 'fleeing' response may be expected to occur in marine mammals (e.g. Seagreen, Neart na Goithe and Awel y Mor). This is a result of discussion in Southall *et al.* (2007) which states that in the absence of empirical data on responses, the use of the TTS-onset threshold may be appropriate for single pulses (like UXO detonation):

11.9.6.26 "Even strong behavioural responses to single pulses, other than those that may secondarily result in injury or death (e.g., stampeding), are expected to dissipate rapidly enough as to have limited long-term consequence. Consequently, upon exposure to a single pulse, the onset of significant behavioural disturbance is proposed to occur at the lowest level of noise exposure that has a measurable transient effect on hearing (i.e., TTS-onset). We recognise that this is not a behavioural effect per se, but we use this auditory effect as a de facto behavioural threshold until better measures are identified. Lesser exposures to a single pulse are not expected to cause significant disturbance, whereas any compromise, even temporarily, to hearing functions has the potential to affect vital rates through altered behaviour." (Southall et al., 2007).

11.9.6.27 "Due to the transient nature of a single pulse, the most severe behavioural reactions will usually be temporary responses, such as startle, rather than prolonged effects, such as modified habitat utilization. A transient behavioural response to a single pulse is unlikely to result in demonstrable effects on individual growth, survival, or reproduction. Consequently, for the unique condition of a single pulse, an auditory effect is used as a de facto disturbance criterion. It is assumed that significant behavioural disturbance might occur if noise exposure is sufficient to have a measurable transient effect on hearing (i.e., TTS-onset). Although TTS is not a behavioural effect per se, this approach is used because any compromise, even temporarily, to hearing functions has the potential to affect vital rates by interfering with essential communication and/or detection capabilities. This approach is expected to be precautionary because TTS at onset levels is unlikely to last a full diel cycle or to have serious biological consequences during the time TTS persists." (Southall et al., 2007).

11.9.6.28 Therefore, an estimation of the extent of behavioural disturbance can be based on the sound levels at which the onset of TTS is predicted to occur from impulsive sounds. TTS-onset thresholds are taken as those proposed for different functional hearing groups by Southall *et al.* (2019).

Disturbance from Other Construction Activities

11.9.6.29 There is currently no guidance on the thresholds to be used to assess disturbance of marine mammals from other construction activity. Therefore, this impact assessment provides a qualitative assessment for these impacts. The assessment is based on the limited evidence that is available in the existing literature for that impact pathway and species combination, where available. The majority of available evidence on the impact of disturbance of marine mammals from other construction activities focuses on the impact of vessel activity and dredging. Both these activities are of relevance during the construction of Salamander, with dredging potentially being required for export cable, array cable and interconnector cable installations.

11.9.7 Population Modelling

11.9.7.1 The iPCoD framework (Harwood *et al.* 2014b, King *et al.* 2015) was used to predict the potential population consequences of the predicted amount of PTS and disturbance resulting from the piling. iPCoD uses a stage structured model of population dynamics with nine age classes and one stage class (adults 10 years and older). The model is used to run a number of simulations of future population trajectory with and without the predicted level of impact, to allow an understanding of the potential future population level consequences of predicted behavioural responses and auditory injury.

11.9.7.2 Simulations were run comparing projections of the baseline population (i.e., under current conditions, assuming current estimates of demographic parameters persist into the future) with a series of paired 'impact' scenarios with identical demographic parameters, incorporating a range of estimates for disturbance. Each simulation was repeated 1,000 times and each simulation draws parameter values from a distribution describing the uncertainty in the parameters. This creates 1,000 matched pairs of population trajectories, differing only with respect to the effect of the disturbance and the distributions of the two trajectories can be compared to demonstrate the magnitude of the long-term effect of the predicted impact on the population, as well as demonstrating the uncertainty in predictions.

11.9.7.3 The effects of disturbance on vital rates (survival and reproduction) are currently unknown. Therefore, expert elicitation was used to construct a probability distribution to represent the knowledge and beliefs of a group of experts regarding a specific Quantity of Interest. In this case, the quantity of interest is the effect of disturbance on the probability of survival and fertility in harbour porpoise, harbour seal and grey seals (Booth *et al.* 2019). The elicitation assumed that the behaviour of the disturbed porpoise would be altered for 6 hours on the day of disturbance, and that no feeding (or nursing) would occur during the 6 hours of disturbance. For seals, the experts assumed that on average, the behaviour of the disturbed seals would be impacted for much less than 24 hours, but did not define an exact duration.

11.9.7.4 Three piling schedules were provided to cover a range of potential indicative piling periods. These were derived using the following assumptions:

- Piling schedule 1: assumes 1 piled anchor is installed per day, resulting in 80 piling days between April 2028 and October 2028 inclusive. This piling schedule is considered to be highly conservative and unlikely to occur, the expectation is that for most WTGs more than 1 piled anchor can be installed in a day.
- Piling schedule 2: assumes 4 piled anchors are installed per day, resulting in 20 piling days between April 2028 and July 2028 inclusive. This piling schedule is considered to be highly optimistic and unlikely to occur, the expectation is that for most WTGs multiple piled anchors can be installed in a day but it is unlikely that all locations can install four in a day.
- Piling schedule 3: assumes between 1 and 4 piled anchors are installed per day, resulting in 40 piling days (on average) between April 2028 and August 2028 inclusive. This piling schedule is considered to be more realistic as it allows for multiple piles to be installed per day across some but not all locations.

11.9.7.5 For each indicative piling scenario, it was assumed that each of the 80 piles had a maximum pile diameter of 3 m and would be installed using a maximum hammer energy of 2,500/1,500 kJ. In reality, a total of 24 piles, which will be used in the construction of the subsea hub, shall have a smaller pile diameter (1.5 m) and will therefore have different hammer energy requirements. As such, the piling scenarios modelled are likely to overestimate the extents of likely disturbance and thus represent the worst-case scenario.

11.9.7.6 For each indicative scenario, the maximum number of animals predicted to be disturbed was assumed for every piled anchor location which will be conservative. The demographic parameters used in the iPCoD modelling were obtained from (Sinclair *et al.* 2020) and are summarised in **Table 11-11**.

Table 11-11 Demographic parameters used in the iPCoD modelling

Species	Harbour porpoise	Harbour seal	Grey seal	Bottlenose dolphin (CES MU)	Bottlenose dolphin (GNS MU)
MU	346,601	364	10,783 (ES MU)	224	2022
Calf/pup survival	0.8455	0.24	0.222	0.925	0.87
Juvenile survival	0.85	0.4	0.94	0.962	0.94
Adult survival	0.925	0.78	0.94	0.98	0.94
Fertility	0.34	0.92	0.84	0.24	0.245
Age at independence	1	1	1	2	2
Age at first birth	5	4	6	9	9

11.10 Limitations and Assumptions

11.10.1.1 There are uncertainties relating to the underwater noise modelling and impact assessment. Broadly, these relate to predicting exposure of animals to underwater noise, predicting the response of animals to underwater noise and predicting potential population consequences of disturbance from underwater noise. Further detail of such uncertainty is presented in **Appendix 1: Limitations and Assumptions**.

11.11 Embedded Mitigation

11.11.1.1 The embedded mitigation relevant to the Marine Mammal assessment is presented in **Table 11-12**.

Table 11-12 Embedded Mitigation for the Marine Mammal assessment

Potential Impact and Effect	Mitigation ID	Mitigation	Project Aspect	Project Phase
Tertiary				
PTS from geophysical surveys, UXO clearance, pile driven anchors and decommissioning activities.	Co16	Marine Mammal Mitigation Protocols (MMMP) for pile driving, geophysical surveys and UXO clearance (if needed) will be implemented. The mitigation measures will be informed by relevant guidance such as: - JNCC (2010): JNCC guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys; - JNCC (2010): JNCC guidelines for minimising the risk of injury to marine mammals from using explosives; and - JNCC (2017): JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys. UXO MMMP to ensure the risk of auditory injury (PTS) from UXO clearance is reduced. Piling MMMP to ensure the risk of auditory injury (PTS) from piling of anchors is reduced. Decommissioning MMMP to ensure the risk of auditory injury (PTS) from decommissioning activities is reduced.	Offshore ECC and OAA	Construction (including pre-construction surveys), Operation and Maintenance, and Decommissioning

Potential Impact and Effect	Mitigation ID	Mitigation	Project Aspect	Project Phase
Entanglement risk	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	Operation and Maintenance
Vessel collision and disturbance	Co11	A Vessel Management Plan (VMP) will be developed and include details of: - Vessel routing to and from construction sites and ports; - Vessel notifications including Notice to Mariners and Kingfisher Bulletin; and - Code of conduct for vessel operators including for the purpose of reducing disturbance and collision with marine fauna.	Offshore ECC and OAA	Construction, Operation and Maintenance, and Decommissioning

11.12 Impacts Scoped Out of the Environmental Impact Assessment Report

11.12.1.1 The Marine Mammal assessment considers all potential impacts identified during scoping, as well as any further potential impacts that were highlighted during consultation to date, as outlined in **Section 11.4** and **Table 11-2.** Impact scoped out of the Marine Mammal assessment are outlined in **Table 11-13.**

Table 11-13 Impacts scoped out of the Marine Mammal assessment

Potential Impact	Project Aspect	Project Phase	Justification
Vessel disturbance during operations and maintenance	Offshore ECC and OAA	Operations and Maintenance	The small number of vessels required for operation and maintenance activities is unlikely to generate an increase in disturbance against the existing baseline of shipping activity.
Risk of injury resulting from collision of marine mammals with installation vessels, during construction and decommissioning	Offshore ECC and OAA	Construction and Decommissioning	It is not expected that increased localised vessel traffic associated with the Offshore Development will increase the risk of collision to marine mammals within the area. Vessel movements will be managed through the implementation of a VMP that will mitigate the negative impacts to marine mammals (e.g. limited vessel speeds, adherence to vessel transit routes). Following relevant (activity-specific) such as

Potential Impact	Project Aspect	Project Phase	Justification
			JNCC guidance to minimise the risks of injury to marine mammals during the construction, operation and maintenance and decommissioning phases of the Offshore Development.
Impacts associated with effects upon marine water quality, particularly due to any disturbed sediments affecting turbidity during construction and decommissioning	Offshore ECC and OAA	Construction and Decommissioning; Operations and Maintenance	Activities relating to the construction and decommissioning of the Offshore Development may influence water quality as a result of sediment disturbance. These impacts are localised and short-lived. Marine mammals often migrate through waters where conditions are turbid for extended periods without significant impacts to species biology or behaviour. For this reason, localised, temporary changes to water quality will not have a significant impact on marine mammals.
Risk of injury resulting from collision of marine mammals with operations and maintenance vessel	Offshore ECC and OAA	Operations and& Maintenance	The small number of vessels required for operation and maintenance activities will be subject to a VMP, resulting in Project vessels unlikely to generate an increase in collision risk against the existing baseline of shipping activity.
Risk associated with electromagnetic fields (EMFs) associated with subsea cabling during operation and maintenance	Offshore ECC and OAA	Operations and& Maintenance	EMFs are emitted along the lengths of subsea cables and can have behavioural and physiological effects on sensitive marine mammals and megafauna species. Existing evidence suggests that the levels of EMFs emitted by offshore renewable energy export cables are at a level low enough that there is no potential for direct significant impacts on marine mammals (Copping and Hemery 2020).
Impacts associated with effects upon marine water quality due to any accidental release of pollutants during operation and maintenance	Offshore ECC and OAA	Construction and Decommissioning; Operations and Maintenance	The accidental release of pollutants is limited to oils and fluids contained within the WTGs and vessels. The potential for full inventory release from a turbine is considered extremely remote and would occur as a slow release, which would be almost undetectable and immediately dispersed, limiting the potential interactions between pollutants and marine mammals.

11.13 Impact Assessment - Construction Phase

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

- Auditory injury (PTS) from pre-construction and construction geophysical surveys;
- Disturbance from pre-construction and construction geophysical surveys;
- Auditory injury (PTS) from UXO clearance;
- Disturbance from UXO clearance;

- Auditory Injury (PTS) from Piling of Anchors;
- Disturbance from Piling of Anchors;
- Auditory Injury (PTS) from Other Construction Activities;
- Disturbance from Other Construction Activities; and
- Indirect Impacts on Prey.

11.13.2 Auditory Injury (Permanent Threshold Shift) from Pre-construction and Construction Geophysical Surveys

11.13.2.1 Pre-construction and construction geophysical equipment could include any or all of the following: sub-bottom profiling (SBP); multibeam echosounder (MBES); Side Scan Sonar (SSS) with piggybacked magnetometer. The SSS/magnetometer would be towed behind the vessel (tow fish), to avoid disturbance from the vessel, and could use ultra-short baseline (USBL) positioning systems.

- Sub Bottom Profiler (SBP): The SBP is a type of geophysical survey tool that uses low-frequency or high-frequency sounds to identify acoustic impedance of the sub-surface geology and to identify transitions from one stratigraphic sequence to another. Sound sources that produce lower frequency pulses can penetrate through and be reflected by subsurface sediments (low-resolution data), whilst higher frequency pulses achieve higher resolution images but do not penetrate the subsurface sediments.
- MBES: MBES is used to acquire detailed seabed topography and water depth by emitting a fan shaped swath of acoustic energy (sound waves) along a survey transect. The sound waves are reflected from the seabed to enable high resolution seafloor mapping. The MBES can be either hull- or ROV-mounted.
- SSS: SSS utilises conical or fan-shaped pulses of sounds directed at the seafloor to provide information on the surface of the seabed through analysis of reflected sound.
- Magnetometer: A magnetometer is used to measure the variation in the earth’s total magnetic field to detect and map ferromagnetic objects on or near the sea floor along the survey’s vessel tracks. Often, two magnetometers are mounted in a gradiometer format to measure the magnetic gradient between the two sensors. The magnetometer is a passive system and, therefore, does not emit any noise.
- USBL system: A USBL system is used to obtain accurate equipment positioning during sampling activities. This system consists of a transceiver mounted under the vessel, and a transponder on deployed equipment. The transceiver transmits an acoustic pulse which is detected by the transponder, followed by a reply of an acoustic pulse from the transponder. This pulse is detected by the transceiver and the time from transmission of the initial pulse is measured by the USBL system and converted into a range.

11.13.2.2 An essential step in assessing the potential for effects on relevant species is a consideration of their auditory sensitivities. Marine mammal hearing groups and auditory injury criteria from Southall *et al*. (2019), and corresponding species of relevance to this assessment, are summarised in **Table 11-14.** There are no audiogram data currently available for low-frequency cetaceans; therefore, predictions are based on the hearing anatomy for each species and considerations of the frequency range of vocalisations.

Table 11-14 Marine mammal hearing groups, estimated hearing range and sensitivity and injury criteria and corresponding species relevant to this assessment (Southall *et al*., 2019)

Hearing Group	Species	Estimated hearing range	Estimated region of greatest sensitivity†	Estimated peak sensitivity†
Low-frequency (LF) cetaceans	Minke whale Humpback whale	7 Hz –35 kHz	200 Hz –19 kHz	-
High-frequency (HF) cetaceans	Bottlenose dolphin White-beaked dolphin Killer whale	150 Hz –160 kHz	8.8 –110 kHz	58 kHz
Very high-frequency (VHF) cetacean	Harbour porpoise	275 Hz –160 kHz	12 –140 kHz	105 kHz
Phocid carnivores in water (PCW)	Harbour seal Grey seal	50 Hz –86 kHz	1.9 –30 kHz	13 kHz

†Region of greatest sensitivity represents low-frequency (F1) and high-frequency (F2) inflection points, while peak sensitivity is the frequency at which the lowest threshold was measured (T0) (Southall *et al*., 2019).

11.13.2.3 Prior to an evaluation in relation to each item of equipment, the overlap between typical survey equipment operating characteristics and marine mammal functional hearing capability is considered in **Table 11-15**. **Table 11-15** presents typical values for geophysical surveys for large offshore wind farms, but equipment specific values will vary between different survey contractors. Where there is no overlap between hearing capability and functional hearing, there is no potential for disturbance effects to occur; however, the potential for injury will still need to be considered if animals could be exposed to sound pressure of sufficient magnitude to cause hearing damage or other harm.

Table 11-15 Comparison of typical noise emitting survey equipment operating characteristics and overlap with the estimated hearing range of different marine mammal functional hearing groups

Equipment	Estimated source pressure level (dB re 1 µPa)	Expected Sound Frequency	LF	HF	VHF	PCW
SBP	210 – 220 dB re 1 µPa (SPL_{peak}) (Hartley Anderson Ltd 2020)	Frequency selectable. Typically 2 – 15kHz with a peak frequency of 3.5 kHz (Hartley Anderson Ltd 2020)	Yes	Yes	Yes	Yes

Equipment	Estimated source pressure level (dB re 1 µPa)	Expected Sound Frequency	LF	HF	VHF	PCW
MBES	210 – 240 dB re 1 µPa (SPLpeak) for multiple beams* (Lurton and Deruiter 2011) 197 dB re 1 µPa (SPLpeak) for a single beam at an operational frequency of 200 kHz (Risch *et al.* 2017)	200 – 400 kHz (Hartley Anderson Ltd 2020)	Above all hearing ranges			
SSS	210 dB re 1 µPa (SPLpeak) (Crocker and Fratantonio 2016, Crocker *et al.* 2019)	300 & 900 kHz (Crocker and Fratantonio 2016, Crocker *et al.* 2019)	Above all hearing ranges			
USBL	187 – 206 dB re 1 µPa (SPLRMS) (Jiménez-Arranz *et al.* 2020)	19 – 34 kHz (Jiménez-Arranz *et al.* 2020)	Yes	Yes	Yes	Yes

**The higher the frequency of operation, the lower the source level tends to be.*

Sensitivity

11.13.2.4 The source levels of USBL equipment are below the PTS-onset thresholds for minke whale, humpback whale, bottlenose dolphins, white-beaked dolphins, killer whales, and grey and harbour seals. Therefore, it is concluded that there would be no risk of PTS onset to any of these species from the use of USBL equipment and the sensitivity their sensitivity is assessed as **Negligible**.

11.13.2.5 While theoretical source levels for USBL exceed the PTS threshold for harbour porpoise by a few dB, noise levels would drop to below the threshold within 10 m of the source and so pose a negligible risk of injury. Furthermore, harbour porpoise hearing is most sensitive at high frequencies between approximately 12 kHz and 140 kHz, with maximum sensitivity occurring at 105 kHz across multiple tested individuals (**Table 11-14**). As such, the frequency at which USBL operates is below that which harbour porpoise are most sensitive to. Harbour porpoise sensitivity to PTS from USBL is therefore assessed as **Negligible.**

11.13.2.6 While the indicative source levels for MBES and SSS exceed the unweighted injury threshold for harbour porpoise and seals, peak energy is far above that of greatest hearing sensitivity and the frequency of the source is sufficiently high that sound pressure levels would be rapidly attenuated to below thresholds for PTS-onset for porpoise within a few meters of the source. As such, the sensitivity of all marine mammals to PTS-onset from use of MBES and SSS equipment is assessed as **Negligible**.

11.13.2.7 While the indicative source levels for SBP exceed the unweighted injury threshold for harbour porpoise and seals, harbour porpoise and seal hearing sensitivity is greatest between 12 –140 kHz (porpoise peak sensitivity: 105 kHz) and 1.9 – 30 kHz (seal peak sensitivity: 13 kHz) respectively. As the operational frequencies of SBP (2 – 15 kHz (peak: 3.5kHz)) shall typically operate below that at which harbour porpoise and seals are most sensitivity to auditory impact, the sensitivity of porpoise and seals to PTS-onset from use of SBP equipment is assessed as **Low.** There is greater overlap between the operational frequencies of SBPs and peak hearing sensitivity for minke whale, but as the source levels are only marginally above the PTS thresholds, minke whale sensitivity to SBP is also assessed as **Low.**

11.13.2.8 The source levels of SBP are typically below the PTS-onset thresholds for dolphins, and the operational frequencies are below that of peak hearing sensitivity. Therefore, the sensitivity of dolphins to PTS effects from SBPs is assessed as **Negligible.**

Impact Magnitude

11.13.2.9 As there is no (minke whale, dolphins seals) or negligible (porpoise) risk of PTS onset to any marine mammals from the use of USBL equipment, the magnitude of impact is assessed as **Negligible.**

11.13.2.10 JNCC (2017) do not advise that mitigation to avoid injury from use of MBES is necessary in shallow (<200 m) waters where the MBES used are of high frequencies (as they are planned to be here). EPS Guidance (JNCC *et al.* 2010) for use of SSS states that "*this type of survey is of a short-term nature and results in a negligible risk of an injury or disturbance offence (under the Regulations)*." An equivalent conclusion was reached by DECC (2011). Furthermore, a recent comprehensive assessment of the characteristics of acoustic survey sources proposed that MBES and SSS should be considered *de minimis* in terms of being not likely to result in PTS to marine mammals or behavioural disturbance under the 160 dB re 1 µPa (rms) threshold adopted in the United States (Ruppel *et al.* 2022). Therefore, the risk of injury from MBES and SSS is concluded to be of **Negligible** magnitude.

11.13.2.11 Considering the anticipated source levels of the SBP equipment, the risk of PTS to marine mammals is generally restricted to harbour porpoise, and modelling exercises have shown the area of potential PTS impact to be restricted to a few tens of metres from the source (BEIS 2020). The JNCC (2017) guidelines for minimising the risk of injury to marine mammals from geophysical surveys contain provisions for SBPs and their implementation is standard for all SBP use in Scottish inshore and offshore waters. Implementation of these guidelines (and embedded mitigation measure, **Table 11-12**) will reduce the already very low risk of injury (PTS) from SBP to all marine mammal species to a negligible level. Therefore, the impact magnitude of PTS from SBP from pre-construction geophysical surveys is assessed as **Negligible** for all marine mammals.

Significant of Impact

11.13.2.12 As the sensitivity of all marine mammals to PTS onset from USBL, MBES and SSS equipment has been assessed as **Negligible**, and the magnitude of impact has been assessed as **Negligible**, the significance of the effect is assessed as **Negligible,** which is **Not Significant** with respect to the EIA Regulations.

11.13.2.13 The sensitivity of marine mammal species to PTS from SBP use has been assessed to be **Negligible** (dolphins) to **Low** (seals, harbour porpoise, minke whale). Considering the embedded mitigation of adherence to the JNCC (2017) guidelines for SBP use, the magnitude of PTS impact from the use of SBP equipment to all marine mammal species has been assessed as **Negligible**. Therefore, the significance of the effect for all marine mammal species is assessed as **Negligible** which is **Not Significant** with respect to the EIA Regulations.

11.13.3 Disturbance from Pre-construction and Construction Geophysical Surveys

Sensitivity

11.13.3.1 As indicated in **Table 11-15**, there is no potential for disturbance effects to occur through use of MBES or SSS, as the sound levels emitted are above 200 kHz and therefore above the hearing frequency range of the marine mammals likely to be present in the region.

11.13.3.2 The sensitivity of all marine mammals to disturbance from MBES and/or SSS is therefore assessed as **Negligible**.

11.13.3.3 As indicated in **Table 11-15**, the expected sound frequency for the USBL falls within the function hearing range for all relevant marine mammal species and, therefore, has the potential to result in disturbance effects.

11.13.3.4 Considering the characteristics of the noise emitted, the risk of disturbance from USBL is considered to be less than that of SBPs. JNCC *et al.* (2010) EPS Guidance concludes that the use of SBPs in geophysical surveys "*could, in a few cases, cause localised short-term impacts on behaviour such as avoidance. However, it is unlikely that this would be considered as disturbance in the terms of the Regulations.*"

11.13.3.5 Therefore, considering the nature of the USBL source, disturbance is likely to be of a very localised spatial extent which is unlikely to extend much beyond that of temporary avoidance associated with the concurrent presence of the survey vessel(s). For example, support and supply vessels of 50-100 m (which encompasses the indicative survey vessels of 70-80 m length) are expected to have broadband source levels in the range 165-180 dB re 1µPa, with the majority of energy below 1 kHz (OSPAR 2009). When using thrusters for dynamic positioning (DP) to hold station during sampling activities, increased sound generation in the order of c. 10 dB over levels when in transit may be expected (Rutenko and Ushchipovskii 2015). Therefore, the noise generated by the survey vessel while holding station on DP is likely to be approaching a similar amplitude to that of the USBL system, albeit with dominant energy at lower frequencies.

11.13.3.6 The sensitivity of marine mammals to disturbance for USBL equipment is therefore assessed as **Low.**

11.13.3.7 As indicated in **Table 11-15**, the expected sound frequency for SBP falls within the functional hearing range for all relevant marine mammal species and, therefore, has the potential to result in disturbance effects. Considering the characteristics of the noise emitted, the risk of disturbance from USBL is considered to be less than that of sub-bottom profilers (SBPs). JNCC et al. (2010) EPS Guidance concludes that the use of SBPs in geophysical surveys "*could, in a few cases, cause localised short-term impacts on behaviour such as avoidance. However, it is unlikely that this would be considered as disturbance in the terms of the Regulations*." The sensitivity of marine mammals to disturbance for SBP equipment is therefore assessed as **Low.**

Impact Magnitude

11.13.3.8 As the sound frequency levels emitted from MBES and SSS are above 200 kHz and therefore above the hearing frequency range of the marine mammals likely to be present in the region, the magnitude of impact is assessed as **Negligible**.

11.13.3.9 considering the source level of the USBL, for a disturbance effect to occur, the animals would have to be in relatively close proximity i.e. within < 1 km. Should the short-term operations result in a response by an animal, this would not be likely to impair the ability of an animal to survive or reproduce, or result in any effects to the local populations or distribution. Any response will likely be temporary; for example, evidence from Thompson *et al.* (2013) suggests that short-term disturbance caused by a commercial two-dimensional seismic survey (a much louder noise source than USBL) does not lead to long-term displacement of harbour porpoises. Therefore, the magnitude of impact is assessed as **Negligible**.

11.13.3.10 There are currently no empirical data available on the behavioural responses of marine mammals to SBP. However, the noise emitted from these sources will be rapidly attenuated with distance from source such that noise levels at which behavioural disturbance would be anticipated to occur will be of small spatial extent. In particular, it is noted that those sources with higher source levels such as SBP, are highly directional, with noise levels outside of the main beam considerably lower and therefore with limited horizontal propagation of noise levels. JNCC *et al.* (2010) EPS Guidance concludes that the use of SBPs in geophysical surveys "*Could, in a few cases, cause localised short-term impacts on behaviour such as avoidance. However, it is unlikely that this would be considered as disturbance in the terms of the Regulations. It is unlikely that injury would occur as an animal would need to locate in the very small zone of ensonification and stay in that zone associated with the vessel for a period of time, which is also unlikely.*" Should the short-term operations result in a response by an animal, this would not be likely to impair the ability of an animal to survive or reproduce, or result in any effects to the local populations or distribution. Any response will likely be temporary; for example, evidence from Thompson *et al.* (2013) suggests that short-term disturbance caused by a commercial two-dimensional seismic survey (a much louder noise source (peak-to-peak source levels estimated to be 242–253 dB re 1 µPa at 1 m) than SBP, does not lead to long-term displacement of harbour porpoises. Therefore, the magnitude of impact is assessed as **Low** for all marine mammals as disturbance shall only cause short-term and/or intermittent and temporary behavioural effects in a limited spatial extent around the source, and therefore only affect a small proportion of the population.

Significance of Impact

11.13.3.11 As the sensitivity of all marine mammals to disturbance from MBES and SSS equipment has been assessed as **Negligible**, and the magnitude of impact has been assessed as **Negligible**, the significance of the effect is assessed as **Negligible**, which is **Not Significant** with respect to the EIA Regulations.

11.13.3.12 As the sensitivity of all marine mammals to disturbance from USBL equipment has been assessed as **Low**, and the magnitude of impact has been assessed as **Negligible**, the significance of the effect is assessed as **Negligible**, which is **Not Significant** with respect to the EIA Regulations.

11.13.3.13 As the sensitivity of all marine mammals to disturbance from SBP equipment has been assessed as **Low**, and the magnitude of impact has been assessed as **Low,** the significance of the effect is assessed as **Negligible,** which is **Not Significant** with respect to the EIA Regulations.

11.13.4 Auditory Injury (Permanent Threshold Shift) from Unexploded Ordnance Clearance

11.13.4.1 If found, a risk assessment will be undertaken and items of UXO will be either avoided by equipment micro-siting, moved, or detonated in situ. Recent advancements in the commercial availability of methods for UXO clearance mean that high-order detonation may be largely or completely avoided. The methods of UXO clearance considered for Salamander may include:

- Removal / relocation;
- Low-order clearance (deflagration); and
- High-order detonation.

11.13.4.2 As the detailed pre-construction surveys have not yet been completed, it is not possible at this time to determine how many items of UXO will require clearance. As a result, a separate Marine Licence will be applied for post-consent for the clearance (where required) of any UXO identified. In order to define the design envelope for consideration of UXO within the EIA, a review of recent information has been undertaken. Current advice from the UK Statutory Nature Conservation Bodies is that the Southall *et al.* (2019) criteria should be used for assessing the impacts from UXO detonation on marine mammals, and this advice has been followed for this assessment. However, the suitability of these criteria for UXO is under discussion due to the lack of empirical evidence from UXO detonations using these metrics, in particular the range-dependent characteristics of the peak sounds, and whether current propagation models can accurately predict the range at which these thresholds are reached.

11.13.4.3 Regardless, the maximum equivalent charge weight for the potential UXO devices that could be present within the site boundary has been estimated as 698 kg (TNT equivalent). The potential auditory injury (PTS) impact ranges have been modelled for the high-order clearance of a 698 kg UXO alongside a range of smaller devices, at charge weights of 25, 55, 120, 240, and 525 kg. In each case, an additional donor weight of 0.5 kg has been included to initiate detonation. Additionally, a low-order clearance scenario has been modelled, assuming a donor charge of 0.25 kg. The unweighted UXO clearance source levels are presented in **Table 11-16**, whilst **Table 11-17** presents the impact ranges for auditory injury (PTS) from UXO clearance, considering various charge weights and impact criteria. Full details of the underwater noise modelling and the resulting auditory injury (PTS-onset) impact areas and ranges are detailed in **Volume ER.A.4, Annex 4.1: Underwater Noise Modelling Report.**

Table 11-16 Summary of the unweighted SPL_{peak} and SEL_{ss} source levels used for Unexploded Ordinance clearance modelling

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 µPa²s @ 1 m
25 kg + donor	284.9 dB re 1 µPa @ 1 m	228.0 dB re 1 µPa²s @ 1 m
55 kg + donor	287.5 dB re 1 µPa @ 1 m	230.1 dB re 1 µPa²s @ 1 m
120 kg + donor	290.0 dB re 1 µPa @ 1 m	232.2 dB re 1 µPa²s @ 1 m
240 kg + donor	292.3 dB re 1 µPa @ 1 m	234.2 dB re 1 µPa²s @ 1 m
525 kg + donor	294.8 dB re 1 µPa @ 1 m	236.4 dB re 1 µPa²s @ 1 m
698 kg + donor	295.7 dB re 1 µPa @ 1 m	237.1 dB re 1 µPa²s @ 1 m

Sensitivity

11.13.4.4 Most of the acoustic energy produced by a high-order detonation is below a few hundred Hz, decreasing on average by about SEL 10 dB per decade above 100 Hz, and there is a pronounced drop-off in energy levels above ~5-10 kHz (von Benda-Beckmann *et al.* 2015, Salomons *et al.* 2021). Therefore, the primary acoustic energy from a high-order UXO detonation is below the region of greatest sensitivity for most marine mammal species considered here (porpoise, dolphins and seals) (Southall *et al.* 2019). If PTS were to occur within this low frequency range, it would be unlikely to result in any significant impact to vital rates of porpoise, dolphins, and seals.

11.13.4.5 Therefore, most marine mammals (porpoise, dolphins, and seals) have been assessed as having a **Low** sensitivity to auditory injury (PTS-onset) from UXO clearance.

11.13.4.6 Recent acoustic characterisation of UXO clearance noise has shown that there is more energy at lower frequencies (<100 Hz) then previously assumed (Robinson *et al.* 2022). Given the lower frequency components of the sound produced by UXO clearance, it is more precautionary to assess minke whales (and other low frequency cetaceans such as humpback whale) as having a **Medium** sensitivity to auditory injury (PTS-onset) from UXO clearance.

Magnitude

11.13.4.7 UXO detonation is defined as a single pulse and thus both the weighted SEL_{ss} criteria and the unweighted SPL_{peak} criteria from Southall *et al.* (2019) have been given in **Table 11-17**. As a result, animal fleeing assumptions do not apply to the values presented.

11.13.4.8 Estimated auditory injury (PTS-onset) impact ranges increased with the size of the charge for all marine mammal groups. With the exception of LF cetaceans (minke whales and humpback whale), PTS-onset impact ranges are larger for the unweighted SPL_{peak} criterion than the weighted SEL_{ss} criterion. At all charge weights, HF cetaceans (dolphins and killer whales) have the smallest predicted impact range of up to 810 m (SPL_{peak}). Seal species and LF cetaceans (minke whale and humpback whale) are predicted to have maximum PTS-onset impact ranges of 2.7 km and 2.4 km (SPL_{peak}) respectively. VHF cetaceans (harbour porpoise) have the largest PTS-onset impact ranges for each charge, with a maximum of 13 km (SPL_{peak}) for a 698 kg charge plus donor. For LF cetaceans (minke whale and humpback whale), the low-frequency sensitivity of their hearing results in larger impact ranges using the weighted SEL_{ss} PTS-onset criteria, with a maximum range of 10 km for the largest charge weight.

11.13.4.9 The auditory injury (PTS-onset) range for low-order clearance is small across all species, charge weight and criteria, with a maximum impact range of <1 km.

Table 11-17 Summary of the auditory injury (Permanent Threshold Shift - onset) impact ranges for Unexploded Ordnance detonation using the impulsive, weighted SEL_{ss} and unweighted SPL_{peak} noise criteria from Southall *et al.* (2019) for marine mammals

Southall *et al.* (2019)	PTS (weighted SEL_{ss})				PTS (unweighted SPL_{peak})			
	LF 183 dB	HF 185 dB	VHF 155 dB	PCW 185 dB	LF 219 dB	HF 230 dB	VHF 202 dB	PCW 218 dB
Low order (0.25 kg)	230 m	< 50 m	80 m	40 m	170 m	60 m	990 m	190 m
25 kg + donor	2.2 km	< 50 m	570 m	390 m	820 m	260 m	4.6 km	910 m
55 kg + donor	3.2 km	< 50 m	740 m	570 m	1.0 km	340 m	6.0 km	1.1 km
120 kg + donor	4.7 km	< 50 m	950 m	830 m	1.3 km	450 m	7.8 km	1.5 km
240 kg + donor	6.5 km	< 50 m	1.1 km	1.1 km	1.7 km	560 m	9.8 km	1.9 km
525 kg + donor	9.5 km	50 m	1.4 km	1.6 km	2.2 km	730 m	12 km	2.5 km
698 kg + donor	10 km	60 m	1.5 km	1.9 km	2.4 km	810 m	13 km	2.7 km

11.13.4.10 Across all marine mammal species, only bottlenose dolphins and white-beaked dolphins are predicted to have ≤1 individual to experience auditory injury (PTS-onset) from UXO clearance activities under both SPL_{peak} and SEL_{ss} scenarios (**Table 11-18**). For harbour porpoise, up to 377 individuals (SPL_{peak}, using the site-specific digital arial survey density estimate) are predicted to experience auditory injury (PTS-onset) from UXO clearance at the greatest charge weight, which is <0.24% of the North Sea MU. For minke whale, up to 13 individuals ($SEL_{ss,}$ using the SCANS IV Block NS-D density estimate) are predicted to experience auditory injury (PTS-onset) from UXO clearance at the largest charge weight, which is 0.07% of the Celtic and Greater North Seas MU.

11.13.4.11 No quantitative assessment is provided for humpback whales or killer whales due to a lack of density estimate or MU size.

11.13.4.12 For all marine mammal species, the unmitigated impact magnitude has been assessed as **Medium.** This is due to the fact that while only a very small number of animals are predicted to be impacted, auditory injury (PTS) is a permanent impact. Therefore, auditory injury from UXO clearance is expected to have a permanent effect on individuals that may influence individual survival but not at a level that would alter population trajectory over a generational scale.

11.13.4.13 However, as the Salamander Project has committed to implementing a UXO-specific MMMP. Although the exact mitigation measures contained with the UXO MMMP are yet to be determined, they will be in line with the latest relevant guidance at the time of this stage of the Salamander Project. Multiple measures are available and have been implemented elsewhere for UXO clearance, such as the use of ADDs and scarer charges to displace animals to beyond the PTS impact range, a preference for low-noise alternatives to high-order detonation, or noise abatement techniques where appropriate. Therefore, the magnitude of the impact is assessed as **Negligible.**

Table 11-18 Summary of the number of individual marine mammals and the proportion of the respective species Management Units based on the impact ranges for Unexploded Ordnance detonation using the impulsive, weighted SEL_{ss} and unweighted SPL_{peak} noise criteria from Southall *et al*. (2019)

			PTS weighted SELss							PTS unweighted SPLpeak						
Species	*Density (#/km²)*	*Impact*	*Low order (0.25 kg)*	*25 kg + donor*	*55 kg + donor*	*120 kg + donor*	*240 kg + donor*	*525 kg + donor*	*698 kg + donor*	*Low order (0.25 kg)*	*25 kg + donor*	*55 kg + donor*	*120 kg + donor*	*240 kg + donor*	*525 kg + donor*	*698 kg + donor*
Harbour porpoise	0.71 (DAS)	# animals	<1	<1	1	2	3	4	5	2	47	80	136	214	321	377
		% NS MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	0.05	0.09	0.13	0.20	0.24
		% UK MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.01	0.02	0.04	0.06	0.09	0.11
	0.599 (SCANS III R)	# animals	<1	1	1	2	2	4	4	2	40	68	114	181	271	318
		% NS MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.04	0.07	0.11	0.17	0.20
		% UK MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.02	0.03	0.05	0.08	0.09
	0.5985 (SCANS IV NS-D)	# animals	<1	1	1	2	2	4	4	2	40	68	114	181	271	318
		% NS MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.04	0.07	0.11	0.17	0.20
		% UK MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.02	0.03	0.05	0.08	0.09
Minke whale	0.0387 (SCANS III R)	# animals	<1	1	1	3	5	11	12	<1	<1	<1	<1	<1	1	1
		% CGNS MU	<0.01	<0.01	<0.01	0.01	0.02	0.05	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

			PTS weighted SELss							PTS unweighted SPLpeak						
Species	*Density (#/km^2)*	*Impact*	*Low order (0.25 kg)*	*25 kg + donor*	*55 kg + donor*	*120 kg + donor*	*240 kg + donor*	*525 kg + donor*	*698 kg + donor*	*Low order (0.25 kg)*	*25 kg + donor*	*55 kg + donor*	*120 kg + donor*	*240 kg + donor*	*525 kg + donor*	*698 kg + donor*
		% UK MU	<0.01	0.01	0.01	0.03	0.02	0.11	0.12	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.01
	0.0419 (SCANS IV NS-D)	# animals	<1	1	1	3	6	12	13	<1	<1	<1	<1	<1	1	1
		% CGNS MU	<0.01	<0.01	<0.01	0.01	0.03	0.06	0.07	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
		% UK MU	<0.01	0.01	0.01	0.03	0.05	0.12	0.13	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.01
Bottlenose dolphin	0.01 (uniform CES MU)	# animals	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
		% CES MU	<0.45	<0.45	<0.45	<0.45	<0.45	<0.45	<0.45	<0.45	<0.45	<0.45	<0.45	<0.45	<0.45	<0.45
	0.003 (uniform GNS MU)	# animals	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
		% GNS MU	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
		% UK MU	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
White-beaked dolphin	0.243 (SCANS III R)	# animals	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
		% CGNS MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
		% UK MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

			PTS weighted SELss							PTS unweighted SPLpeak						
Species	*Density (#/km²)*	*Impact*	*Low order (0.25 kg)*	*25 kg + donor*	*55 kg + donor*	*120 kg + donor*	*240 kg + donor*	*525 kg + donor*	*698 kg + donor*	*Low order (0.25 kg)*	*25 kg + donor*	*55 kg + donor*	*120 kg + donor*	*240 kg + donor*	*525 kg + donor*	*698 kg + donor*
	0.0799 (SCANS IV NS-D)	# animals	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
		% CGNS MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
		% UK MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Harbour seal	0.00002 (average OAA and Offshore ECC)	# animals	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
		% ES MU	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27
Grey seal	0.004 (average OAA and Offshore ECC)	# animals	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
		% ES MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Significance of Impact

11.13.4.14 The sensitivity of porpoise, dolphins and seals to PTS onset from UXO has been assessed as **Low**, and the sensitivity of minke whales to PTS onset from UXO has been assessed as **Medium**.

11.13.4.15 As the Salamander Project has committed to implementing a UXO-specific MMMP, the magnitude of impact for all marine mammals is reduced to **Negligible**. As such, the impact of PTS from UXO clearance is considered to be of **Negligible** significance, which is Not Significant with respect to the EIA Regulations.

11.13.5 Disturbance from Unexploded Ordnance Clearance

11.13.5.1 This assessment presents results for each of the following behavioural disturbance thresholds:

- 26 km effective deterrence range (EDR) for high-order detonation;
- 5 km EDR for low-order clearance; and
- TTS-onset thresholds for both high order detonation - and low-order clearance.

Sensitivity – All Behavioural Disturbance Thresholds

11.13.5.2 It is noted in the JNCC (2020) guidance that, although UXO detonation is considered a loud underwater noise source, "...a one-off explosion would probably only elicit a startle response and would not cause widespread and prolonged displacement...". Whilst detonations will usually be undertaken as part of a campaign and, therefore, there may result in multiple detonations over several days (JNCC 2020), each detonation will be of a short-term duration. Therefore, it is not expected that disturbance from a single UXO detonation would result in any significant impacts, and that disturbance from a single noise event would not be sufficient to result in any changes to the vital rates of individuals. Therefore, the sensitivity of marine mammals for disturbance from UXO clearance is expected to be **Low**, irrespective of the disturbance threshold used in the assessed.

11.13.5.3 The below sections provide a summary of the magnitude of impact and significance of impact for each behavioural disturbance threshold used.

26 km Effective Deterrent Ranges

11.13.5.4 The 26 km EDR has been used here for illustrative purposes and should be viewed with caution as there is no empirical evidence to support this impact range for any species of marine mammal.

Magnitude of Impact

11.13.5.5 The greatest estimated disturbance in terms of % MU is to bottlenose dolphins and white-beaked dolphins, where up to 9 bottlenose dolphins (4.02% CES MU) and 516 white-beaked dolphins (1.17% MU) are predicted to be disturbed (**Table 11-19**). The percentage of the bottlenose dolphin MU anticipated to be impacted is greatest when using the CES MU density estimate and, therefore, this figure is considered as the realistic worst-case scenario.

11.13.5.6 The 26 km EDR for UXO clearance is based on the high-order detonation of UXOs. However, there is no empirical evidence of marine mammal avoidance from such events. It is expected that the detonation of a UXO would elicit a startle response and potentially very short duration behavioural responses and would therefore not be expected to cause widespread and prolonged displacement (JNCC 2020). The consequence of the impact is therefore short-term and intermittent with temporary behavioural effects that are very unlikely to alter survival and reproductive rates to the extent that the population trajectory would be altered.

Therefore, disturbance impacts associated with high-order UXO clearance on all marine mammals are assessed as **Low** magnitude.

Table 11-19 Estimated number of marine mammals potentially at risk of disturbance during Unexploded Ordnance clearance (assuming a 26 km Effective Deterrence Range, resulting in a 2,123.72 km^2 impact area)

Species	Density	# Impacted	% MU	% UK MU
Harbour porpoise	0.71 porpoise/km² (DAS)	1,508	0.44%	0.94%
	0.599 porpoise/km² (SCANS III Block R)	1,272	0.37%	0.80%
	0.5985 porpoise/km² (SCANS IV NS-D)	1,271	0.37%	0.80%
Minke whale	0.0387 whales/km² (SCANS III Block R)	82	0.41%	0.80%
	0.0419 whales/km² (SCANS IV NS-D)	89	0.44%	0.87%
Bottlenose dolphin	0.01 dolphins/km² (uniform across CES MU)	9	4.02% CES MU	
	0.003 dolphins/km² (uniform across GNS MU)	6	0.30% GNS MU 0.32% UK GNS MU	
White-beaked dolphin	0.243 dolphins/km² (SCANS III Block R)	516	1.17%	1.52%
	0.0799 dolphins/km² (SCANS IV NS-D)	170	0.39%	0.50%
Grey seal	0.04 seals/km² (average across Offshore Array and Offshore ECC)	8	0.07% ES MU	
Harbour seal	0.00002 seals/km² (average across Offshore Array and Offshore ECC)	0	<0.27% ES MU	

Significance of Impact

11.13.5.7 The sensitivity of all marine mammals to disturbance from high-order UXO clearance has been assessed as **Low**, whilst the magnitude of the impact has been assessed as **Low**. Therefore, for all marine mammals the significance of the impact is assessed as **Negligible** impact, which is **Not Significant** with respect to the EIA Regulations.

<u>5 km Effective Deterrent Ranges</u>

11.13.5.8 It is important to note that while high-order detonation represents the realistic very worst-case scenario for UXO clearance, it is highly likely that low-order clearance methods (deflagration) will be used instead.

Magnitude of Impact

11.13.5.9 The 5 km EDR has been used here for illustrative purposes and should be viewed with caution as there is no empirical evidence to support this impact range for any species of marine mammal (**Table 11-20**).

11.13.5.10 The greatest estimated disturbance occurs for bottlenose dolphins, where 1 dolphin is predicted to be disturbed (0.45% CES MU) (**Table 11-20**). The percentage of the bottlenose dolphin MU anticipated to be impacted is greatest when using CES density estimate and, therefore, this figure is considered as the realistic worst-case scenario. It is expected that the detonation of a UXO would elicit a startle response and potentially very short duration behavioural responses and would therefore not be expected to cause widespread and prolonged displacement (JNCC 2020). The consequence of the impact is short-term and intermittent with temporary behavioural effects that are very unlikely to alter survival and reproductive rates to the extent that the population trajectory would be altered. Therefore, disturbance impacts associated with low-order UXO clearance on all marine mammals are assessed as **Low** magnitude.

Table 11-20 Estimated number of marine mammals potentially at risk of disturbance during Unexploded Ordnance clearance (assuming an Effective Deterrence Range of 5 km, resulting in a 78.54 km^2 impact area)

Species	Density	# Impacted	% MU	% UK MU
Harbour porpoise	0.71 porpoise/km^2 (DAS)	56	0.02%	0.04%
	0.599 porpoise/km^2 (SCANS III Block R)	47	0.01%	0.03%
	0.5985 porpoise/km^2 (SCANS IV NS-D)	47	0.01%	0.03%
Minke whale	0.0387 whales/km^2 (SCANS III Block R)	3	0.01%	0.03%
	0.0419 whales/km^2 (SCANS IV NS-D)	3	0.01%	0.03%
Bottlenose dolphin	0.01 dolphins/km^2 (uniform across CES MU)	1	0.45% CES MU	
	0.003 dolphins/km^2 (uniform across GNS MU)	<1	<0.05% GNS MU <0.05% UK GNS MU	
White-beaked dolphin	0.243 dolphins/km^2 (SCANS III Block R)	19	0.04%	0.06%
	0.0799 dolphins/km^2 (SCANS IV NS-D)	6	0.01%	0.02%
Grey seal	0.004 seals/km^2 (average across Offshore Array and Offshore ECC)	<1	<0.27% ES MU	
Harbour seal	0.00002 seals/km^2 (average across Offshore Array and Offshore ECC)	<1	<0.01% ES MU	

Significance of Impact

11.13.5.11 Given that the sensitivity of all marine mammals to disturbance from low-order UXO clearance has been assessed as **Low** and the magnitude of the impact to all marine mammals has also been assessed as **Low** the impact of disturbance from low-order UXO clearance to all marine mammals is assessed as being of **Negligible** significance**,** which is **Not Significant** with respect to the EIA Regulations.

Temporary Threshold Shift- Onset as a Proxy for Disturbance

11.13.5.12 **Table 11-21** presents the TTS as a proxy for disturbance impact ranges for UXO detonation considering various charge weights and impact criteria. Full details of the underwater noise modelling and the resulting TTS-onset impact areas and ranges are detailed in **Volume ER.A.4, Annex 4.1: Underwater Noise Modelling Report.**

Magnitude of Impact

11.13.5.13 Estimated TTS impact ranges increased with the size of the charge for all marine mammal groups (**Table 11-21**). At all charge weight, HF cetaceans (dolphins) have the smallest predicted impact range of < 50 m to 590 m for weighted SEL_{ss} noise criteria and 100 m to 1.4 km for unweighted SPL_{peak} noise criteria. Impact ranges for VHF cetaceans (harbour porpoise) were greatest under unweighted SPL_{peak} noise criteria and ranged from 1.8 km to 25 km, whilst for PCW (seals) impact ranges were greatest under a weighted SEL_{ss} scenario and ranged from 570 m to 22 km (smallest to largest charge). LF cetaceans (minke whale) show the greatest impact range under the weighted SEL_{ss} noise criteria, with TTS-onset predicted at 3.2 km to 110 km (smallest to largest charge).

11.13.5.14 For bottlenose dolphin and common dolphin, less than 1% of the MU are predicted to be subject to TTS across all charge weight under both SEL_{ss} and SPL_{peak} noise criteria (**Table 11-22**). For harbour porpoise, the greatest TTS impact is at the highest charge weight for unweighted noise criteria (SPL_{peak}), where 1,394 individuals are anticipated to be subject to TTS, which is 0.40% of the MU. For minke whales 1,593 individuals (7.92% MU) are predicted to be subject to TTS at the largest charge weight for weighted single strike (SEL_{ss}) noise criteria. The largest impact for pinnipeds is for grey seals, where 6 seals (1.67% MU) are predicted to be subject to TTS respectively at the largest charge weight, again, for weighted single strike (SEL_{ss}) noise criteria.

11.13.5.15 Southall et al. (2007) states that the use of TTS as a proxy for disturbance is "expected to be precautionary because TTS at onset levels is unlikely to last a full diel cycle or to have serious biological consequences during the time TTS persists.". TTS-onset thresholds are therefore likely to over-estimate the true behavioural response of any number of individuals predicted to be impacted.

11.13.5.16 In the case of minke whale, sound is unlikely to propagate as far as the theoretical predicted ranges for the highest charge weight (**Table 11-21**), and therefore the number of individuals predicted to be impacted (and proportion of MU) presented in **Table 11-22** is likely to be significantly less.

11.13.5.17 It is expected that the detonation of a UXO would elicit a startle response and potentially very short duration behavioural responses and would therefore not be expected to cause widespread and prolonged displacement (JNCC 2020). Given the percentage of the MUs predicted to be impacted across all marine mammals, and the fact the consequence of the impact is likely short-term and intermittent with temporary behavioural effects that are very unlikely to alter survival and reproductive rates to the extent that the population trajectory would be altered, TTS impacts associated with UXO clearance on all marine mammals are assessed as **Low** magnitude.

Significance of Impact

11.13.5.18 Given that the sensitivity of all marine mammals to disturbance from UXO clearance has been assessed as **Low** and the magnitude of the impact to all marine mammals has also been assessed as **Low,** the impact of TTS as a proxy for disturbance from UXO clearance to all marine mammals is assessed as being of **Negligible** significance, which is **Not Significant** with respect to the EIA Regulations.

Table 11-21 Maximum range impacted using Temporary Threshold Shift as a proxy for disturbance for Unexploded Ordnance clearance

	TTS weighted SEL_{ss}							TTS unweighted SPL_{peak}						
Species	*Low order (0.25 kg)*	*25 kg + donor*	*55 kg + donor*	*120 kg + donor*	*240 kg + donor*	*525 kg + donor*	*698 kg + donor*	*Low order (0.25 kg)*	*25 kg + donor*	*55 kg + donor*	*120 kg + donor*	*240 kg + donor*	*525 kg + donor*	*698 kg + donor*
LF Cetacean (minke whale)	3.2 km	29 km	41 km	57 km	76 km	100 km	110 km	320 m	1.5 km	1.9 km	2.5 km	3.2 km	4.1 km	4.5 km
HF cetaceans (dolphins)	<50 m	150 m	210 m	300 m	390 m	530 m	590 m	100 m	490 m	640 m	830 m	1.0 km	1.3 km	1.4 km
VHF cetacean (porpoise)	750 m	2.4 km	2.8 km	3.2 km	3.5 km	4.0 km	4.1 km	1.8 km	8.5 km	11 km	14 km	18 km	23 km	25 km
PCW (seals)	570 m	5.2 km	7.5 km	10 km	14 km	19 km	22 km	360 m	1.6 km	2.1 km	2.8 km	3.5 km	4.6 km	5.0 km

Table 11-22 Estimated number of marine mammals potentially at risk of disturbance (using Temporary Threshold Shift as a proxy) during Unexploded Ordnance clearance

			TTS weighted SEL_{ss}							**TTS unweighted SPL_{peak}**						
Species	*Density (#/km²)*	*Impact*	*Low order (0.25 kg)*	*25 kg + donor*	*55 kg + donor*	*120 kg + donor*	*240 kg + donor*	*525 kg + donor*	*698 kg + donor*	*Low order (0.25 kg)*	*25 kg + donor*	*55 kg + donor*	*120 kg + donor*	*240 kg + donor*	*525 kg + donor*	*698 kg + donor*
Harbour porpoise	0.71 (DAS)	# animals	1	13	17	23	27	36	37	7	161	270	437	723	1180	1394
		% NS MU	<0.01	<0.01	0.01	0.01	0.01	0.01	0.01	<0.01	0.05	0.08	0.13	0.21	0.34	0.40
		% UK MU	<0.01	0.01	0.01	0.01	0.02	0.02	0.02	<0.01	0.10	0.17	0.27	0.45	0.74	0.87
	0.599 (SCANS III R)	# animals	1	11	15	19	23	30	32	6	136	228	369	610	995	1176
		% NS MU	<0.01	<0.01	<0.01	0.01	0.01	0.01	0.01	<0.01	0.04	0.07	0.11	0.18	0.29	0.34
		% UK MU	<0.01	0.01	0.01	0.01	0.01	0.02	0.02	<0.01	0.09	0.14	0.23	0.38	0.62	0.74
	0.5985 (SCANS IV NS-D)	# animals	1	11	15	19	23	30	32	6	136	228	369	610	995	1176
		% NS MU	<0.01	<0.01	<0.01	0.01	0.01	0.01	0.01	<0.01	0.04	0.07	0.11	0.18	0.29	0.34
		% UK MU	<0.01	0.01	0.01	0.01	0.01	0.02	0.02	<0.01	0.09	0.14	0.23	0.38	0.62	0.74
Minke whale	0.0387 (SCANS III R)	# animals	1	102	204	395	702	1216	1471	<1	<1	<1	1	1	2	2
		% CGNS MU	<0.01	0.51	1.01	1.96	3.49	6.04	7.31	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.01

			TTS weighted SEL_{ss}							TTS unweighted SPL_{peak}						
Species	*Density (#/km²)*	*Impact*	*Low order (0.25 kg)*	*25 kg + donor*	*55 kg + donor*	*120 kg + donor*	*240 kg + donor*	*525 kg + donor*	*698 kg + donor*	*Low order (0.25 kg)*	*25 kg + donor*	*55 kg + donor*	*120 kg + donor*	*240 kg + donor*	*525 kg + donor*	*698 kg + donor*
		% UK MU	0.01	0.99	1.98	3.84	6.82	11.82	14.30	<0.01	<0.01	<0.01	0.01	0.01	0.02	0.02
	0.0419 (SCANS IV NS-D)	# animals	1	111	221	428	760	1316	1593	<1	<1	<1	1	1	2	3
		% CGNS MU	0.01	0.55	1.10	2.13	3.78	6.54	7.92	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.01
		% UK MU	0.01	1.08	2.16	4.18	7.44	12.87	15.57	<0.01	<0.01	<0.01	0.01	0.01	0.02	0.02
Bottlenose dolphin	0.01 (uniform CES MU)	# animals	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
		% CES MU	<0.45	<0.45	<0.45	<0.45	<0.45	<0.45	<0.45	<0.45	<0.45	<0.45	<0.45	<0.45	<0.45	<0.45
	0.003 (uniform GNS MU)	# animals	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
		% GNS MU	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
		% UK MU	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
White-beaked dolphin	0.243 (SCANS III R)	# animals	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1	1	1	1
		% CGNS MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
		% UK MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

			TTS weighted SEL_{ss}							**TTS unweighted SPL_{peak}**						
Species	*Density (#/km²)*	*Impact*	*Low order (0.25 kg)*	*25 kg + donor*	*55 kg + donor*	*120 kg + donor*	*240 kg + donor*	*525 kg + donor*	*698 kg + donor*	*Low order (0.25 kg)*	*25 kg + donor*	*55 kg + donor*	*120 kg + donor*	*240 kg + donor*	*525 kg + donor*	*698 kg + donor*
	0.0799 (SCANS IV NS-D)	# animals	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
		% CGNS MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
		% UK MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Harbour seal	0.00002 (average OAA and Offshore ECC)	# animals	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
		% ES MU	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27
Grey seal	0.004 (average OAA and Offshore ECC)	# animals	<1	<1	1	1	2	5	6	<1	<1	<1	<1	<1	<1	<1
		% ES MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

11.13.6 Auditory Injury (Permanent Threshold Shift) from Piling of Anchors

<u>Sensitivity</u>

Harbour Porpoise

11.13.6.1 The ecological consequences of PTS for marine mammals are uncertain. At an expert elicitation workshop for the interim Population Consequences of Disturbance framework (iPCoD framework), experts in marine mammal hearing discussed the nature, extent and potential consequence of PTS to UK marine mammal species arising from exposure to repeated low-frequency impulsive noise such as pile driving (Booth and Heinis 2018). This workshop outlined and collated the best and most recent empirical data available on the effects of PTS on marine mammals. Several general points came out in discussions as part of the elicitation. These included that PTS did not mean animals were deaf, that the limitations of the ambient noise environment should be considered and that the magnitude and frequency band in which PTS occurs are critical to assessing the effect on vital rates.

11.13.6.2 Southall *et al.* (2007) defined the onset of TTS as *"being a temporary elevation of a hearing threshold by 6 dB"* (in which the reference pressure for the dB is 1µPa). Although 6 dB of TTS is a somewhat arbitrary definition of onset, it has been adopted largely because 6 dB is a measurable quantity that is typically outside the variability of repeated thresholds measurements. The onset of PTS was defined as a non-recoverable elevation of the hearing threshold of 6 dB, for similar reasons. Based upon TTS growth rates obtained from the scientific literature, it has been assumed that the onset of PTS occurs after TTS has grown to 40 dB. The growth rate of TTS is dependent on the frequency of exposure, but is nevertheless assumed to occur as a function of an exposure that results in 40 dB of TTS, i.e., 40 dB of TTS is assumed to equate to 6 dB of PTS.

11.13.6.3 For piling noise, most energy is between ~30 – 500 Hz, with a peak usually between 100 – 300 Hz and energy extending above 2 kHz (Kastelein *et al.* 2015a, Kastelein *et al.* 2016). Studies have shown that exposure to impulsive pile driving noise induces TTS in a relatively narrow frequency band in harbour porpoise and harbour seals (reviewed in Finneran 2015), with statistically significant TTS occurringng at 4 and 8 kHz (Kastelein *et al.* 2016) and centred at 4 kHz (Kastelein *et al.* 2012a, Kastelein *et al.* 2012b, Kastelein *et al.* 2013b, Kastelein *et al.* 2017). Therefore, during the expert elicitation, the experts agreed that any threshold shifts as a result of pile driving would manifest themselves in the 2 – 10 kHz range (Kastelein *et al.* 2017) and that a PTS 'notch' of 6 – 18 dB in a narrow frequency band in the 2 – 10 kHz region is unlikely to significantly affect the fitness of individuals (ability to survive and reproduce). The expert elicitation concluded that:

- *"… the effects of a 6 dB PTS in the 2-10 kHz band was unlikely to have a large effect on survival or fertility of the species of interest.*
- *… for all species experts indicated that the most likely predicted effect on survival or fertility as a result of 6 dB PTS was likely to be very small (i.e., <5% reduction in survival or fertility).*
- *… the defined PTS was likely to have a slightly larger effect on calves/pups and juveniles than on mature females' survival or fertility."*

11.13.6.4 For harbour porpoise, the predicted decline in vital rates from the impact of a 6 dB PTS in the 2-10 kHz band for different percentiles of the elicited probability distribution are provided in **Table 11-23**.

Table 11-23 Predicted decline in harbour porpoise vital rates for different percentiles of the elicited probability distribution

Percentiles of the elicited probability distribution	10%	20%	30%	40%	50%	60%	70%	80%	90%
Adult survival	0	0	0	0.01	0.01	0.03	0.05	0.1	0.23
Fertility	0	0	0.02	0.05	0.09	0.16	0.3	0.7	1.35
Calf/Juvenile survival	0	0	0.02	0.09	0.18	0.31	0.49	0.8	1.46

11.13.6.5 The data provided in Table 11-23 should be interpreted as:

- Experts estimated that the median decline in an individual mature female harbour porpoise's survival was 0.01% (due to a 6 dB PTS (a notch a few kHz wide and 6 dB high) occurring somewhere in the hearing between 2-10 kHz).
- Experts estimated that the median decline in an individual mature female harbour porpoise's fertility was 0.09% (due to a 6 dB PTS (a notch a few kHz wide and 6 dB high) occurring somewhere in the hearing between 2-10 kHz).
- Experts estimated that the median decline in an individual harbour porpoise juvenile or dependent calf survival was 0.18% (due to a 6 dB PTS (a notch a few kHz wide and 6 dB high) occurring somewhere in the hearing between 2-10 kHz).

11.13.6.6 Furthermore, data collected during wind farm construction have demonstrated that porpoise detections around the pile driving site decline several hours to days prior to the start of pile driving. It is assumed that this is due to the increase in other construction related activities and vessel presence in advance of the actual pile driving (Brandt *et al.* 2018, Graham *et al.* 2019, Benhemma-Le Gall *et al.* 2021, Benhemma-Le Gall *et al.* 2023). Therefore, the presence of construction related vessels prior to the start of piling can act as a local-scale deterrent for harbour porpoise and therefore reduce the risk of auditory injury. Assumptions that harbour porpoise are present in the vicinity of the pile driving at the start of the soft start are therefore likely to be overly conservative.

11.13.6.7 Whilst PTS is a permanent effect which cannot be recovered from, the evidence does not suggest that PTS from piling will cause a material impact on either survival or reproductive rates; therefore, harbour porpoise have been assessed as having a **Low** sensitivity to PTS from pile driving.

Bottlenose Dolphin

11.13.6.8 As for harbour porpoise, the ecological consequences of PTS for bottlenose dolphins are uncertain. At the same expert elicitation workshop detailed above in the porpoise section, experts in marine mammal hearing discussed the nature, extent and potential consequence of PTS to bottlenose dolphins arising from exposure to repeated low-frequency impulsive noise such as pile driving (Booth and Heinis 2018, Fernandez-Betelu *et al.* 2022). The predicted decline in bottlenose dolphin vital rates from the impact of a 6 dB PTS in the 2-10 kHz band for different percentiles of the elicited probability distribution are provided in **Table 11-24**.

Table 11-24 Predicted decline in bottlenose dolphin vital rates for different percentiles of the elicited probability distribution

Percentiles of the elicited probability distribution	10%	20%	30%	40%	50%	60%	70%	80%	90%
Adult survival	0	0.18	0.57	1.04	1.6	2.34	3.39	5.18	10.99
Fertility	0	0.04	0.13	0.26	0.43	0.85	1.66	3.49	6.22
Juvenile survival	0.01	0.11	0.35	0.75	1.32	2.14	3.3	5.19	11.24
Calf survival	0	0.29	0.93	1.77	2.96	4.96	7.81	10.69	14.79

11.13.6.9 The data provided in Table 11-24 should be interpreted as:

- Experts estimated that the median decline in an individual mature female bottlenose dolphin's fertility was 0.43% (due to a 6 dB PTS (a notch a few kHz wide and 6 dB high) occurring somewhere in the hearing between 2-10 kHz).
- Experts estimated that the median decline in an individual mature female bottlenose dolphin's survival was 1.6% (due to a 6 dB PTS (a notch a few kHz wide and 6 dB high) occurring somewhere in the hearing between 2-10 kHz).
- Experts estimated that the median decline in an individual bottlenose dolphin juvenile survival was 1.32% (due to a 6 dB PTS (a notch a few kHz wide and 6 dB high) occurring somewhere in the hearing between 2-10 kHz).
- Experts estimated that the median decline in an individual bottlenose dolphin dependent calf survival was 2.96% (due to a 6 dB PTS (a notch a few kHz wide and 6 dB high) occurring somewhere in the hearing between 2-10 kHz).

11.13.6.10 Whilst PTS is a permanent effect which cannot be recovered from, the evidence does not suggest that PTS from piling will cause a significant impact on either survival or reproductive rates, bottlenose dolphin have been assessed as having a **Low** sensitivity to PTS.

White-beaked Dolphin

11.13.6.11 As it is also a high frequency cetacean, it is anticipated that the sensitivity of white-beaked dolphins to PTS onset from piling will be the same as that of bottlenose dolphins. Therefore, white-beaked dolphins have been assessed as having a **Low** sensitivity to PTS.

Minke Whale

11.13.6.12 The low frequency noise produced during piling may be more likely to overlap with the hearing range of low frequency cetacean species such as minke whales. Minke whale communication signals have been demonstrated to be below 2 kHz (Edds-Walton 2000, Mellinger *et al.* 2000, Gedamke *et al.* 2001, Risch *et al.* 2013, Risch *et al.* 2014). Tubelli *et al.* (2012) estimated the most sensitive hearing range (the region with thresholds within 40 dB of best sensitivity) to extend from 30 to 100 Hz up to 7.5 to 25 kHz, depending on the specific model used. Whilst PTS is a permanent effect which cannot be recovered from, a 2-10 kHz notch of 6 dB will affect only a small region of minke whale hearing, which is unlikely to cause a significant impact on either survival or reproductive rates.

11.13.6.13 Given the lack of data, and acknowledging their lower-frequency hearing abilities, minke whales have been conservatively assessed as having a **Medium** sensitivity to PTS from pile driving.

Seals

11.13.6.14 At an expert elicitation workshop, experts in marine mammal hearing discussed the nature, extent and potential consequence of PTS to UK marine mammal species (Booth and Heinis 2018). This workshop outlined and collated the best and most recent empirical data available on the effects of PTS on marine mammals.

11.13.6.15 The predicted decline in harbour and grey seals vital rates from the impact of a 6 dB PTS in the 2-10 kHz band for different percentiles of the elicited probability distribution are provided in **Table 11-25**. The data provided in **Table 11-25** should be interpreted as:

- Experts estimated that the median decline in an individual mature female seal's survival was 0.39% (due to a 6 dB PTS (a notch a few kHz wide and 6 dB high) occurring somewhere in the hearing between 2-10 kHz).
- Experts estimated that the median decline in an individual mature female seal's fertility was 0.27% (due to a 6 dB PTS (a notch a few kHz wide and 6 dB high) occurring somewhere in the hearing between 2-10 kHz).
- Experts estimated that the median decline in an individual seal pup/juvenile survival was 0.52% (due to a 6 dB PTS (a notch a few kHz wide and 6 dB high) occurring somewhere in the hearing between 2-10 kHz).

11.13.6.16 Whilst PTS is a permanent effect which cannot be recovered from, the evidence does not suggest that PTS from piling will cause a significant impact on either survival or reproductive rates; therefore, both seal species have been assessed as having a **Low** sensitivity to PTS from piling.

Table 11-25 Predicted decline in harbour and grey seal vital rates for different percentiles of the elicited probability distribution.

Percentiles of the elicited probability distribution	10%	20%	30%	40%	50%	60%	70%	80%	90%
Adult survival	0.02	0.1	0.18	0.27	0.39	0.55	0.78	1.14	1.89
Fertility	0.01	0.02	0.05	0.14	0.27	0.48	0.88	1.48	4.34
Calf survival	0	0.04	0.15	0.32	0.52	0.8	1.21	1.88	3

Magnitude

11.13.6.17 The predicted areas and maximum impact ranges for auditory injury (PTS-onset) from pile driving for each marine mammal receptor are outlined in:

- **Table 11-26**: instantaneous PTS at the East Location (Scenario 1 & 2)
- **Table 11-27**: cumulative PTS at the East Location (Scenario 1 & 2)
- **Table 11-28**: instantaneous PTS at the West Location (Scenario 1 & 2)
- **Table 11-29**: cumulative PTS at the West Location (Scenario 1 & 2).

11.13.6.18 For minke whales, the maximum auditory injury impact range was 21 km for the installation of 1 piled anchor under Scenario 1 (2,500 kJ) at the East location. This equates to a maximum of 44 minke whales experiencing auditory injury (0.22% of the MU, or 0.43% of the UK portion of the MU). For harbour porpoise, the maximum auditory injury impact range was 6.9 km for the installation of 1 piled anchor under Scenario 1 (2,500 kJ) at the East location. This equates to a maximum of 85 harbour porpoise experiencing auditory injury when using the site-specific digital aerial survey density estimate (0.02% of the MU, or 0.05% of the UK portion of the MU).

11.13.6.19 For both seal species and dolphin species, the maximum auditory injury impact range was <100 m for both Scenario 1 and 2 and at both locations. This equates to <1 individual impacted for each species (bottlenose dolphin, white-beaked dolphin, grey and harbour seal) and <0.01% of the MU.

11.13.6.20 It is important to note that there are no empirical data on the threshold for auditory injury in the form of PTS onset for marine mammals (see **Section 11.9.5**. Where PTS-onset ranges are provided, it is not expected that all individuals within that range will experience PTS (see **Section 11.10**). The number of animals predicted to be within PTS-onset ranges are therefore precautionary, as this assessment assumes that all animals within the PTS-onset range are impacted.

11.13.6.21 In addition, the predicted PTS-onset ranges assume that sound is impulsive throughout, for which there is evidence to the contrary. Hastie *et al.* (2019) estimated the transition from impulsive to non-impulsive characteristics of impact piling noise during the installation of offshore wind turbine foundations at the Wash and in the Moray Firth. This analysis showed that the noise signal experienced a high degree of change in its impulsive characteristics with increasing distance. Based on these data it is expected that the probability of a signal being defined as “impulsive” (using the criteria of rise time being less than 25 milliseconds) reduces to only 20% between ~2 and 5 km from the source. Predicted PTS impact ranges based on the impulsive noise thresholds may therefore be overestimates in cases where the impact ranges lie beyond this. Any animal present beyond that distance when piling starts will only be exposed to non-impulsive noise, and therefore impact ranges should be based on the non-impulsive thresholds.

11.13.6.22 The Salamander Project has committed to implementing a piling specific MMMP to ensure that the risk of auditory injury (PTS) is reduced to negligible levels as far as reasonably possible (see **Section 11.11** and **Table 11-12**). The exact mitigation measures contained with the piling MMMP are yet to be determined, but they will be in line with the latest relevant guidance at the time of this stage of the Salamander Project. Multiple measures are available and have been implemented elsewhere for piling, such as the use of ADDs to displace animals (range limited), or noise abatement techniques where appropriate. Therefore, the magnitude of impact is assessed as **Negligible** for all marine mammals.

Table 11-26 Auditory injury (Permanent Threshold Shift) East location – Instantaneous Permanent Threshold Shift

Species	Density	Area (km^2)	Max Range (m)	# animals	% MU	% UK MU
Scenario 1: Instantaneous PTS (SPLpeak) (2,500 kJ)						
Minke whale	Lacey *et al.* (2022)	< 0.01	< 50	<1	<0.01	<0.01
	SCANS IV			<1	<0.01	<0.01
Bottlenose dolphin	0.003 (GNS MU)	< 0.01	< 50	<1	<0.01	<0.01

Species	Density	Area (km^2)	Max Range (m)	# animals	% MU	% UK MU
White-beaked dolphin	Lacey *et al.* (2022)			<1	<0.01	<0.01
	SCANS IV			<1	<0.01	<0.01
Harbour porpoise	Lacey *et al.* (2022)	1.2	610	1	<0.01	<0.01
	0.71 (DAS)			1	<0.01	<0.01
	SCANS IV			<1	<0.01	<0.01
Harbour seal	Carter *et al.* (2022)	0.01	< 50	<1	<0.01	-
Grey seal	Carter *et al.* (2022)			<1	<0.01	-
Scenario 2: Instantaneous PTS (SPL_{peak}) (1,500 kJ)						
Minke whale	Lacey *et al.* (2022)	< 0.01	< 50	<1	<0.01	<0.01
	SCANS IV			<1	<0.01	<0.01
Bottlenose dolphin	0.003 (GNS MU)	< 0.01	< 50	<1	<0.01	<0.01
White-beaked dolphin	Lacey *et al.* (2022)			<1	<0.01	<0.01
	SCANS IV			<1	<0.01	<0.01
Harbour porpoise	Lacey *et al.* (2022)	0.67	460	1	<0.01	<0.01
	0.71 (DAS)			1	<0.01	<0.01
	SCANS IV			1	<0.01	<0.01
Harbour seal	Carter *et al.* (2022)	0.01	< 50	<1	<0.01	-
Grey seal	Carter *et al.* (2022)			<1	<0.01	-

Table 11-27 Auditory injury (Permanent Threshold Shift) East location – Cumulative Permanent Threshold Shift

Species	Density	Area (km2)	Max Range (m)	# animals	% MU	% UK MU
Scenario 1: Cumulative PTS (SELcum) single piled anchor (2,500 kJ)						
Minke whale	Lacey *et al.* (2022)	1,000	21,000	22	0.11	0.22

Species	Density	Area (km2)	Max Range (m)	# animals	% MU	% UK MU
	SCANS IV			44	0.22	0.43
Bottlenose dolphin	0.003 (GNS MU)	< 0.1	< 100	<1	<0.01	<0.01
White-beaked dolphin	Lacey *et al.* (2022)			<1	<0.01	<0.01
	SCANS IV			<1	<0.01	<0.01
Harbour porpoise	Lacey *et al.* (2022)	120	6,900	66	0.02	0.04
	0.71 (DAS)			85	0.02	0.05
	SCANS IV			74	0.02	0.05
Harbour seal	Carter *et al.* (2022)	< 0.1	< 100	<1	<0.01	-
Grey seal	Carter *et al.* (2022)			<1	<0.01	-
Scenario 2: Cumulative PTS (SEL_{cum}) 4 piled anchors per day (1,500 kJ)						
Minke whale	Lacey *et al.* (2022)	43	5,300	1	<0.01	0.01
	SCANS IV			2	0.01	0.02
Bottlenose dolphin	0.003 (GNS MU)	<0.1	<100	<1	<0.01	<0.01
White-beaked dolphin	Lacey *et al.* (2022)			<1	<0.01	<0.01
	SCANS IV			<1	<0.01	<0.01
Harbour porpoise	Lacey *et al.* (2022)	<0.1	<100	<1	<0.01	<0.01
	0.71 (DAS)			<1	<0.01	<0.01
	SCANS IV			<1	<0.01	<0.01
Harbour seal	Carter *et al.* (2022)	<0.1	<100	<1	<0.01	-
Grey seal	Carter *et al.* (2022)			<1	<0.01	-

Table 11-28 Auditory injury (Permanent Threshold Shift) West location – Instantaneous Permanent Threshold Shift

Species	Density	Area (km2)	Max Range (m)	# animals	% MU	% UK MU
Instantaneous PTS (SPL_{peak}) (2,500 kJ)						
Minke whale	Lacey *et al.* (2022)	< 0.01	< 50	<1	<0.01	<0.01
Bottlenose dolphin	0.003 (GNS MU)	< 0.01	< 50	<1	<0.01	<0.01
White-beaked dolphin	Lacey *et al.* (2022)			<1	<0.01	<0.01
Harbour porpoise	Lacey *et al.* (2022)	1.2	610	1	<0.01	<0.01
	0.71 (DAS)			1	<0.01	<0.01
Harbour seal	Carter *et al.* (2022)	0.01	< 50	<1	<0.01	-
Grey seal	Carter *et al.* (2022)			<1	<0.01	-
Instantaneous PTS (SPL_{peak}) (1,500 kJ)						
Minke whale	Lacey *et al.* (2022)	< 0.01	< 50	<1	<0.01	<0.01
	SCANS IV			<1	<0.01	<0.01
Bottlenose dolphin	0.003 (GNS MU)	< 0.01	< 50	<1	<0.01	<0.01
White-beaked dolphin	Lacey *et al.* (2022)			<1	<0.01	<0.01
	SCANS IV			<1	<0.01	<0.01
Harbour porpoise	Lacey *et al.* (2022)	0.7	460	1	<0.01	<0.01
	0.71 (DAS)			1	<0.01	<0.01
	SCANS IV			<1	<0.01	<0.01
Harbour seal	Carter *et al.* (2022)	0.01	< 50	<1	<0.01	-
Grey seal	Carter *et al.* (2022)			<1	<0.01	-

Table 11-29 Auditory injury (Permanent Threshold Shift) West location – Cumulative Permanent Threshold Shift

Species	Density	Area (km²)	Max Range (m)	# animals	% MU	% UK MU
Cumulative PTS (SEL_{cum}) single piled anchor (2,500 kJ)						
Minke whale	Lacey *et al.* (2022)	960	21,000	19	0.10	0.19
	SCANS IV			40	0.20	0.39
Bottlenose dolphin	0.003 (GNS MU)	< 0.1	< 100	<1	<0.01	<0.01
White-beaked dolphin	Lacey *et al.* (2022)			<1	<0.01	<0.01
	SCANS IV			<1	<0.01	<0.01
Harbour porpoise	Lacey *et al.* (2022)	120	6,800	61	0.02	0.05
	0.71 (DAS)			85	0.02	0.05
	SCANS IV			72	0.02	0.05
Harbour seal	Carter *et al.* (2022)	< 0.1	< 100	<1	<0.01	-
Grey seal	Carter *et al.* (2022)			<1	<0.01	-
Cumulative PTS (SEL_{cum}) 4 piled anchors per day (1,500 kJ)						
Minke whale	Lacey *et al.* (2022)	38	4,700	1	<0.01	0.01
	SCANS IV			2	0.01	0.02
Bottlenose dolphin	0.003 (GNS MU)	<0.1	<100	<1	<0.01	<0.01
White-beaked dolphin	Lacey *et al.* (2022)			<1	<0.01	<0.01
	SCANS IV			<1	<0.01	<0.01
Harbour porpoise	Lacey *et al.* (2022)	<0.1	<100	<1	<0.01	<0.01
	0.71 (DAS)			<1	<0.01	<0.01
	SCANS IV			<1	<0.01	<0.01
Harbour seal	Carter *et al.* (2022)	<0.1	<100	<1	<0.01	-
Grey seal	Carter *et al.* (2022)			<1	<0.01	-

Significance of Impact

11.13.6.23 The sensitivity of minke whales and harbour porpoise has been assessed as **Medium** and for dolphin and seal species, the sensitivity has been assessed as **Low**. Pile driving with embedded mitigation has been assessed as a **Negligible** magnitude. As such, for all marine mammal species, PTS from pile driving for all marine mammal receptors are considered to be of **Negligible** significance, which is **Not Significant** with respect to the EIA Regulations.

11.13.7 Disturbance from Piling of Anchors

Sensitivity

Harbour Porpoise

11.13.7.1 Previous studies have shown that harbour porpoises are displaced from the vicinity of piling events. For example, studies at wind farms in the German North Sea have recorded large declines in harbour porpoise detections close to the piling (>90% decline at noise levels above 170 dB) with decreasing effect with increasing distance from the pile (25% decline at noise levels between 145 and 150 dB) (Brandt *et al.* 2016). The detection rates revealed that harbour porpoise were only displaced from the piling area in the short term (1 to 3 days) (Brandt *et al.* 2011, Dähne *et al.* 2013, Brandt *et al.* 2016, Brandt *et al.* 2018). Harbour porpoise are small cetaceans which makes them vulnerable to heat loss and requires them to maintain a high metabolic rate with little energy remaining for fat storage (e.g. Rojano-Doñate *et al.* 2018). This makes them vulnerable to starvation if they are unable to obtain sufficient levels of prey intake.

11.13.7.2 Studies using Digital Acoustic Recording Tags (DTAGs) have shown that harbour porpoise tagged after capture in pound nets foraged on small prey nearly continuously during both the day and the night on their release (Wisniewska *et al.* 2016). However, Hoekendijk *et al.* (2018) point out that this could be an extreme short-term response to capture in nets, and may not reflect natural harbour porpoise behaviour. Nevertheless, if the foraging efficiency of harbour porpoise is disturbed or if they are displaced from a high-quality foraging ground, and are unable to find suitable alternative feeding grounds, they could potentially be at risk of changes to their overall fitness if they are not able to compensate and obtain sufficient food intake to meet their metabolic demands.

11.13.7.3 However, the results from Wisniewska *et al.* (2016) could also suggest that harbour porpoises have an ability to respond to short term reductions in food intake, implying a resilience to disturbance. As Hoekendijk *et al.* (2018) and Booth (2020) argue, this could help explain why harbour porpoises are such an abundant and successful species. It is important to note that the studies providing evidence for the responsiveness of harbour porpoises to piling noise have not provided any evidence for subsequent individual consequences. In this way, responsiveness to disturbance cannot reliably be equated to sensitivity to disturbance and harbour porpoises may well be able to compensate by moving quickly to alternative areas to feed, while at the same time increasing their feeding rates.

11.13.7.4 Monitoring of harbour porpoise activity at the Beatrice Offshore Wind Farm during pile driving activity has indicated that harbour porpoises were displaced from the immediate vicinity of the pile driving activity – with a 50% probability of response occurring at approximately 7 km (Graham *et al.* 2019). This monitoring also indicated that the response diminished over the construction period (excluding pre-construction surveys), so that eight months into the construction phase, the range at which there was a 50% probability of response was only 1.3 km. In addition, the study indicated that harbour porpoise activity recovered between pile driving days.

11.13.7.5 A study of tagged harbour porpoises has shown large variability between individual responses to a seismic survey airgun stimulus (van Beest *et al.* 2018). Of the five harbour porpoises tagged and exposed to airgun pulses at ranges of 420–690 m (SEL 135–147 dB re 1 μPa^2s), one individual showed rapid and directed movements away from the source. Two individuals displayed shorter and shallower dives immediately after exposure and the remaining two animals did not show any quantifiable response. Therefore, there is expected to be a high level of variability in responses from individual harbour porpoises exposed to low frequency broadband pulsed noise (including both airguns and pile-driving).

11.13.7.6 At an expert elicitation workshop, experts in marine mammal physiology, behaviour and energetics discussed the nature, extent and potential consequences of disturbance to harbour porpoise from exposure to low frequency broadband pulsed noise (e.g. pile-driving, airgun pulses) (Booth *et al.* 2019). Experts were asked to estimate the potential consequences of a six-hour period of zero energy intake, assuming that disturbance from a pile driving event resulted in missed foraging opportunities for this duration. A Dynamic Energy Budget (DEB) model for harbour porpoise (based on the DEB model in Hin *et al.* (2019)) was used to aid discussions regarding the potential effects of missed foraging opportunities on survival and reproduction. The model described the way in which the life history processes (growth, reproduction and survival) of a female and her calf depend on the way in which assimilated energy is allocated between different processes and was used during the elicitation to model the effects of energy intake and reserves following simulated disturbance. The experts agreed that first year calf survival (post-weaning) and fertility were the most likely vital rates to be affected by disturbance, but that juvenile and adult survival were unlikely to be significantly affected as these life-stages were considered to be more robust. Experts agreed that the final third of the year was the most critical for harbour porpoises as they reach the end of the current lactation period and the start of new pregnancies, therefore it was thought that significant impacts on fertility would only occur when animals received repeated exposure throughout the whole year. Experts agreed it would likely take high levels of repeated disturbance to an individual before there was any effect on that individual's fertility (**Figure 11-6** left), and that it was very unlikely an animal would terminate a pregnancy early. The experts agreed that calf survival could be reduced by only a few days of repeated disturbance to a mother/calf pair during early lactation (**Figure 11-6** right); however, it is highly unlikely that the same mother-calf pair would repeatedly return to the area in order to receive these levels of repeated disturbance.

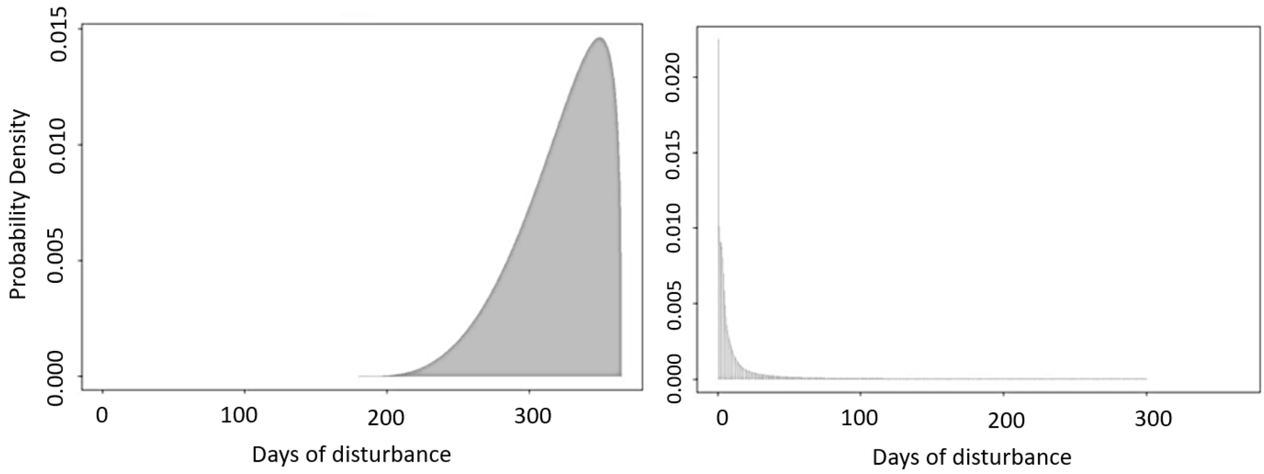


Figure 11-6 Probability distributions showing the consensus of the expert elicitation for harbour porpoise disturbance from piling (Booth *et al*., 2019). Left: the number of days of disturbance (i.e. days on which an animal does not feed for six hours) a pregnant female could 'tolerate' before it has any effect on fertility. Right: the number of days of disturbance (of six hours zero energy intake) a mother/ calf pair could 'tolerate' before it has any effect on survival.

11.13.7.7 A recent study by (Benhemma-Le Gall et al. 2021) provided two key findings in relation to harbour porpoise response to pile driving. Harbour porpoise were not completely displaced from the piling site: detections of clicks (echolocation) and buzzing (associated with prey capture) in the short-range (2 km) did not cease in response to pile driving, and harbor porpoise appeared to compensate: detections of both clicks (echolocation) and buzzing (associated with prey capture) increased above baseline levels with increasing distance from the pile, which suggests that those harbour porpoise that are displaced from the near-field resume foraging at a greater distance from the piling location (**Figure 11-7**). Therefore, harbour porpoise that experience displacement are expected to be able to compensate for the lost foraging opportunities.

11.13.7.8 Due to observed responsiveness to piling, their income breeder life history, and the low numbers of days of disturbance expected to affect calf survival, harbour porpoises have been assessed as having a Low sensitivity to disturbance from pile driving.

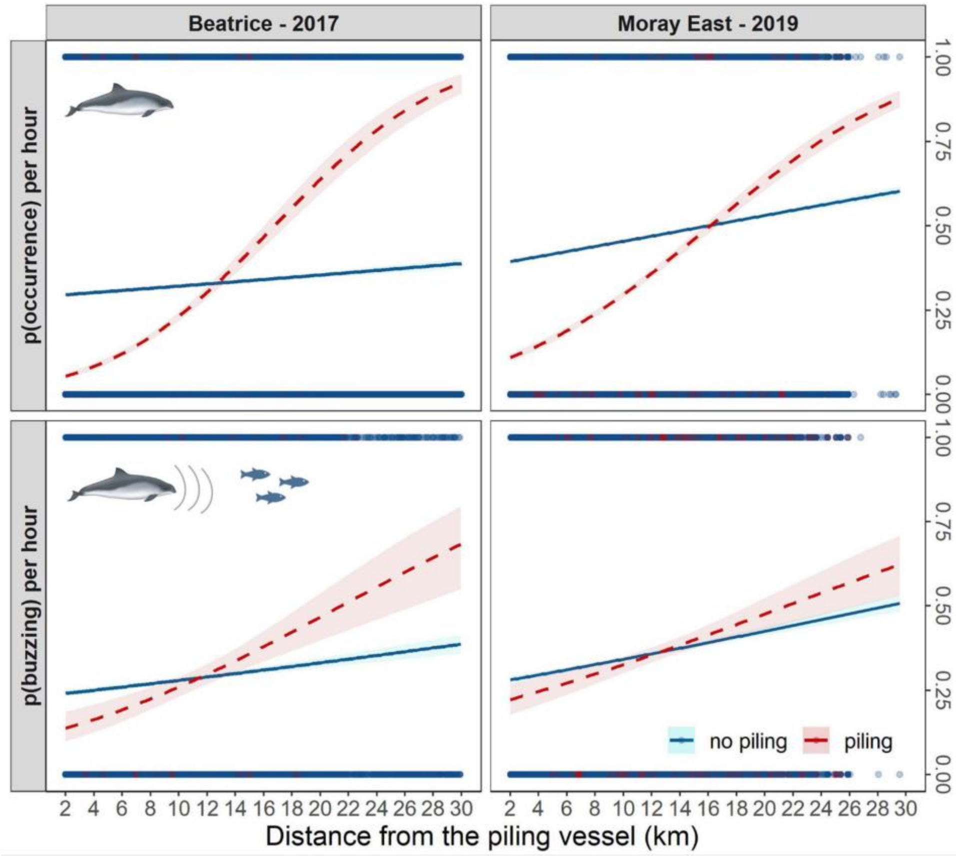


Figure 11-7 The probability of harbour porpoise occurrence and buzzing activity per hour during (dashed red line) and out with (blue line) pile-driving hours, in relation to distance from the pile-driving vessel at Beatrice (left) and Moray East (right). Obtained from Benhemma-Le Gall *et al.* (2021).

Bottlenose Dolphin

11.13.7.9 Bottlenose dolphins have been shown to be displaced from an area as a result of the noise produced by offshore construction activities; for example, avoidance behaviour in bottlenose dolphins has been shown in relation to dredging activities, piling and seismic surveys (Pirotta *et al.* 2013, Graham *et al.* 2017c, Fernandez-Betelu *et al.* 2021). In a study on bottlenose dolphins in the Moray Firth (in relation to the construction of the Nigg Energy Park in the Cromarty Firth), small effects of pile driving on dolphin presence have been observed; however, dolphins were not excluded from the vicinity of the piling activities (Graham *et al.* 2017c). In this study the median peak-to-peak source levels recorded during impact piling were estimated to be 240 dB re 1µPa (range 8 dB) with a single pulse source level of 198 dB re 1 µPa^{2}s. The pile driving resulted in a slight reduction of the presence, detection positive hours and the encounter duration for dolphins within the Cromarty Firth; however, this response was only significant for the encounter durations. Encounter durations decreased within the Cromarty Firth (though only by a few minutes) and increased outside of the Cromarty Firth on days of piling activity. These data highlight a small spatial and temporal scale disturbance to bottlenose dolphins as a result of impact piling activities.

11.13.7.10 According to the opinions of the experts, disturbance would be most likely to affect bottlenose dolphin calf survival, where: “it exceeded 30-50 days, because it could result in mothers becoming separated from their calves and this could affect the amount of milk transferred from the mother to her calf" (Harwood et al. 2014a). There is the potential for behavioural disturbance and displacement to result in disruption in foraging and resting activities and an increase in travel and energetic costs. However, it has been previously shown that bottlenose dolphins have the ability to compensate for behavioural responses as a result of increased commercial vessel activity, where longer term overall activity time budget remained the same despite the immediate behavioural response to disturbance (New et al. 2013). Therefore, while there remains the potential for disturbance and displacement to affect individual behaviour, it is not expected that this would result in an overall change in individual energy budget since animals have been shown to compensate for time lost due to disturbance. Therefore, no change to vital rates is expected, and thus bottlenose dolphins are considered to have a **Low** sensitivity to disturbance from pile driving.

White-beaked Dolphin

11.13.7.11 There is a single study detailing white-beaked dolphin responses to playbacks of amplitude-modulated tones and synthetic pulse-bursts; responses were observed in 90 out of 123 exposures and received levels varied between 153 and 161 dB re 1 µPa for pulse-burst signals (Rasmussen *et al*. 2016). Due to the limited information on the effects of disturbance on white-beaked dolphins, bottlenose dolphins can be used as a proxy since both species are categorised as high-frequency cetaceans. In the absence of species-specific data for white-beaked dolphins, bottlenose dolphin information is used instead. Therefore, white-beaked dolphins are considered to have a **Low** sensitivity to disturbance from pile driving.

Minke Whale

11.13.7.12 There is little information available on the behavioural responses of minke whales to underwater noise. Minke whales have been shown to change their diving patterns and behavioural state in response to disturbance from whale watching vessels; and it was suggested that a reduction in foraging activity at feeding grounds could result in reduced reproductive success in this capital breeding species (Christiansen *et al.* 2013). There is only one study showing minke whale reactions to sonar signals (Sivle *et al.* 2015) with behavioural response severity scores above 4 (the stage at which avoidance to a sound source first occurs) for a received SPL of 146 dB re 1 µPa (score 7[4]) and a received SPL of 158 dB re 1 µPa (score 8[5]). There is a study detailing minke whale responses to a Lofitech Acoustic Deterrent Device (ADD) which has a source level of 204 dB re 1 µPa @ 1 m, which showed minke whales within 500 m and 1,000 m of the source exhibiting a behavioural response. The estimated received level at 1,000 m was 136.1 dB re 1 µPa (McGarry *et al.* 2017). There are no equivalent such studies of responses to pile driving noise.

[4] Defined in Sivle *et al.* (2015) as: Prolonged avoidance – The animal increased speed and swam directly away from the sound source throughout the rest of the exposure. Opportunistic visual observations of skim feeding at the surface before the start of the sonar exposure indicated that this response might also have involved a cessation of feeding.

[5] Defined in Sivle *et al.* (2015) as: Obvious progressive aversion (and sensitization) – The animal continued to increase its speed as the exposure progressed, swimming at such a high speed that the distance to the source ship remained constant. About halfway through the exposure, the dive pattern changed to shallower diving, which may be a way to move more effectively away from the source.

11.13.7.13 Since minke whales are known to forage in UK waters in the summer months, there is the potential for displacement to impact on reproductive rates. However, due to their large size and capacity for energy storage, it is expected that minke whales will be able to tolerate temporary displacement from foraging areas much better than harbour porpoise and individuals are expected to be able to recover from any impact on vital rates. Therefore, minke whales have been assessed as having a **Low** sensitivity to disturbance from pile driving.

Harbour Seal

11.13.7.14 A study of tagged harbour seals in the Wash has shown that they are displaced from the vicinity of piles during impact piling activities. Russell *et al.* (2016a) showed that seal abundance was significantly reduced within an area with a radius of 25 km from a pile during piling activities, with a 19 to 83% decline in abundance during impact piling compared to during breaks in piling. The duration of the displacement was only in the short-term as seals returned to non-piling distributions within two hours after the end of a piling event. Unlike harbour porpoise, harbour seals store energy in a thick layer of blubber, which means that they are more tolerant of periods of fasting when hauled out and resting between foraging trips, and when hauled out during the breeding and moulting periods. Therefore, they are unlikely to be particularly sensitive to short-term displacement from foraging grounds during periods of active piling.

11.13.7.15 At the expert elicitation workshop (Booth *et al.* 2019), experts agreed the most likely potential consequences of a six hour period of zero energy intake, assuming that disturbance (from exposure to low frequency broadband pulsed noise (e.g., impact piling, airgun pulses)) resulted in missed foraging opportunities. In general, it was agreed that harbour seals were considered to have a reasonable ability to compensate for lost foraging opportunities due to their generalist diet, mobility, life history and adequate fat stores. The survival of 'weaned of the year' animals and fertility were determined to be the most sensitive life history parameters to disturbance (i.e., leading to reduced energy intake). Juvenile harbour seals are typically considered to be coastal foragers (Booth *et al*. 2019) and so less likely to be exposed to disturbances and similarly pups were thought to be unlikely to be exposed to disturbance due to their proximity to land. Unlike for harbour porpoise, there was no DEB model available to simulate the effects of disturbance on seal energy intake and reserves; therefore, the opinions of the experts were less certain. Experts considered that the location of the disturbance would influence the effect of the disturbance, with a greater effect if animals were disturbed at a foraging ground as opposed to when animals were transiting through an area. It was thought that for an animal in bad condition, moderate levels of repeated disturbance might be sufficient to reduce fertility (**Figure 11-8** left); however, there was a large amount of uncertainty in this estimate. The 'weaned of the year' were considered to be most vulnerable following the post-weaning fast, and that during this time, experts felt it might take ~60 days of repeated disturbance before there was expected to be any effect on the probability of survival (**Figure 11-8** right); however, again, there was a lot of uncertainty surrounding this estimate. Similar to above, it is considered unlikely that individual harbour seals would repeatedly return to a site where they had been previously displaced from in order to experience this number of days of repeated disturbance.

11.13.7.16 Due to observed responsiveness to piling, harbour seals have been assessed as having **Medium** sensitivity to disturbance and resulting displacement from foraging grounds during impact piling events.

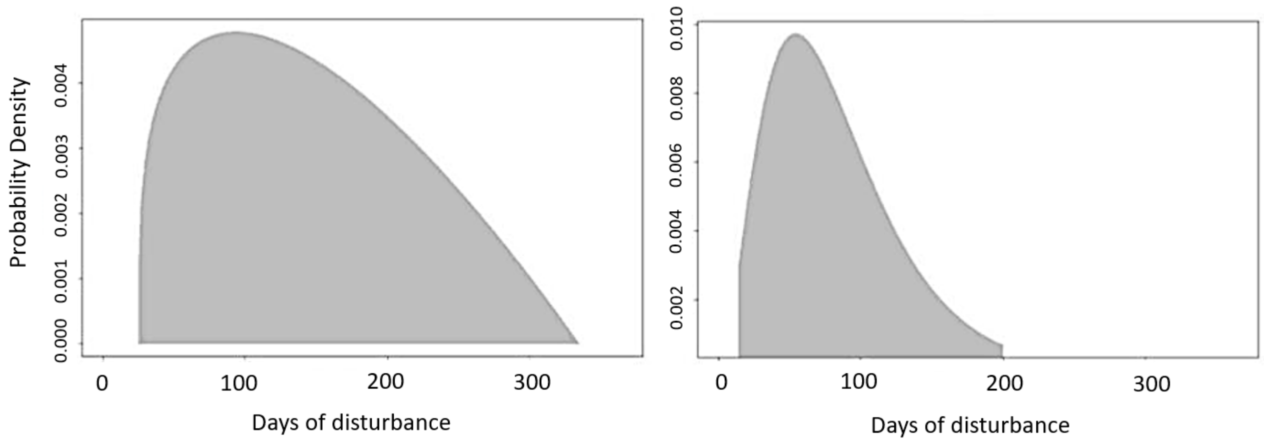


Figure 11-8 Probability distributions showing the consensus of the expert elicitation for harbour seal disturbance from piling. X-axis = days of disturbance; y-axis = probability density. Left: the number of days of disturbance (i.e. days on which an animal does not feed for six hours) a pregnant female could 'tolerate' before it has any effect on fertility. Right: the number of days of disturbance (of six hours zero energy intake) a 'weaned of the year' harbour seal could 'tolerate' before it has any effect on survival. Figures obtained from Booth *et al.* (2019).

Grey Seal

11.13.7.17 There are still limited data on grey seal behavioural responses to pile driving. The key dataset on this topic is presented in Aarts *et al.* (2018) where 20 grey seals were tagged in the Wadden Sea to record their responses to pile driving at two offshore wind farms: Luchterduinen in 2014 and Gemini in 2015. The grey seals showed varying responses to the pile driving, including no response, altered surfacing and diving behaviour, and changes in swimming direction. The most common reaction was a decline in descent speed and a reduction in bottom time, which suggests a change in behaviour from foraging to horizontal movement.

11.13.7.18 The distances at which seals responded varied significantly; in one instance a grey seal showed responses at 45 km from the pile location, while other grey seals showed no response when within 12 km. Differences in responses could be attributed to differences in hearing sensitivity between individuals and in sound transmission with environmental conditions or the behaviour and motivation for the seal to be in the area. The telemetry data also showed that seals returned to the pile driving area after pile driving ceased. While this evidence base is from studies of grey seals tagged in the Wadden Sea, it is expected that grey seals in waters north of Scotland would respond in a similar way, and therefore the data are considered to be applicable.

11.13.7.19 The expert elicitation workshop in Amsterdam in 2018 (Booth *et al.* 2019) concluded that grey seals were considered to have a reasonable ability to compensate for lost foraging opportunities due to their generalist diet, mobility, life history and adequate fat stores and that the survival of 'weaned of the year' animals and fertility were determined to be the most sensitive parameters to disturbance (i.e. reduced energy intake). However, in general, experts agreed that grey seals would be much more robust than harbour seals to the effects of disturbance due to their larger energy stores and more generalist and adaptable foraging strategies. It was agreed that grey seals would require moderate-high levels of repeated disturbance before there was any effect on fertility rates (**Figure 11-9** left). The 'weaned of the year' were considered to be most vulnerable following the post-weaning fast, and that during this time it might take ~60 days of repeated disturbance before there was expected to be any effect on weaned-of-the-year survival (**Figure 11-9** right), however there was a lot of uncertainty surrounding this estimate.

11.13.7.20 Grey seals are capital breeders and store energy in a thick layer of blubber, which means that, in combination with their large body size, they are tolerant of periods of fasting as part of their normal life history. Grey seals are also highly adaptable to a changing environment and are capable of adjusting their metabolic rate and foraging tactics, to compensate for different periods of energy demand and supply (Beck *et al.* 2003, Sparling *et al.* 2006). Grey seals are also very wide ranging and are capable of moving large distances between different haul out and foraging regions (Russell *et al.* 2013). Therefore, they are unlikely to be particularly sensitive to displacement from foraging grounds during periods of active piling.

11.13.7.21 Hastie *et al.* (2021) found that grey seal avoidance rates in response to pile driving sounds were dependent on the quality of the prey patch, with grey seals continuing to forage at high density prey patches when exposed to pile driving sounds but showing reduced foraging success at low density prey patches when exposed to pile driving sounds. Additionally, the seals showed an initial aversive response to the pile driving playbacks (lower proportion of dives spent foraging) but this diminished during each trial. Therefore, the likelihood of grey seal response is expected to be linked to the quality of the prey patch.

11.13.7.22 Due to observed responsiveness to piling, and their life-history characteristics, grey seals have been assessed as having **Negligible** sensitivity to disturbance and resulting displacement from foraging grounds during pile-driving events.

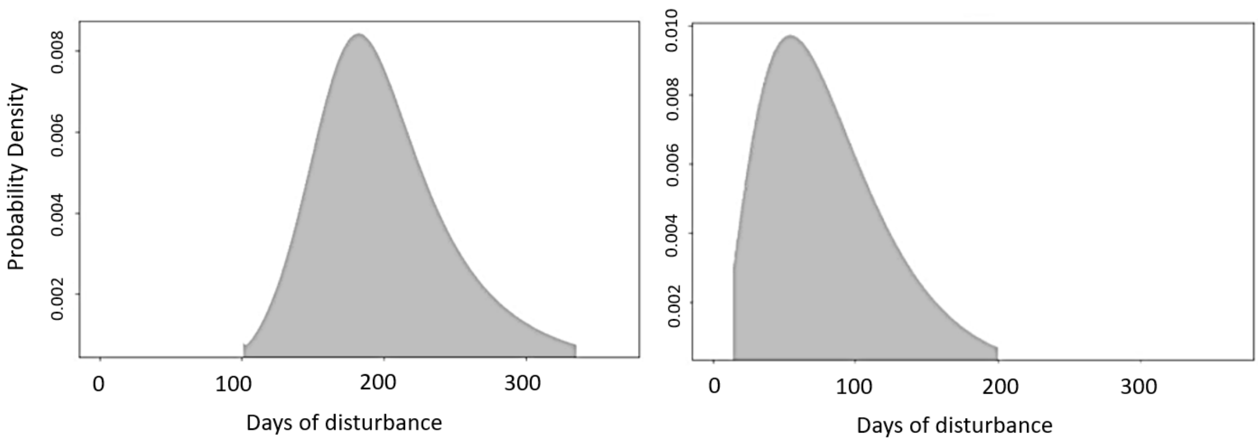


Figure 11-9 Probability distributions showing the consensus of the expert elicitation for grey seal disturbance from piling (Booth *et al*., 2019). Left: the number of days of disturbance (i.e. days on which an animal does not feed for six hours) a pregnant female could 'tolerate' before it has any effect on fertility. Right: the number of days of disturbance (of six hours zero energy intake) a 'weaned of the year' grey seal could 'tolerate' before it has any effect on survival.

Impact Magnitude

11.13.7.23 **Table 11-30** and **Table 11-31** outline the number of each marine mammal receptor predicted to experience behavioural disturbance as a result of anchor piling at 2,500 kJ hammer energy (Scenario 1), and 1,500 kJ hammer energy (Scenario 2), assessed as a proportion of their respective MU. Disturbance from concurrent piling events has not been assessed, as simultaneous piling activities are not within the Salamander Project Design Envelope (see **Table 11-5**).

Table 11-30 Predicted impact for disturbance from piling under Scenario 1 (2,500 kJ)

Species	Density (#/km^2)	Impact	East location	West location
Harbour porpoise (Lacey *et al.* 2022)	Grid cell specific	Number animals total in MU (UK MU)	11,958 (11,722)	11,306 (11,123)
		% of MU total (UK MU)	3.45% (7.34%)	3.26% (6.97%)
Harbour porpoise (Gilles *et al.* 2023)	Multiple SCANS IV blocks: 0.2813 CS-K 0.5985 NS-D 0.5156 NS-E 0.4393 NS-F 1.0398 NS-G	Number animals total in MU (UK MU)	12,366 (12,013)	11,728 (11,456)
		% of MU total (UK MU)	3.57% (7.53%)	3.38% (7.18%)
Minke whale (Lacey *et al.* 2022)	Grid cell specific	Number animals total in MU (UK MU)	603 (585)	571 (557)
		% of MU total (UK MU)	3.00% (5.69%)	2.84% (5.41%)
Minke whale (Gilles *et al.* 2023)	Multiple SCANS IV blocks: 0.0116 CS-K 0.0419 NS-D 0.0121 NS-E	Number animals total in MU (UK MU)	1,535 (1,343)	1,336 (1,187)
		% of MU total (UK MU)	7.63% (13.13%)	6.64% (11.61%)

Species	Density (#/km²)	Impact	East location	West location
	0.0271 NS-F 1.0103 NS-G			
Bottlenose dolphin (Split by MU)	0.01 in CES MU & 0.003 in GNS MU	Number animals total (by MU)	84 (25 in CES MU, 59 in GNS MU)	83 (27 in CES MU, 56 in GNS MU)
		% of MU combined CES & GNS (by MU)	3.74% (11.16% CES MU, 2.92% GNS MU)	3.70% (12.05% CES MU, 2.77% GNS MU)
Bottlenose dolphin (Split 2 km from coast)	0.11 within 2 km of coast & 0.003 beyond	Number animals	78 (12 within 2 km of coast, 66 beyond)	75 (12 within 2 km of coast, 63 beyond)
		% of MU combined CES & GNS (by MU)	3.47% (5.36% in CES MU, 3.26% in GNS MU)	3.34% (5.36% in CES MU, 3.12% in GNS MU)
White-beaked dolphin (Lacey *et al.* 2022)	Grid cell specific	Number animals total in MU (UK MU)	5,697 (5,691)	5,283 (5,279)
		% of MU total (UK MU)	12.96% (16.73%)	12.02% (15.52%)
White-beaked dolphin (Gilles *et al.* 2023)	Multiple SCANS IV blocks: 0.1352 CS-K 0.0799 NS-D 0.1775 NS-E 0.3056 NS-F 0.1051 NS-G	Number animals total in MU (UK MU)	2,702 (2,580)	2,606 (2,513)
		% of MU total (UK MU)	6.15% (7.58%)	5.93% (7.39%)

Species	Density (#/km²)	Impact	East location	West location
Harbour seal (Carter *et al.* 2020)	Grid cell specific	Number animals (95% CI)	3 (0 – 7)	4 (0 – 7)
		% of MU (95% CI)	0.82 (0.00 – 1.92)	1.10 (0.00 – 1.92)
Grey seal (Carter *et al.* 2020)	Grid cell specific	Number animals (95% CI)	1,395 (120 – 2,714)	1,429 (120 – 2,775)
		% of Combined MUs & East Scot MU alone (95% CI)	Combined MUs: 2.66 (0.23 – 5.18) East Scot MU: 12.94 (1.11 – 25.17)	Combined MUs: 2.73 (0.23 – 5.30) East Scot MU: 13.25 (1.11 – 25.73)

Table 11-31 Predicted impact for disturbance from piling under Scenario 2 (1,500 kJ)

Species	Density (#/km2)	Impact	East location	West location
Harbour porpoise (Lacey *et al.* 2022)	Grid cell specific	Number animals total in MU (UK MU)	9,760 (9,602)	9,210 (9,094)
		% of MU total (UK MU)	2.82% (6.02%)	2.66% (5.70%)
Harbour porpoise (Gilles *et al.* 2023)	Multiple SCANS IV blocks: 0.2813 CS-K 0.5985 NS-D 0.5156 NS-E 0.4393 NS-F	Number animals total in MU (UK MU)	10,093 (9,877)	9,557 (9,398)
		% of MU total (UK MU)	2.91% (6.19%)	2.76% (5.89%)

Species	Density (#/km2)	Impact	East location	West location
	1.0398 NS-G			
Minke whale (Lacey *et al.* 2022)	Grid cell specific	Number animals total in MU (UK MU)	487 (475)	460 (452)
		% of MU total (UK MU)	2.42% (4.62%)	2.28% (4.39%)
Minke whale (Gilles *et al.* 2023)	Multiple SCANS IV blocks:	Number animals total in MU (UK MU)	1,148 (1,033)	979 (895)
	0.0116 CS-K 0.0419 NS-D 0.0121 NS-E 0.0271 NS-F 1.0103 NS-G	% of MU total (UK MU)	5.71% (10.04%)	4.87% (8.70%)
Bottlenose dolphin (Split by MU)	0.01 in CES MU & 0.003 in GNS MU	Number animals total (by MU)	69 (21 in CES MU, 48 in GNS MU)	68 (23 in CES MU, 45 in GNS MU)
		% of MU combined CES & GNS (by MU)	3.07% (9.38% CES MU, 2.54% GNS MU)	3.03% (10.28% CES MU, 2.39% GNS MU)
Bottlenose dolphin (Split 2 km from coast)	0.11 within 2 km of coast & 0.003 beyond	Number animals	63 (10 within 2 km of coast, 53 beyond)	63(11 within 2 km of coast, 52 beyond)
		% of MU combined CES & GNS (by MU)	2.80% (4.46% in CES MU, 2.62% in GNS MU)	2.80% (4.91% in CES MU, 2.57% in GNS MU)
	Grid cell specific	Number animals total in MU (UK MU)	4,882 (4,879)	4,497 (4,497)

Species	Density (#/km2)	Impact	East location	West location
White-beaked dolphin (Lacey *et al.* 2022)		% of MU total (UK MU)	11.11% (14.43%)	10.23% (13.22%)
White-beaked dolphin (Gilles *et al.* 2023)	Multiple SCANS IV blocks: 0.1352 CS-K 0.0799 NS-D 0.1775 NS-E 0.3056 NS-F 0.1051 NS-G	Number animals total in MU (UK MU)	2,161 (2,086)	2,088 (2,034)
		% of MU total (UK MU)	4.92% (6.35%)	4.75% (4.63%)
Harbour seal (Carter *et al.* 2020)	Grid cell specific	Number animals (95% CI)	2 (0 – 4)	2 (0 – 4)
		% of MU (95% CI)	0.55 (0.00 – 1.10)	0.55 (0.00 – 1.10)
Grey seal (Carter *et al.* 2020)	Grid cell specific	Number animals (95% CI)	1,042 (80 – 2,058)	1,065 (89 – 2,084)
		% of Combined MUs & East Scot MU alone (95% CI)	Combined MUs: 1.99 (0.15 – 3.93) East Scot MU: 9.66 (0.74 – 19.09)	Combined MUs: 2.04 (0.17 – 3.98) East Scot MU: 9.88 (0.83 – 19.33)

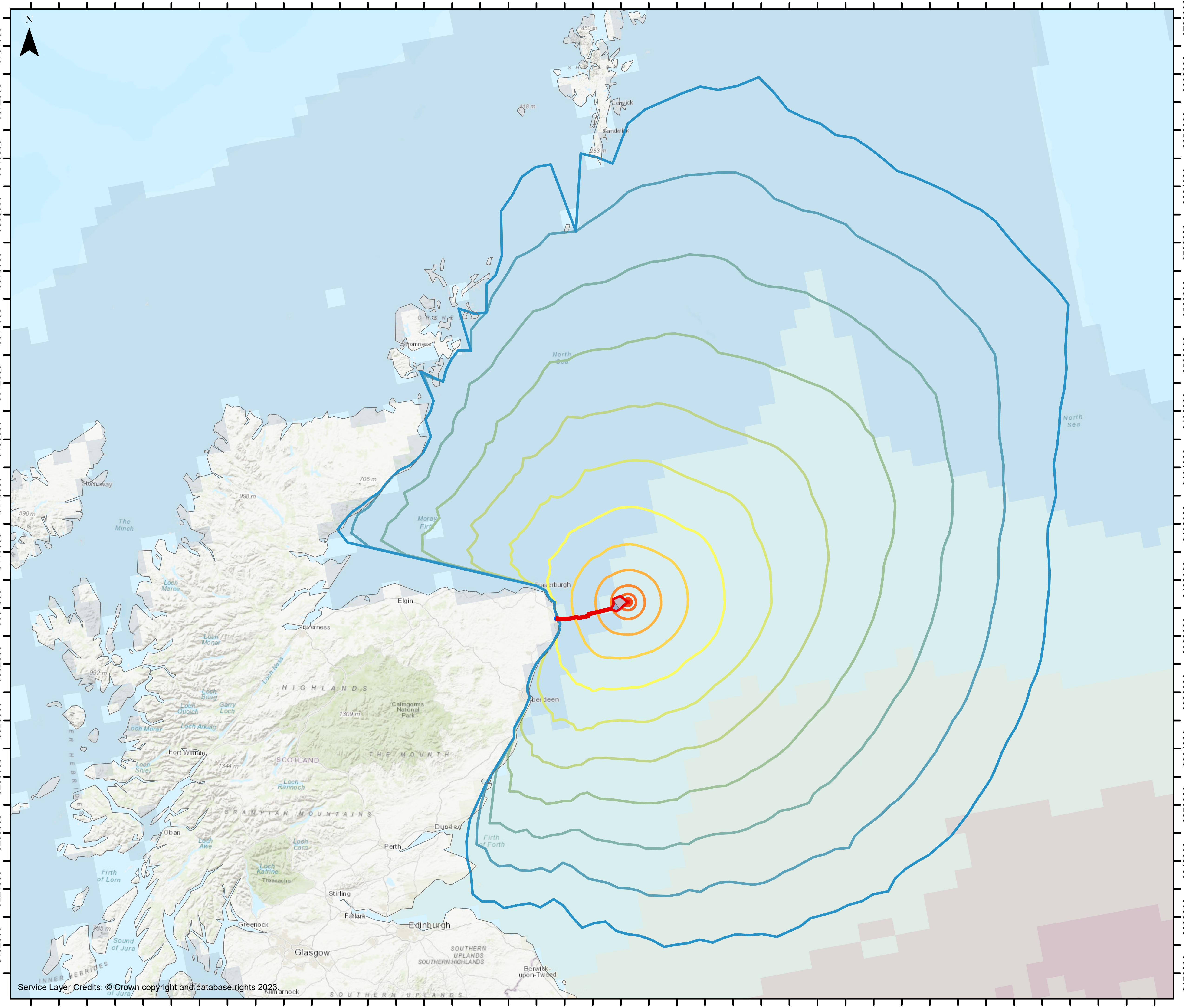
Harbour Porpoise

11.13.7.24 The greatest level of disturbance impacts on harbour porpoise are expected from piling at 2,500 kJ hammer energy (Scenario 1). Using the Lacey *et al*. (2022) grid cell specific density surface, an estimated 11,958 harbour porpoise, equating to 3.45% of the MU, will experience behavioural disturbance as a result of piling of a single piled anchor per day (2,500 kJ) at the E location (11,722 within the UK MU, 7.34% UK MU). Using the Gilles *et al.* (2023) SCANS IV uniform density estimates, an estimated 12,366 harbour porpoise (3.57% MU) will experience behavioural disturbance from piling of a single piled anchor per day (2,500 kJ) at the E location (12,013 within the UK MU, 7.53% UK MU).

Salamander

Figure 11-10

Disturbance contours for anchor piling at the East location overlain on the harbour porpoise density surface



Legend

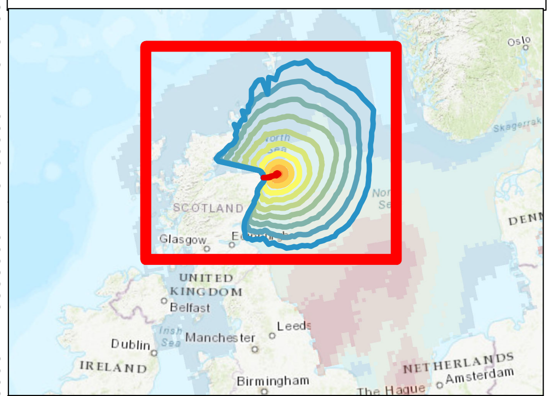
- Offshore Development Area
- Offshore Array
- Offshore Export Cable Corridor
- 12 nm limit
- Indicative Onshore development area

Lacey et al. 2020 Harbour porpoise density

- 0.00 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- >1.25

SELss dB re 1 μPa²s (5dB) East Location

- 120
- 125
- 130
- 135
- 140
- 145
- 150
- 155
- 160
- 165
- 170
- 175
- 180



Coordinate System: WGS 1984 UTM Zone 30N

Scale @ A4 : 20,000,000

0 25 50 100 Kilometers

0 12.5 25 50 Nautical Miles

Rev	Description	Date
01	Final	02/04/2024
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Approved by : AB

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11.13.7.25 To determine whether this level of disturbance is expected to result in population level impacts, iPCoD modelling was conducted. Modelling assumed the installation of piled anchors over a single construction (piling) year, resulting in 80, 20 or 40 days of piling depending on the piling schedule used (see **Section 11.9.7** for details on the piling schedules). The disturbance value used in each of the models was 12,366 harbour porpoise per day since this was the highest number of animals predicted to be impacted by a single location.

11.13.7.26 For each of the piling schedules, the results of the iPCoD modelling show that there is no effect of disturbance resulting from Salamander on the size and trajectory of the harbour porpoise population. The realistic worst-case scenario (assuming 80 piling days) results are presented in full here (**Figure 11-11**, **Table 11-32**). The impacts from the other two piling schedules would be the same or lower since they consisted of fewer piling days.

11.13.7.27 The iPCoD results show that the level of disturbance is not sufficient to result in any changes at the population level, since the impacted population is predicted to continue at a stable trajectory, the same as the un-impacted population. The impact is therefore short-term, with full rapid recovery expected to result in imperceptible changes to the receptor population. The magnitude of disturbance from piled anchors has therefore been assessed as **Negligible**.

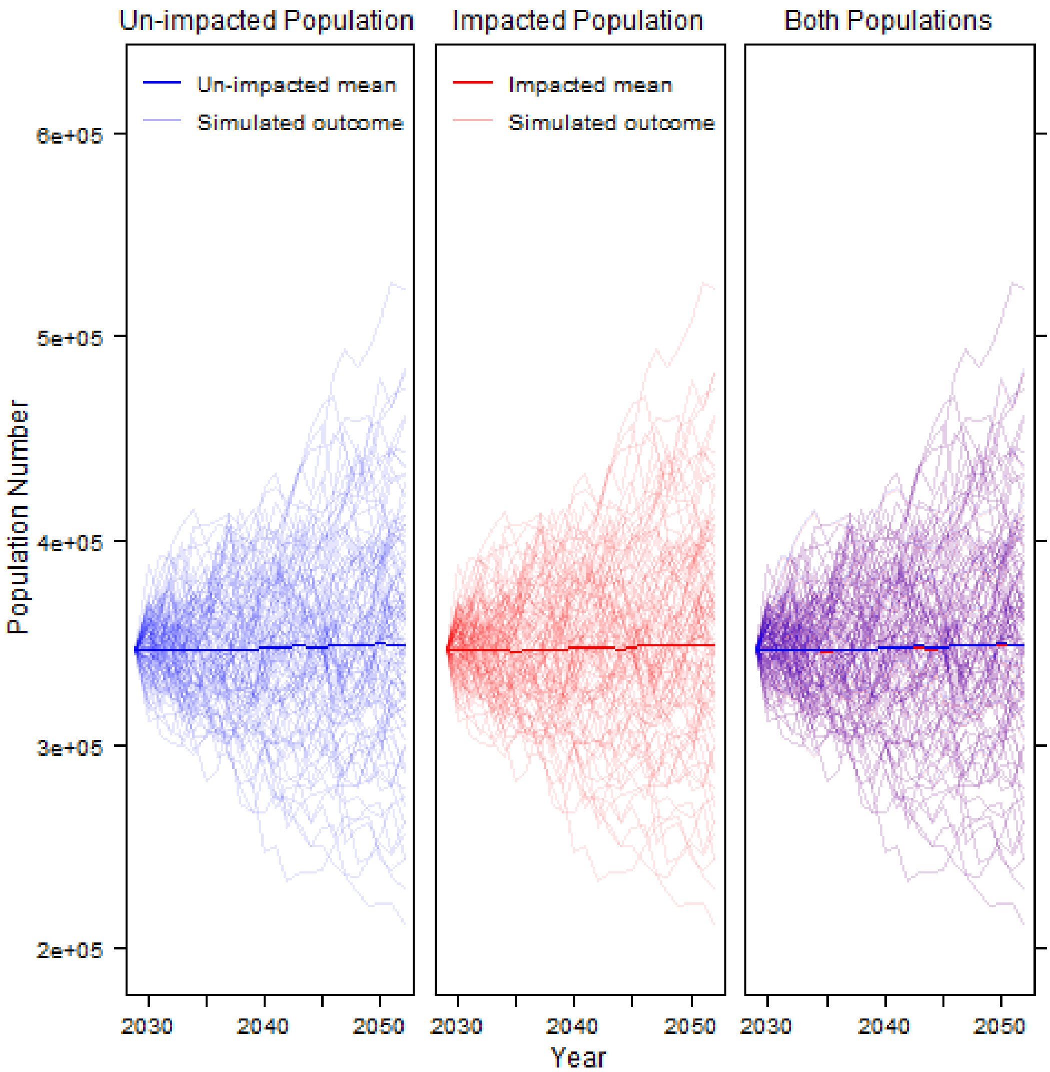


Figure 11-11 Predicted population trajectories for the un-impacted (baseline) and impacted harbour porpoise iPCoD simulations (80 days piling of anchor piles), impacting 12,366 harbour porpoise per day.

Table 11-32 Predicted impact of disturbance from pile driving activities on harbour porpoise using the day piling schedule.

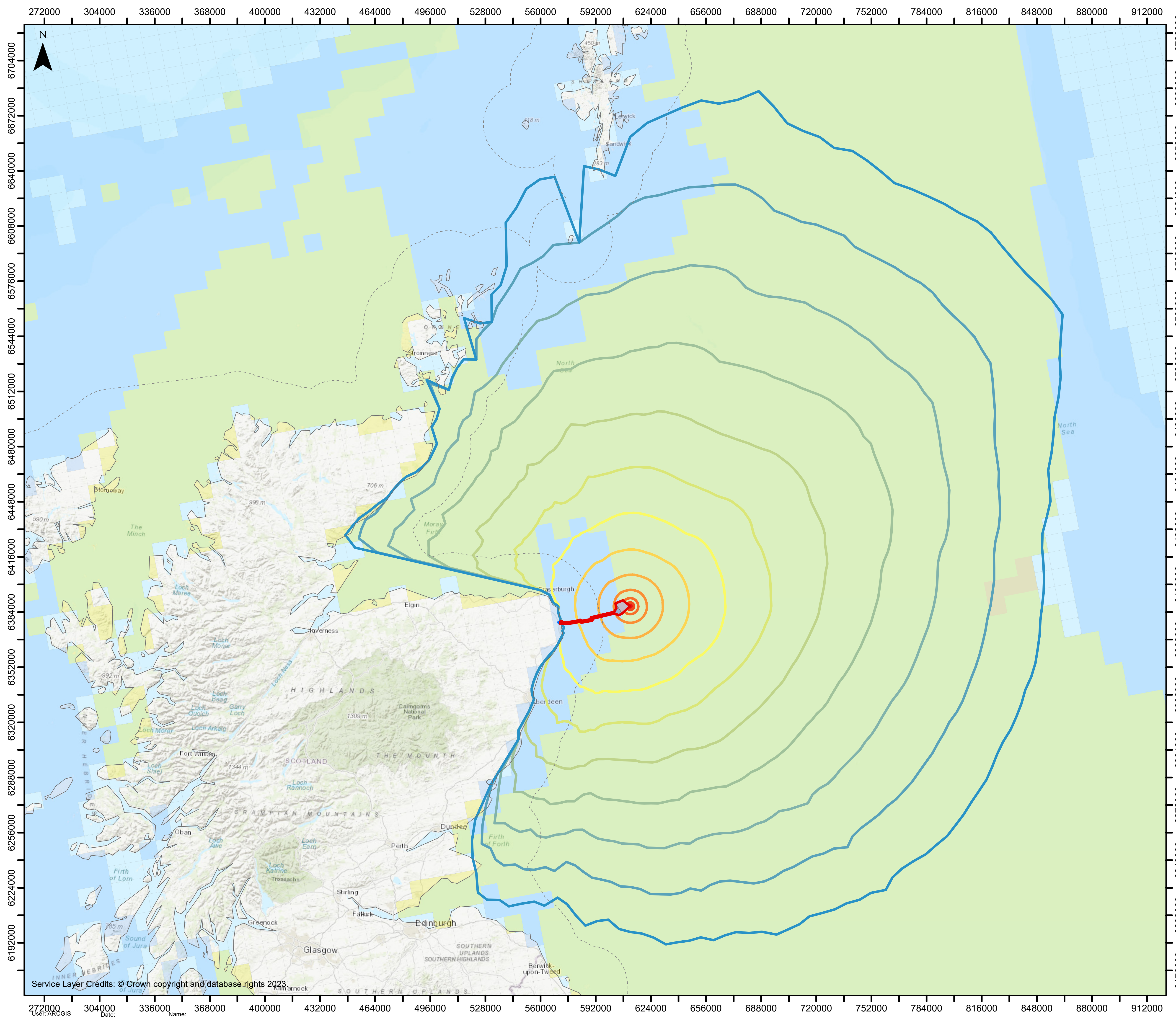
Simulation year	Un-impacted mean population size	Impacted mean population size	Impacted as % of un-impacted population size	Median ratio impacted:un-impacted growth rate
End 2027 (before piling commences)	346,602	346,602	100	1.00
End 2028 (after piling stops)	346,442	346,380	99.98	1.00
End 2034 (6 years after piling stops)	346,152	345,938	99.94	0.99
End 2040 (12 years after piling stops)	347,807	347,579	99.93	0.99

Minke Whale

11.13.7.28 The greatest level of disturbance impacts on minke whale are expected from piling at 2,500 kJ hammer energy (Scenario 1). Using the Lacey *et al*. (2022) grid cell specific density surface, an estimated 603 minke whales, equating to 3.00% of the MU, will experience behavioural disturbance per day as a result of anchor piling at the E location (585 within the UK EEZ, 5.69% UK MU). Using the Gilles *et al*. (2023) SCANS IV uniform density surfaces, an estimated 1,535 minke whale (7.63% MU) will experience behavioural disturbance from piling of a single piled anchor (2,500 kJ) at the E location (1,343 within the UK MU, 13.13% UK MU).

11.13.7.29 **Figure 11-12** shows the behavioural disturbance dose-response contours for the installation of a piled anchor at the East location under Scenario 1.

11.13.7.30 The impact is predicted to be of relatively short in duration (80 days, realistic worst-case scenario), intermittent, and temporary. It is also important to note here that minke whales are expected to only be present in the summer months, and therefore any pile driving activities that occur outside the summer months is expected to have no impact on minke whales as none are expected to be present. Given the seasonal presence, the number of whales predicted to be impacted and the proportion of the population this represents, this impact is considered to be of **Low** magnitude.



Salamander

Figure 11-12

Disturbance contours for anchor piling at the East location overlain on the minke whale density surface

Legend

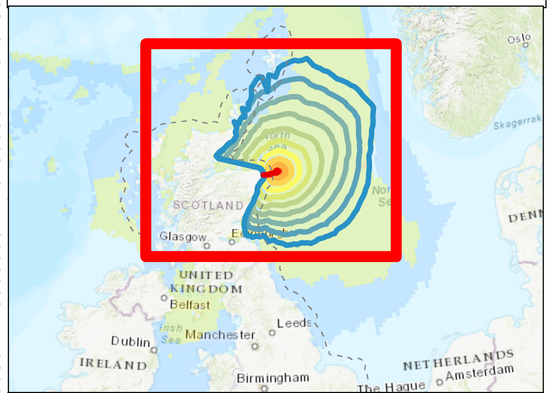
- Offshore Development Area
- Offshore Array Area
- Offshore Export Cable Corridor
- Indicative Onshore development area
- 12 nm limit

Lacey et al. 2020 Minke whale density

- 0.00 - 0.01
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.08
- 0.08 - 0.10
- >0.10

SELss dB re 1 µPa²s (5dB) East Location

- 120
- 125
- 130
- 135
- 140
- 145
- 150
- 155
- 160
- 165
- 170
- 175
- 180



Coordinate System: WGS 1984 UTM Zone 30N

Scale @ A4 : 2,000,000

0 25 50 100 Kilometers

0 12.5 25 50 Nautical Miles

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Bottlenose Dolphin

11.13.7.31 Given the uncertainty in the bottlenose dolphin density estimates, two different approaches have been used in the disturbance assessment:

- The impact contours were split such that the area of the contours within the CES MU assumed a density of 0.01 dolphins/km^2, while the portion of the impact contour located in the GNS MU assumed a density of 0.003 dolphins/km^2.
- The impact contours were split such that the area of the contours within 2 km of the mainland coastline assumed a density of 0.11 dolphins/km^2, while the rest of the contour assumed a density of 0.003 dolphins/km^2. This is considered to be a more accurate reflection of bottlenose dolphin distribution within the CES MU since they are known to be largely restricted to highly coastal waters.

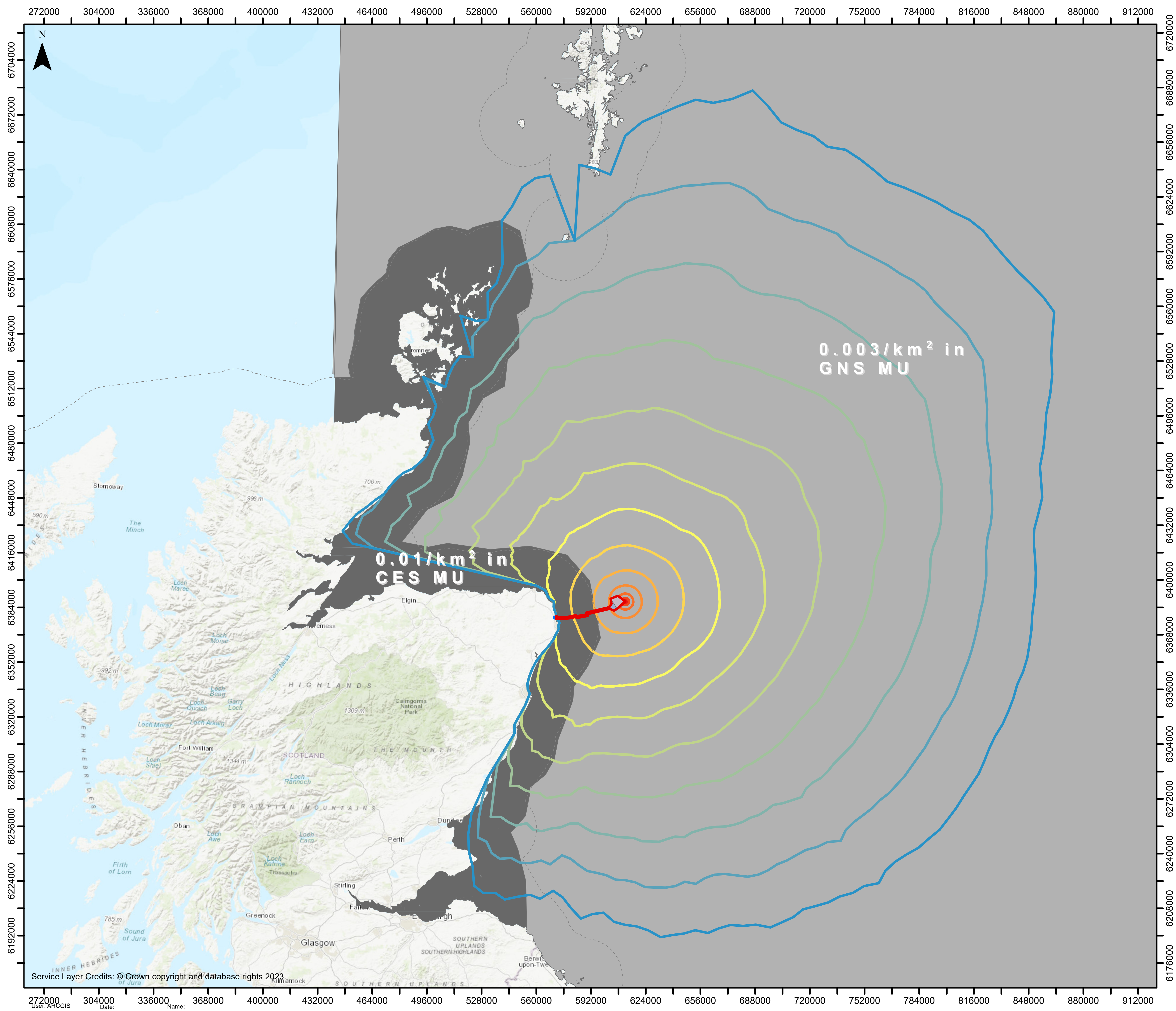
11.13.7.32 The greatest level of disturbance impacts on bottlenose dolphin are expected from piling at 2,500 kJ hammer energy (Scenario 1). Splitting the impact contours by the MU resulted in a total of 84 bottlenose dolphins predicted to experience behavioural disturbance as a result of anchor piling at the E location (equating to 4.1% of the combined CES & NS MUs). The number of animals impacted within the CES MU is 25 dolphins (11.16% MU), while the number of animals impacted in the GNS MU is 59 dolphins (2.92% MU). **Figure 11-13** shows the behavioural disturbance dose-response contours for the installation of a piled anchor at the E location using the MU split approach under Scenario 1.

11.13.7.33 Splitting the impact contours to account for higher densities within 2 km from the mainland (**Figure 11-14**), resulted in a total of 78 bottlenose dolphins predicted to experience behavioural disturbance as a result of anchor piling at the E location (equating to 3.47% of the combined CES & NS MUs). The number of animals predicted to be impacted within 2 km from the mainland coast is 12, while the number of animals predicted to be impacted beyond 2 km from the mainland coast is 66 dolphins.

Salamander

Figure 11-13

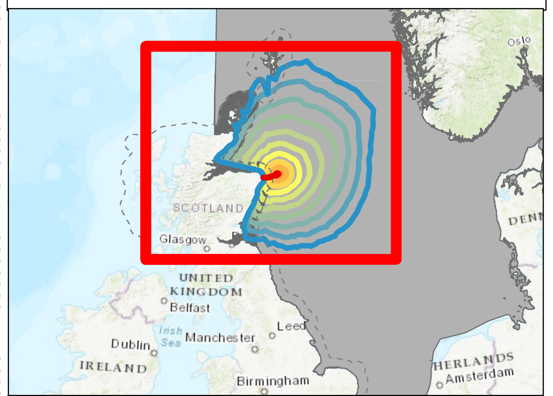
Disturbance contours for anchor piling at the East location using the MU split approach



Legend

- Offshore Development Area
- Offshore Array
- Offshore Export Cable Corridor
- Indicative Onshore development area
- 12 nm limit
- Greater North Sea (GNS) Management Unit (MU)
- Coastal East Scotland (CES) Management Unit (MU)

SELss dB re 1 μPa²s (5dB) East Location: 120, 125, 130, 135, 140, 145, 150, 155, 160, 165, 170, 175, 180



Coordinate System: WGS 1984 UTM Zone 30N

Scale @ A4 : 20,000,000

0 25 50 100 Kilometers

0 12.5 25 50 Nautical Miles

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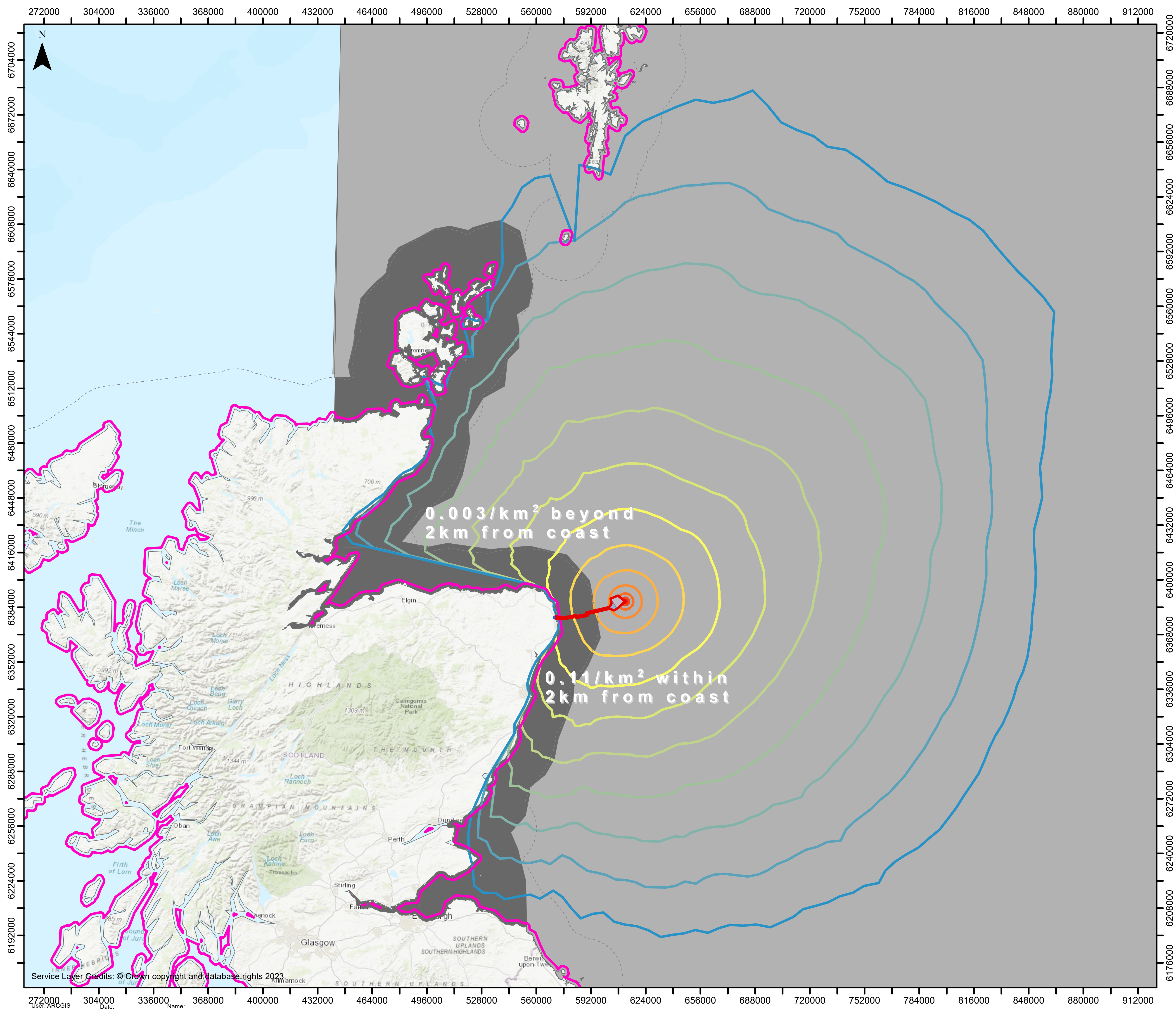


Salamander

Figure 11-14

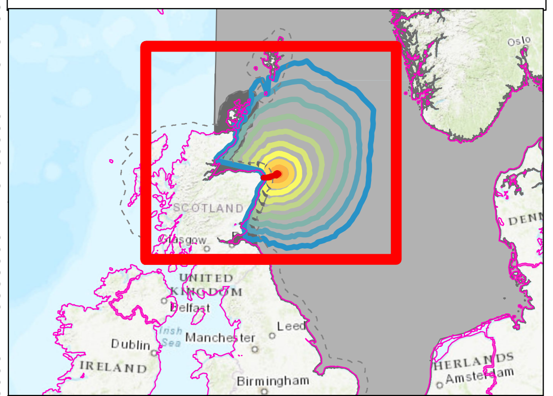
Disturbance contours for anchor piling at the East location using the 2 km from coastline split approach

Legend

- Offshore Development Area
- Offshore Array
- Offshore Export Cable Corridor
- Indicative Onshore development area
- 12 nm limit
- 2km buffer
- Greater North Sea (GNS) Management Unit (MU)
- Coastal East Scotland (CES) Management Unit (MU)

SELss dB re 1 μPa²s (5dB) East Location

- 120
- 125
- 130
- 135
- 140
- 145
- 150
- 155
- 160
- 165
- 170
- 175
- 180



Coordinate System: WGS 1984 UTM Zone 30N

Scale @ A4 : 2,000,000

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0 12.5 25 50 Nautical Miles

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11.13.7.34 The bottlenose dolphin assessment used the harbour porpoise dose-response function in the absence of similar empirical data. However, this makes the assumption that the same disturbance relationship is observed in bottlenose dolphins. It is anticipated that this approach will be overly precautionary as evidence suggests that dolphin species are less sensitive to disturbance compared to harbour porpoise. A literature review of recent (post Southall *et al.* (2007)) behavioural responses by harbour porpoises and bottlenose dolphins to noise was conducted by Moray Offshore Renewables Limited (2012). Several studies have reported a moderate to high level of behavioural response at a wide range of received SPLs (100 and 180 dB re 1µPa) (Lucke *et al.* 2009, Tougaard *et al.* 2009, Brandt *et al.* 2011). Conversely, a study by Niu *et al.* (2012) reported moderate level responses to non-pulsed noise by bottlenose dolphins at received SPLs of 140 dB re 1µPa. Another high frequency cetacean, Risso's dolphin, reported no behavioural response at received SPLs of 135 dB re 1µPa (Southall *et al.* 2010). Whilst both species showed a high degree of variability in responses and a general positive trend with higher responses at higher received levels, moderate level responses were observed above 80 dB re 1µPa in harbour porpoise (for non-pulsed noise) and above 140 dB re 1µPa in bottlenose dolphins (Moray Offshore Renewables Limited 2012), indicating that moderate level responses by bottlenose dolphins will be exhibited at a higher received SPL and, therefore, they are likely to show a lesser response to disturbance.

11.13.7.35 To determine whether this level of disturbance is expected to result in population level impacts, iPCoD modelling was conducted. Modelling assumed the installation of pile anchors over a single construction (piling) year, resulting in a realistic worst-case scenario of 80 piling days throughout this period. Different disturbance values were used in each of the models to reflect the number of individuals likely to be impacted in either the CES MU or GNS MU. As such, modelled scenarios included either 27 bottlenose dolphins (CES MU) per day, or 59 bottlenose dolphins (GNS MU) per day. These were the highest numbers of animals predicted to be impacted by a single location.

11.13.7.36 It's important to note that the number of bottlenose dolphins for the CES MU population have generally increased since 2009 (Cheney *et al.* 2012, Cheney *et al.* 2013, Cheney *et al.* 2014a, Arso Civil *et al.* 2021). Trends of increasing abundance have been identified both within the Moray Firth (Cheney *et al.* 2013, Cheney *et al.* 2014b, Quick *et al.* 2014, Cheney *et al.* 2018) and Tay Estuary (Quick *et al.* 2014, Arso Civil *et al.* 2018a, Arso Civil *et al.* 2019, Arso Civil *et al.* 2021) areas of the CES MU. These trends are expected to continue, and thus it is predicted that the population size of bottlenose dolphins within the CES MU shall continue to increase (Arso Civil *et al.* 2021).

11.13.7.37 Only results for the realistic worst-case 80 day piling schedule is presented in full here (Figure 11-15, Table 11-33 and Table 11-34, Figure 11-16). The impacts from the other two piling schedules would be the same or lower since they consisted of fewer piling days.

11.13.7.38 For each of the piling schedules, the results of the iPCoD modelling show that there is no effect of disturbance resulting from Salamander on the projected increasing population size and trajectory of the bottlenose dolphins in the CES MU. For both the unimpacted and impacted populations, fluctuations in population size are observed but, ultimately, the population is predicted to continue to increase over time and thus there are no long-term impacts to the population (**Figure 11-15**, **Table 11-33**).

11.13.7.39 For the GNS MU and each of the piling schedules, the results of the iPCoD modelling show that there is no effect of disturbance resulting from Salamander on the size and trajectory of the bottlenose dolphin population. For both the unimpacted and impacted populations, fluctuations in population size are observed but, ultimately, the population remains stable over time and thus there are no long-term impacts to the population (**Table 11-34**, **Figure 11-16**).

11.13.7.40 As such, it is expected that the predicted level of disturbance is not sufficient to result in any changes at the population level, since the impact population is predicted to continue at a stable trajectory for the GNS MU, and continue to increase for the CES MU, the same as the un-impacted population. The impact is therefore short-term, with full rapid recovery expected to result in imperceptible changes to the receptor population. The magnitude of disturbance from piling of piled anchors has therefore been assessed as Negligible.

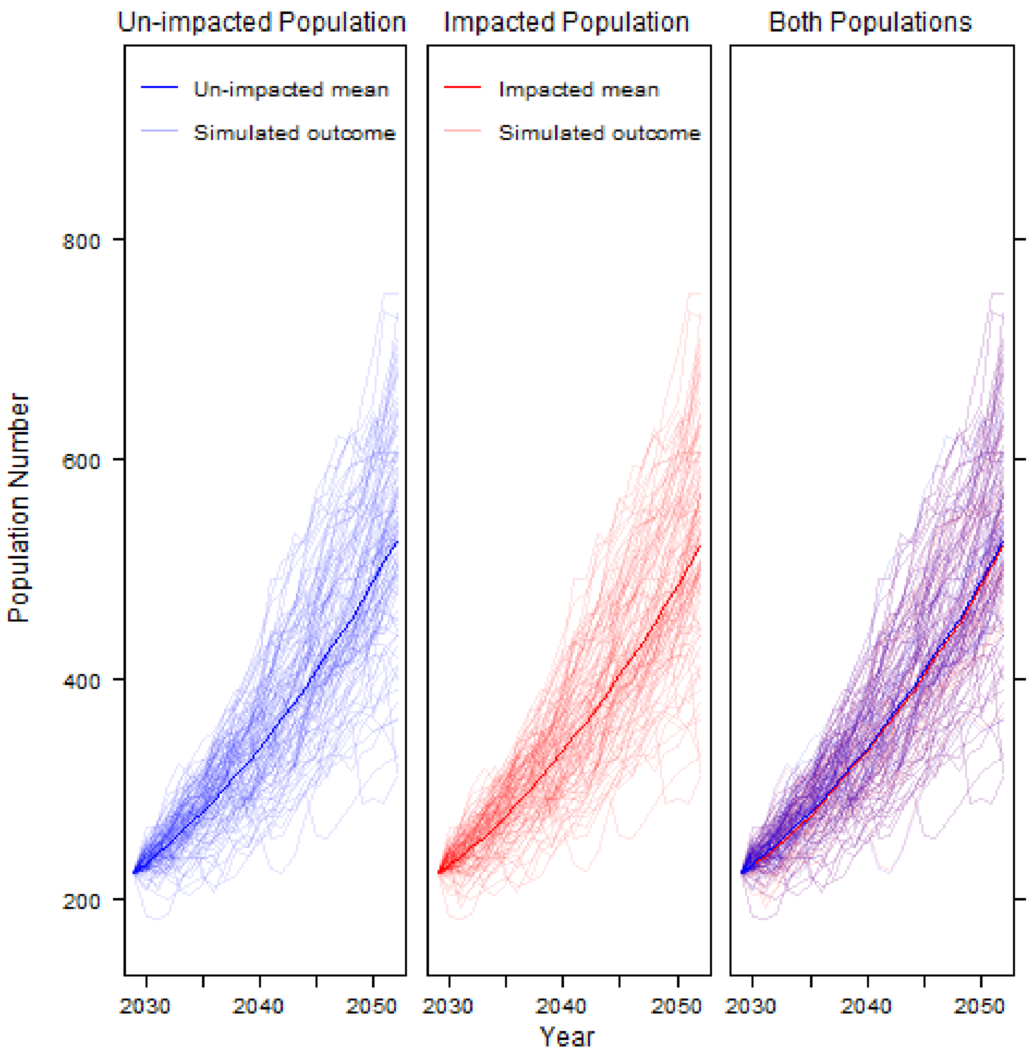


Figure 11-15 Predicted population trajectories for the un-impacted (baseline) and impacted bottlenose dolphin (Coastal East Scotland Management Unit) iPCoD simulations (80 days piling of anchor piles), impacting 27 bottlenose dolphins per day.

Table 11-33 Predicted impact of disturbance from pile driving activities on bottlenose dolphin (Coastal East Scotland Management Unit) using the 80 day piling schedule.

Simulation year	Un-impacted mean population size	Impacted mean population size	Impacted as % of un-impacted population size	Median ratio impacted:un-impacted growth rate
End 2027 (before piling commences)	224	224	100	1.00
End 2028 (after piling stops)	233	232	99.57	1.00
End 2034 (6 years after piling stops)	290	288	99.31	1.00
End 2040 (12 years after piling stops)	337	334	99.11	1.00

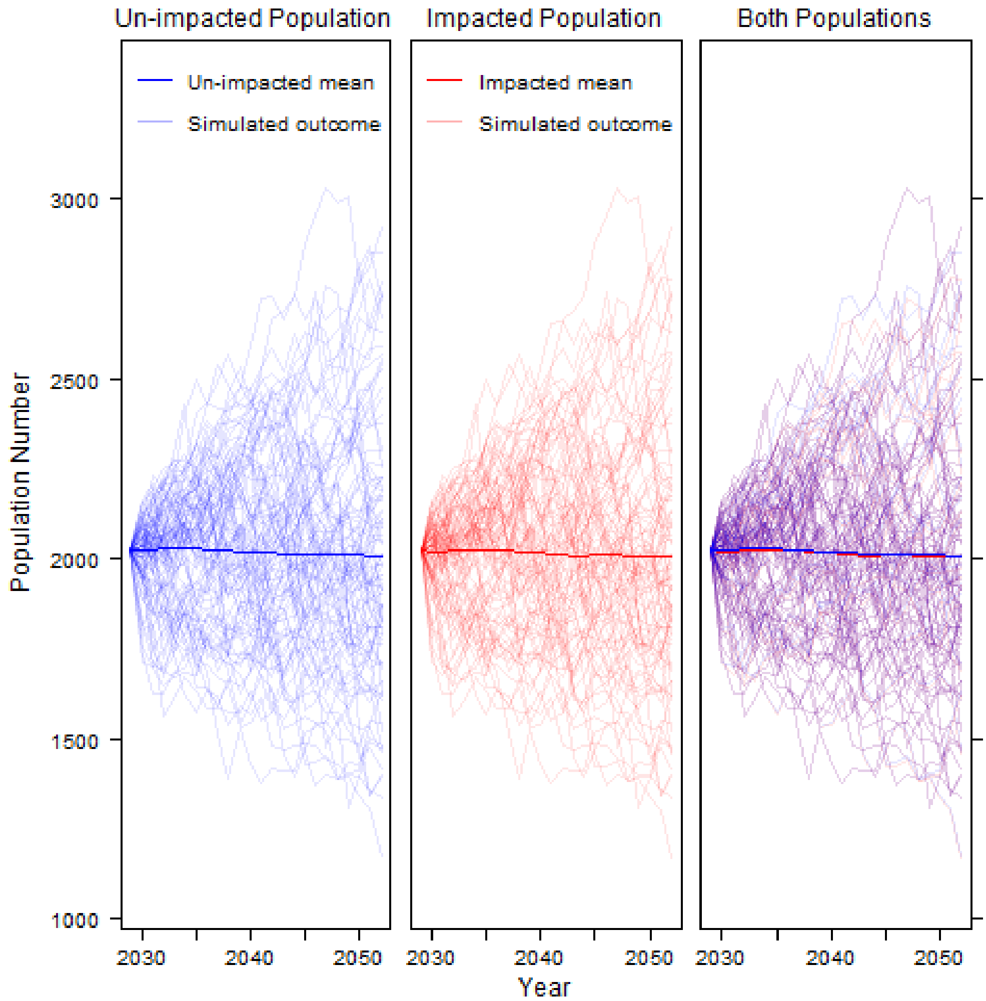


Figure 11-16 Predicted population trajectories for the un-impacted (baseline) and impacted bottlenose dolphin (Greater North Sea Management Unit) iPCoD simulations (80 days piling of anchor piles), impacting 27 bottlenose dolphins per day

Table 11-34 Predicted impact of disturbance from pile driving activities on bottlenose dolphin (Greater North Sea Management Unit) using the 80 day piling schedule

Simulation year	Un-impacted mean population size	Impacted mean population size	Impacted as % of un-impacted population size	Median ratio impacted:un-impacted growth rate
End 2027 (before piling commences)	2,024	2,024	100	1.00
End 2028 (after piling stops)	2,023	2,022	99.95	1.00
End 2034 (6 years after piling stops)	2,028	2,025	99.85	1.00
End 2040 (12 years after piling stops)	2,017	2,013	99.80	1.00

White-beaked Dolphin

11.13.7.41 The greatest level of disturbance impacts on white-beaked dolphin are expected from piling at 2,500 kJ hammer energy (Scenario 1). Using the Lacey *et al*. (2022) grid cell specific density surface, an estimated 5,697 white-beaked dolphins, equating to 12.96% of the MU, will experience behavioural disturbance as a result of anchor piling at the E location (5,691 within the UK EEZ, 16.73% UK MU).

11.13.7.42 As described above for bottlenose dolphins, the harbour porpoise dose-response function has been used as a proxy for all dolphin species in the absence of similar empirical data. It is anticipated that this approach will be overly precautionary as evidence suggests that dolphin species are less sensitive to disturbance compared to harbour porpoise (see detail above).

11.13.7.43 The movement patterns of white-beaked dolphins in UK waters are poorly understood, and as such, it is not known the level of repeated disturbance an individual dolphin would be expected to receive. At one extreme, it could be assumed that there is no movement/turn-over of individuals in the area, and thus the same dolphins would be expected to be disturbed repeatedly on up to 80 piling days (realistic worst-case scenario) over a 1-year piling activity period. However, this is considered to be highly conservative since the limited data available of white-beaked dolphin movement patterns suggests that white-beaked dolphins have large home range areas and show low site fidelity (Bertulli *et al.* 2015). It is more likely that animals transit through the area within their large home-range, and thus individuals are only available to be disturbed over a limited number of days when present in the disturbance area.

11.13.7.44 Although there is a lack of data on white-beaked dolphin responses to pile driving, and the fact that iPCoD is not available for this species to determine whether or not this level of impact is likely to result in a population level impact, it is anticipated that the magnitude of impact should be similar to those assessed for bottlenose dolphins as part of the GNS MU. However, since this cannot be confirmed, it is conservative to conclude a **Low** magnitude, since it is possible that impacts could result in a slight deviation from the baseline.

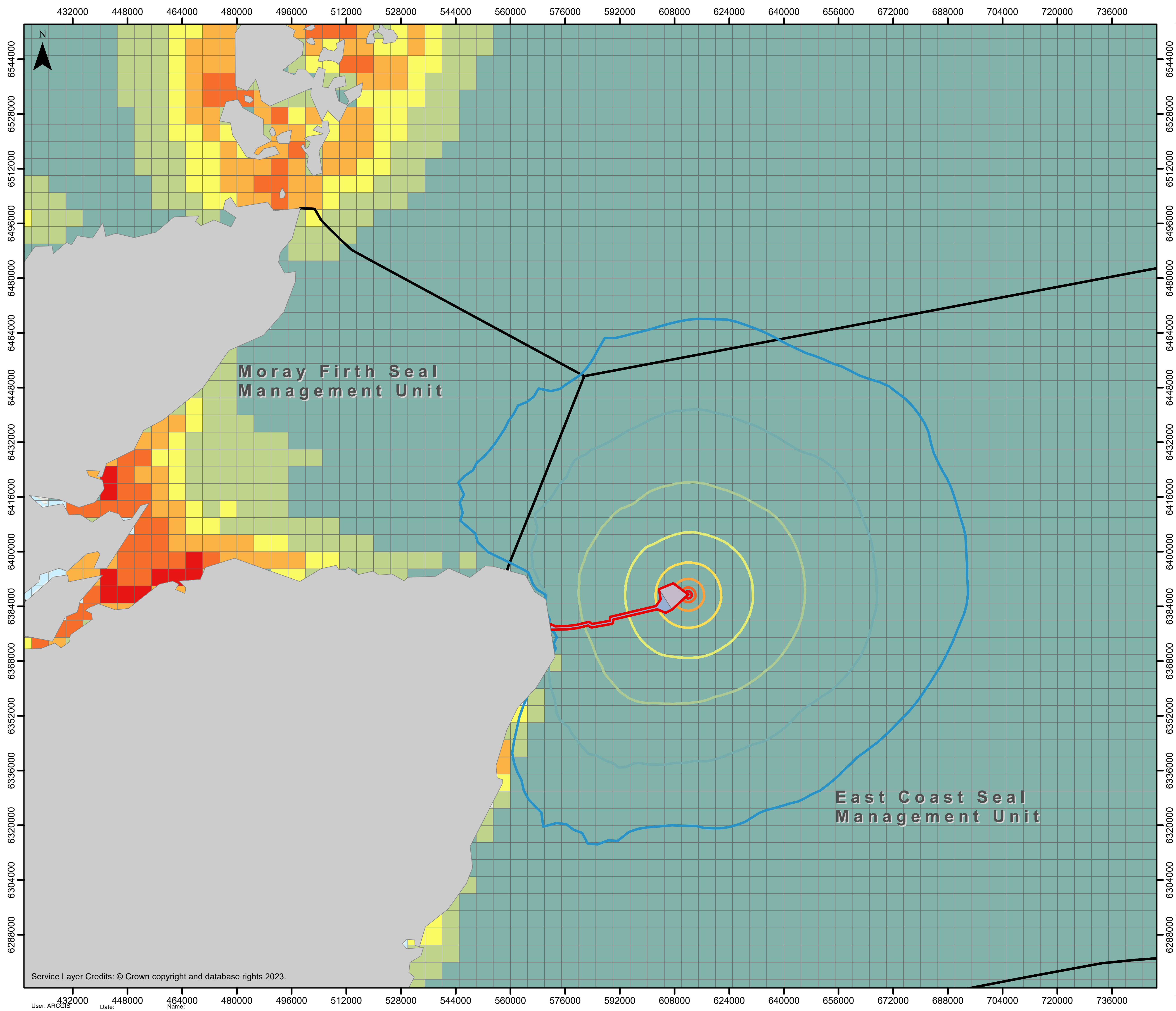
Harbour Seal

11.13.7.45 The greatest level of disturbance impacts on harbour seal are expected from piling at 2,500 kJ hammer energy (Scenario 1). The results for harbour seals are presented with 95% confidence intervals as there was a large amount of uncertainty in dose-response function. A total of 4 harbour seals (95% CI: 0 – 7) are predicted to be impacted within the East Scotland MU due to anchor piling at the western location. This represents 1.10% (95% CI: 0.82% - 1.92%) of the East Scotland MU. **Figure 11-17** shows the behavioural disturbance dose-response contours for the installation of a piled anchor under Scenario 1.

Salamander

Figure 11-17

Harbour seal disturbance contours for anchor piling at the East location overlain on the mean % British Isles population (Carter et al., 2020)



Legend

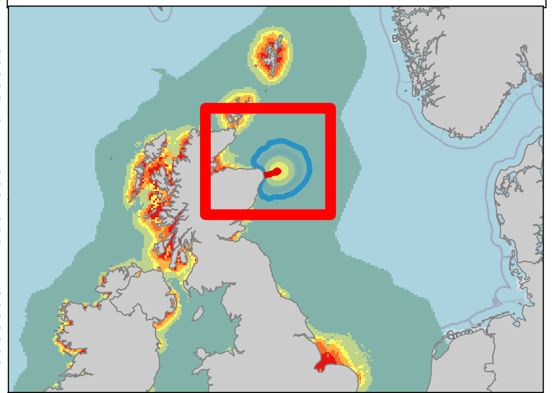
- Offshore Development Area
- Offshore Array Area
- Offshore Export Cable Corridor
- Indicative Onshore development area
- 12 nm limit
- Seal Management Units

% mean British Isles at-sea population

- 0.00
- 0.00 - 0.001
- 0.001 - 0.005
- 0.005 - 0.01
- 0.01 - 0.025
- 0.025 - 0.05
- >0.05

SELss dB re 1 μPa²s (5dB) East Location

- 145
- 150
- 155
- 160
- 165
- 170
- 175
- 180



Coordinate System: WGS 1984 UTM Zone 30N

Scale @ A4 : 1,000,000

0 12.5 25 50 Kilometers

0 5 10 20 Nautical Miles

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11.13.7.46 To determine whether this level of disturbance is expected to result in population level impacts, iPCoD modelling was conducted. Modelling assumed the installation of piled anchors over a single construction (piling) year, resulting in 80, 20 or 40 days of piling depending on the piling schedule used (see **Section 11.9.7** for details on the piling schedules).

11.13.7.47 For each of the piling schedules, the results of the iPCoD modelling show that there is no effect of disturbance resulting from Salamander on the size and trajectory of the harbour seal population. The realistic worst-case scenario (assuming 80 piling days) results are presented in full here (**Figure 11-18** and **Table 11-35**). The impacts from the other two piling schedules would be the same or lower since they consisted of fewer piling days.

11.13.7.48 The iPCoD results show that the level of disturbance predicted is not sufficient to result in any changes at the population level since the impacted population is predicted to continue at a stable trajectory, the same as the un-impacted population. The impact is therefore short-term, with full rapid recovery expected to result in imperceptible changes to the receptor population. The magnitude of disturbance from pile driving has therefore been assessed as **Negligible**.

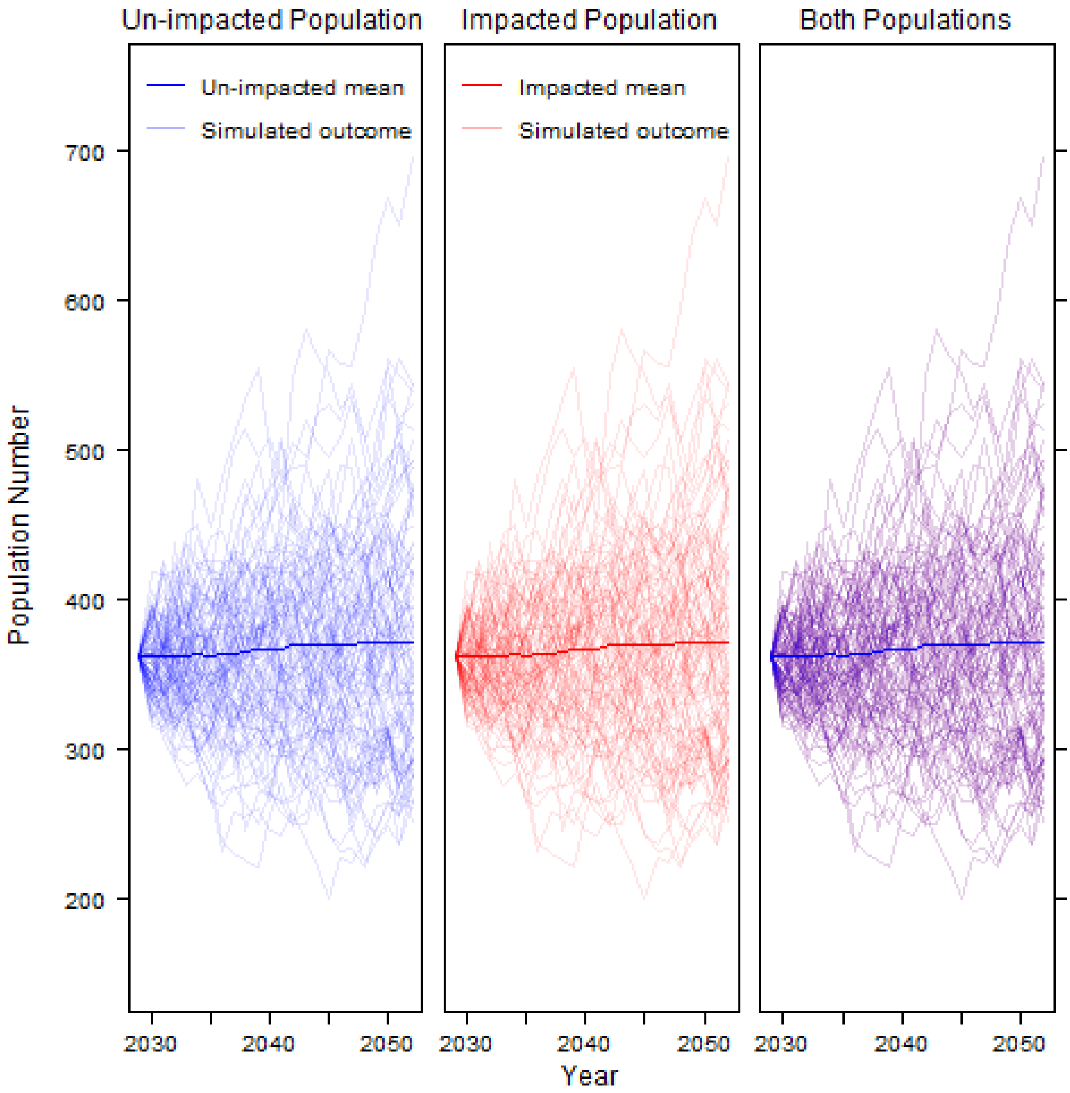


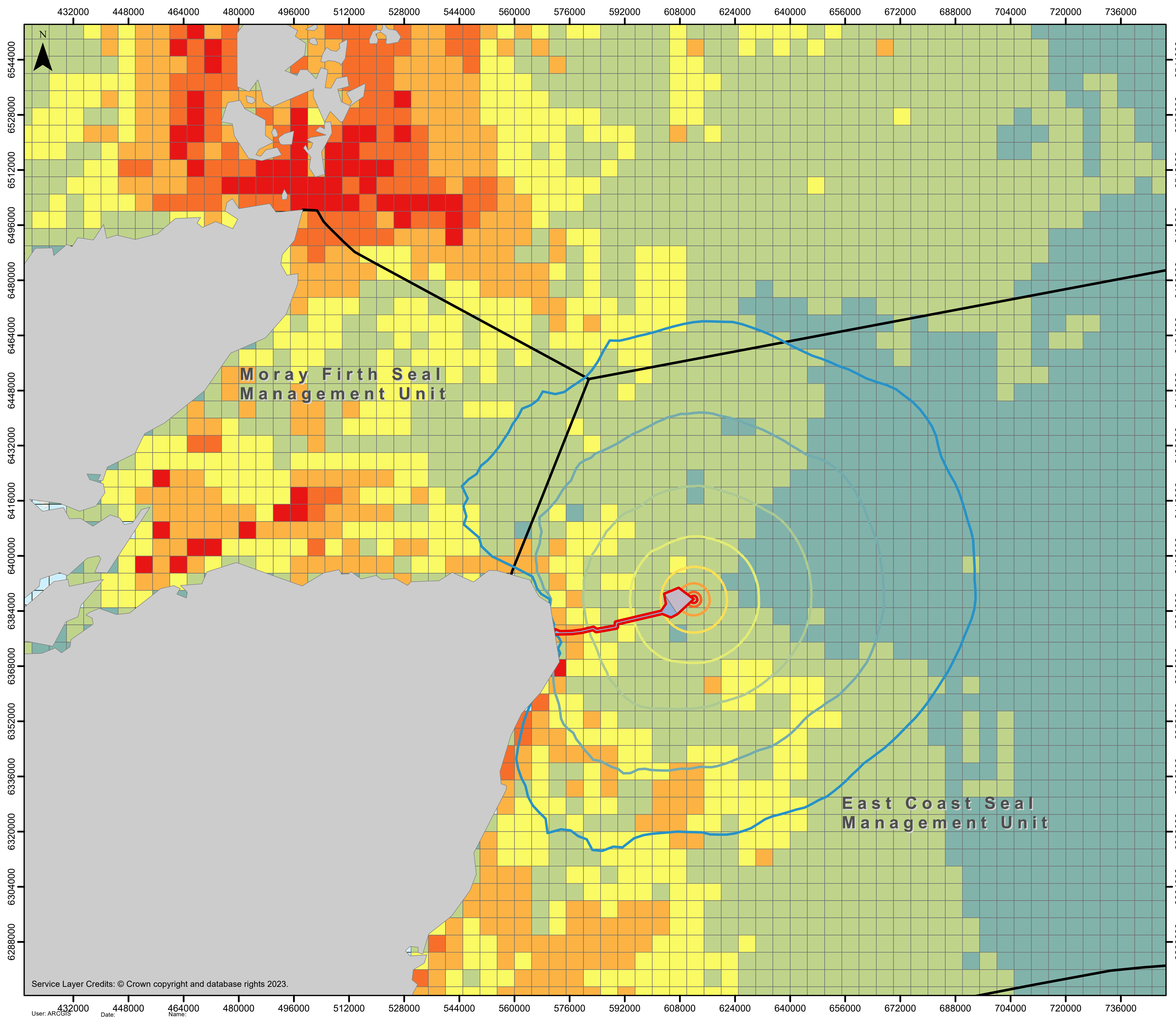
Figure 11-18 Predicted population trajectories for the un-impacted (baseline) and impacted harbour seals (East Scotland SMU) iPCoD simulations (80 days piling of anchor piles), impacting 4 harbour seals per day

Table 11-35 Predicted impact of disturbance from pile driving activities on harbour seals using the 80 day piling schedule.

Simulation year	Un-impacted mean population size	Impacted mean population size	Impacted as % of un-impacted population size	Median ratio impacted:un-impacted growth rate
End 2027 (before piling commences)	362	362	100	1.00
End 2028 (after piling stops)	363	363	100	1.00
End 2034 (6 years after piling stops)	364	364	100	1.00
End 2040 (12 years after piling stops)	364	364	100	1.00

Grey Seal

11.13.7.49 The greatest level of disturbance impacts on grey seals are expected from piling at 2,500 kJ hammer energy (Scenario 1). The results for grey seals are presented with 95% confidence intervals as there was a large amount of uncertainty in dose-response function. A total of 1,429 grey seals (95% CI: 120 – 2,775) are predicted to be impacted due to anchor piling at the western location. This represents 2.73% (95% CI: 0.23% - 5.30%) of the combined Moray Firth and East Scotland MUs, and 13.25% (95% CI: 1.11% - 25.73%) of the East Scotland MU. **Figure 11-19** shows the behavioural disturbance dose-response contours for the installation of a piled anchor under Scenario 1.



Salamander

Figure 11-19

Grey seal disturbance contours for anchor piling at the East location overlain on the mean % British Isles population (Carter et al., 2020)

Legend

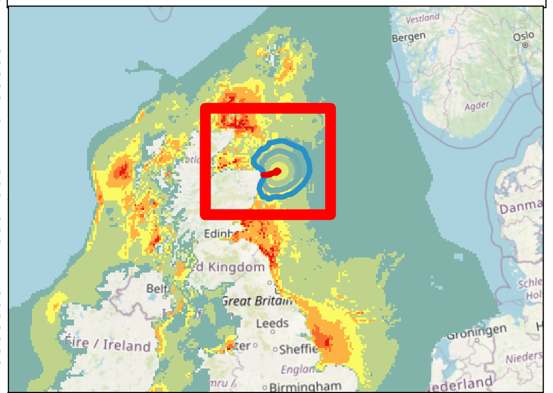
- Offshore Development Area
- Offshore Array
- Offshore Export Cable Corridor
- Indicative Onshore development area
- 12 nm limit
- Seal Management Units

% mean British Isles at-sea population

- 0.00
- 0.00 - 0.001
- 0.001 - 0.005
- 0.005 - 0.01
- 0.01 - 0.025
- 0.025 - 0.05
- >0.05

SELss dB re 1 μPa²s (5dB) East Location

- 145
- 150
- 155
- 160
- 165
- 170
- 175
- 180



Coordinate System: WGS 1984 UTM Zone 30N

Scale @ A4 : 1,000,000

0 12.5 25 50 Kilometers

0 5 10 20 Nautical Miles

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11.13.7.50 To determine whether this level of disturbance is expected to result in population level impacts to grey seals, iPCoD modelling was conducted. Modelling assumed the installation of piled anchors over a single construction (piling) year, resulting in 80, 20 or 40 days of piling depending on the piling schedule used (see **Section 11.9.7** for details on the piling schedules). The disturbance value included in each of the modelled scenarios was 1,429 grey seals per day since this was the highest number of animals predicted to be impacted by a single location.

11.13.7.51 For each of the piling schedules, the results of the iPCoD modelling show that there is no effect of disturbance resulting from Salamander on the size and trajectory of the grey seal population. The realistic worst-case scenario (assuming 80 piling days) results are presented in full here (**Figure 11-20** and **Table 11-36**). The impacts from the other two piling schedules would be the same or lower since they consisted of fewer piling days.

11.13.7.52 The iPCoD results show that the level of disturbance predicted is not sufficient to result in any changes at the population level since the impacted population is predicted to continue at a stable trajectory, the same as the un-impacted population. The impact is therefore short-term, with full rapid recovery expected to result in imperceptible changes to the receptor population. The magnitude of disturbance from pile driving has therefore been assessed as **Negligible.**

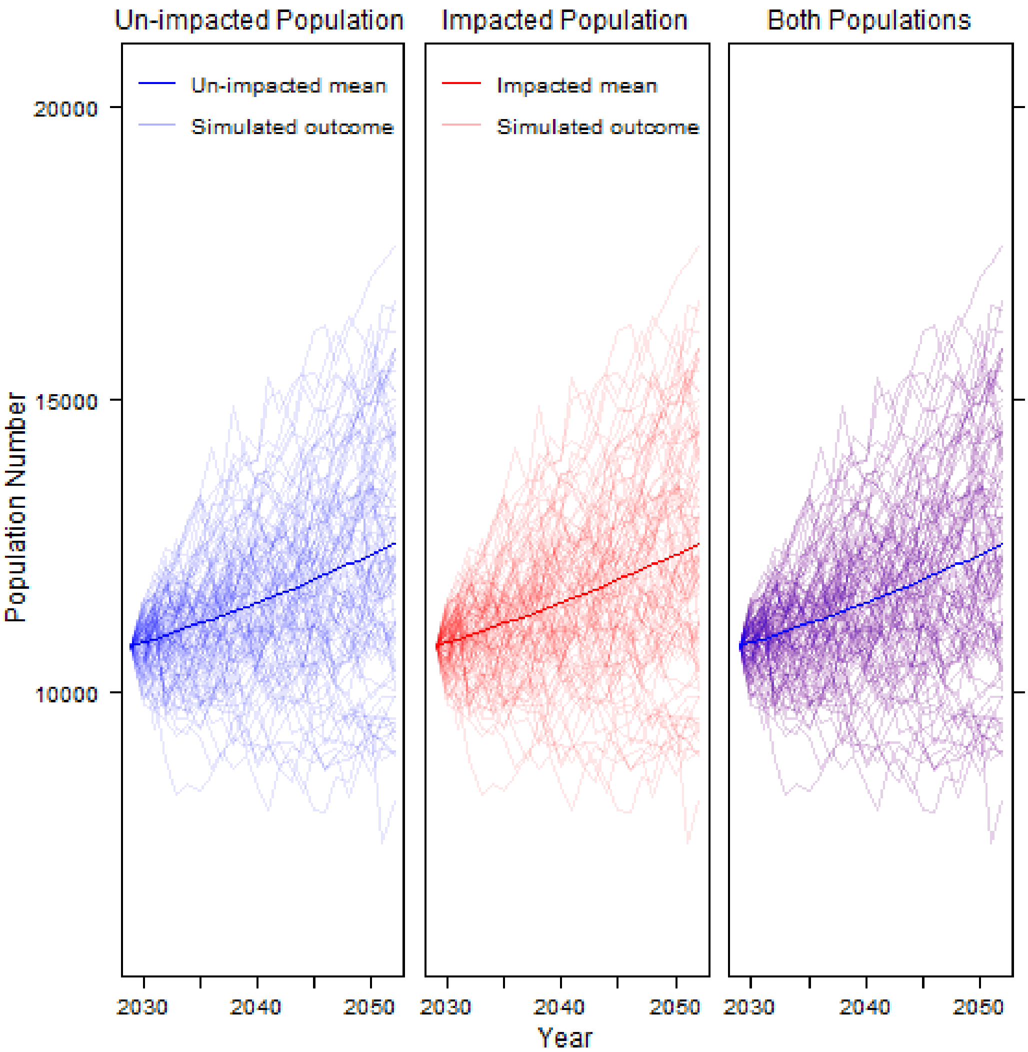

Figure 11-20 Predicted population trajectories for the un-impacted (baseline) and impacted grey seal (East Scotland Seal Management Unit) iPCoD simulations (80 days piling of anchor piles), impacting 1,429 grey seals per day.

Table 11-36 Predicted impact of disturbance from pile driving activities on grey seals (East Scotland Seal Management Unit) using the 80 day piling schedule.

Simulation year	Un-impacted mean population size	Impacted mean population size	Impacted as % of un-impacted population size	Median ratio impacted:un-impacted growth rate
End 2027 (before piling commences)	10,788	10,788	100	1.00
End 2028 (after piling stops)	10,861	10,861	100	1.00
End 2034 (6 years after piling stops)	11,290	11,290	100	1.00
End 2040 (12 years after piling stops)	11,755	11,755	100	1.00

Significance of Impact

11.13.7.53 For harbour porpoise, the sensitivity has been assessed as **Low,** whilst the magnitude of disturbance (informed by iPCoD modelling) has been assessed as **Negligible.** Therefore, impacts of disturbance from pile driving to harbour porpoise have been assessed as **Negligible,** which is **Not Significant** with respect to the EIA Regulations.

11.13.7.54 For bottlenose dolphins the sensitivity has been assessed as **Low**, and the magnitude of disturbance (informed by iPCoD modelling) from pile driving have been assessed as **Negligible**, this impact has been assessed as being of **Negligible** significance, which is **Not Significant** with respect to the EIA Regulations.

11.13.7.55 For white-beaked dolphins the sensitivity has been assessed as **Low**, and the magnitude of disturbance from pile driving have been assessed as **Low**, this impact has been assessed as being of **Negligible** significance, which is N**ot Significant** with respect to the EIA Regulations.

11.13.7.56 For minke whale, the sensitivity has been assessed as **Low,** whilst the magnitude of disturbance has been assessed as **Low.** Therefore, impacts of disturbance from pile driving to minke whales have been assessed as **Negligible,** which is N**ot Significant** with respect to the EIA Regulations.

11.13.7.57 For harbour seals, the sensitivity has been assessed as **Medium** whilst the magnitude of disturbance (informed by iPCoD modelling) from pile driving has been assessed as **Negligible**. Therefore, impacts of disturbance from pile driving to harbour seals have been assessed as **Negligible,** which is **Not Significant** with respect to the EIA Regulations.

11.13.7.58 Given that the sensitivity of grey seals has been assessed as **Negligible**, and the magnitude of disturbance (informed by iPCoD modelling) from pile driving have been assessed as **Negligible,** this impact has been assessed as being of **Negligible** significance, which is **Not Significant** with respect to the EIA Regulations.

11.13.8 Auditory Injury (Permanent Threshold Shift) from Other Construction Activities

Sensitivity

Dredging

11.13.8.1 Dredging is described as a continuous broadband sound source, with the main energy below 1 kHz; however, the frequency and sound pressure level can vary considerably depending on the equipment, activity, and environmental characteristics (Todd *et al.* 2015). For the offshore Salamander Project, dredging will potentially be required for seabed preparation work for piled anchors as well as for export cable, array cable and interconnector cable installations. The source level of dredging has been described to vary between SPL 172-190 dB re 1 µPa @ 1 m with a frequency range of 45 Hz to 7 kHz (Evans 1990, Thompson *et al.* 2009, Verboom 2014). It is expected that the underwater noise generated by dredging will be below the PTS-onset threshold (Todd *et al.* 2015) and thus the risk of injury is unlikely, though disturbance may occur. For harbour porpoise, dolphins and seals, the hearing sensitivity below 1 kHz is relatively poor and thus it is expected that a PTS at this frequency would result in little impact to vital rates. Therefore, the sensitivity of harbour porpoise, dolphins and seals to PTS from dredging is assessed as **Low**.

11.13.8.2 The low frequency noise produced during dredging may be more likely to overlap with the hearing range of low frequency cetacean species such as minke whales. Minke whale communication signals have been demonstrated to be below 2 kHz (Edds-Walton 2000, Mellinger *et al.* 2000, Gedamke *et al.* 2001, Risch *et al.* 2013, Risch *et al.* 2014). Tubelli *et al.* (2012) estimated the most sensitive hearing range (the region with thresholds within 40 dB of best sensitivity) to extend from 30 to 100 Hz up to 7.5 to 25 kHz, depending on the specific model used. Therefore, the sensitivity of minke whale to PTS from dredging is precautionarily assessed as **Medium**.

Drilling

11.13.8.3 The continuous sound produced by drilling has been likened to that produced by potential dredging activity; low frequency noise caused by rotating machinery (Greene 1987). Recordings of drilling at the North Hoyle Offshore Wind Farm suggest that the sound produced has a fundamental frequency at 125 Hz (Nedwell *et al.* 2003). For harbour porpoise, dolphins and seals, the hearing sensitivity below 1 kHz is relatively poor and thus it is expected that a PTS at these low frequency ranges would result in little impact to vital rates. Therefore, the sensitivity of harbour porpoise, dolphins and seals to PTS from drilling noise is assessed as **Low**. The low frequency noise produced during cable laying may be more likely to overlap with the hearing range of low frequency cetacean species such as minke whales. Therefore, the sensitivity of minke whales to PTS from drilling is precautionarily assessed as **Medium**.

Cable Laying

11.13.8.4 Underwater noise generated during cable installation is generally considered to have a low potential for impacts to marine mammals due to the non-impulsive nature of the noise generated and the fact that any generated noise is likely to be dominated by the vessel from which installation is taking place (Genesis 2011). OSPAR (2009) summarise general characteristics of commercial vessel noise. Vessel noise is continuous, and is dominated by sounds from propellers, thrusters and various rotating machinery (e.g., power generation, pumps). In general, support and supply vessels (50-100 m) are expected to have broadband source levels in the range 165-180 dB re 1µPa, with the majority of energy below 1 kHz (OSPAR 2009). Large commercial vessels (>100 m) produce relatively loud and predominately low frequency sounds, with the strongest energy concentrated below several hundred Hz. For harbour porpoise, dolphins and seals, the hearing sensitivity below 1 kHz is relatively poor and thus it is expected that a PTS at these low frequency ranges would result in little impact to vital rates. Therefore, the sensitivity of harbour porpoise, dolphins and seals to PTS from cable laying is assessed as **Low**. The low frequency noise produced during cable laying may be more likely to overlap with the hearing range of low frequency cetacean species such as minke whales. Therefore, the sensitivity of minke whales to PTS from cable laying is assessed as **Medium**.

Trenching

11.13.8.5 Underwater noise generation during cable trenching is highly variable and dependent on the physical properties of the seabed that is being cut. At the North Hoyle OWF, trenching activities had a peak frequency between 100 Hz – 1 kHz and in general the sound levels were only 10-15 dB above background levels (Nedwell *et al.* 2003). For harbour porpoise, dolphins and seals, hearing sensitivity below 1 kHz is relatively poor and thus it is expected that a PTS at these low frequency ranges would result in little impact to vital rates. Therefore, the sensitivity of harbour porpoise, dolphins and seals to PTS from trenching is assessed as **Low**. The low frequency noise produced during trenching may be more likely to overlap with the hearing range of low frequency cetacean species such as minke whales. Therefore, the sensitivity of minke whale to PTS from trenching is precautionarily assessed as **Medium**.

Rock Placement

11.13.8.6 Underwater noise generation during rock placement activities is largely unknown. One study of rock placement activities in the Yell Sound in Shetland found that rock placement noise produced low frequency tonal noise from the machinery, but that measured noise levels were within background levels (Nedwell and Howell 2004). Therefore, it is highly likely that any generated noise is likely to be dominated by the vessel from which activities take place. Therefore, the sensitivity of harbour porpoise, dolphins and seals to PTS from rock placement is expected to be **Low**. The low frequency noise produced during rock placement may be more likely to overlap with the hearing range of low frequency cetacean species such as minke whales. Therefore, the sensitivity of minke whale to PTS from rock placement is precautionarily assessed as **Medium**.

Impact Magnitude

11.13.8.7 For all non-piling construction activities assessed (**Table 11-37**), the PTS-onset impact ranges are <100 m. Non-piling construction noise sources will have an extremely local spatial extent and will be transient and intermittent. While auditory injury is a permanent effect from which an animal cannot recover, no animals are expected to be within these tiny impact ranges and thus the overall magnitude is **Negligible**.

Table 11-37 Auditory injury impact ranges for non-piling construction noise (using weighted SEL_{cum})

	LF (199 dB)	HF (198 dB)	VHF (173 dB)	PCW (201 dB)
Dredging (Backhoe)	< 100 m	< 100 m	< 100 m	< 100 m
Dredging (Suction)	< 100 m	< 100 m	< 100 m	< 100 m
Drilling	< 100 m	< 100 m	< 100 m	< 100 m
Cable laying	< 100 m	< 100 m	< 100 m	< 100 m

	LF (199 dB)	HF (198 dB)	VHF (173 dB)	PCW (201 dB)
Trenching	< 100 m	< 100 m	< 100 m	< 100 m
Rock placement	< 100 m	< 100 m	< 100 m	< 100 m

Significance of Impact

11.13.8.8 The sensitivity of harbour porpoise, dolphins and seals to auditory injury from other construction activities has been assessed as **Low** and minke whales have precautionarily been assessed as **Medium** sensitivity.

11.13.8.9 The magnitude of impact of PTS to all marine mammals from other construction activities has been assessed as **Negligible**.

11.13.8.10 Therefore, the significance of auditory injury from other non-piling construction activities is assessed as **Negligible**, which is N**ot Significant** with respect to the EIA Regulations.

11.13.9 Disturbance from Other Construction Activities

Sensitivity

Cetaceans

11.13.9.1 Information regarding the sensitivity of marine mammals to other construction activities is currently limited. Available studies focus primarily on disturbance from dredging and confirmed behavioural responses have been observed in cetaceans. Pirotta *et al.* (2013) noted that bottlenose dolphin presence in foraging areas of Aberdeen harbour decreased as dredging intensity increased. Due to the consistently high presence of shipping activity all year round, the dolphins were considered to be habituated to high levels of vessel disturbance and, therefore, in this particular instance, Pirotta *et al.* (2013) concluded that the avoidance behaviour was a direct result of dredging activity. However, this distinction in the source of the disturbance reaction cannot always be determined. For example, Anderwald *et al.* (2013) observed minke whales off the coast of Ireland in an area of high vessel traffic during the installation of a gas pipeline where dredging activity occurred. The data suggested that the avoidance response observed was likely attributed to the vessel presence rather than the dredging and construction activities themselves. As the disturbance impact from other construction activities is closely associated with the disturbance from vessel presence required for the activity, it is difficult to determine the sensitivity specifically to disturbance from other construction activities in isolation (Todd *et al.* 2015).

11.13.9.2 Harbour porpoise occurrence decreased at the Beatrice and Moray East offshore wind farms during non-piling construction periods (Benhemma-Le Gall *et al.* 2021). During non-piling construction periods, the probability of detecting harbour porpoise decreased by 17% as the sound pressure levels from vessels during the construction period increased by 57 dB (note: vessel activity included not only wind farm construction related vessels, but also other third-party traffic such as fishing vessels, bulk carrier and cargo vessels). Despite the decreased occurrence of harbour porpoise, harbour porpoise continued to regularly use both the Beatrice and Moray East sites throughout the three-year construction period. A reduction in porpoise occurrence and buzzing was associated with increased vessel activity; however, this was of a local scale, observed only at mean vessel distances of 2 km and 3 km from acoustic recorders. At 4 km mean vessel distance, there was no reduction in buzzing activity with increasing vessel activity (Benhemma-Le Gall *et al.* 2021).

11.13.9.3 While harbour porpoise may be sensitive to disturbance from other construction-related activities, it is expected that they are able to compensate for any short-term local displacement, and thus it is not expected that individual vital rates would be impacted. Therefore, the sensitivity of harbour porpoise to disturbance from other non-piling construction activities is considered to be **Low.**

11.13.9.4 For dolphin species, disturbance responses to non-piling construction activity appears to vary. Increased dredging activity at Aberdeen harbour was associated with a reduction in bottlenose dolphin presence and, during the initial dredge operations, bottlenose dolphins were absent for five weeks (Pirotta *et al.* 2013). In an urbanised estuary in Western Australia, bottlenose dolphin responses to dredging varied between sites. At one site no bottlenose dolphins were sighted on days when backhoe dredging was present, while dolphins remained using the other site (Marley *et al.* 2017b). A study conducted in northwest Ireland concluded that construction related activity (including dredging) did not result in any evidence of a negative impact to common dolphins (Culloch *et al.* 2016). Therefore, the sensitivity of dolphin species to disturbance from other non-piling construction activities is assessed as **Low**.

11.13.9.5 The same study conducted by Culloch *et al.* (2016) found evidence that the fine-scale temporal occurrence of minke whales in northwest Ireland was influenced by the presence of construction activity, with lower occurrence rates on these days (Culloch *et al.* 2016). Due to their large size and capacity for energy storage, it is expected that minke whales will be able to tolerate temporary displacement from foraging areas much better than harbour porpoise and individuals are expected to be able to recover from any impact on vital rates. Therefore, the sensitivity of minke whales to disturbance from other non-piling construction activities is assessed as **Low**.

Seals

11.13.9.6 While seals are sensitive to disturbance from pile driving activities, there is evidence that the displacement is limited to the piling activity period only. At the Lincs Wind Farm, seal usage in the vicinity of construction activity was not significantly decreased during breaks in the piling activities and displacement was limited to within 2 hours of the piling activity (Russell *et al.* 2016a). There was no evidence of displacement during the overall construction period (excluding pre-construction surveys), and the authors recommended that environmental assessments should focus on short-term displacement to seals during piling rather than displacement during construction as a whole. Even during periods of piling at the Lincs offshore wind farm, individual seals travelled in and out of the Wash which suggests that the motivation to forage offshore and come ashore to haul out could outweigh the deterrence effect of piling. The OAA is located in a relatively low-density area for both species of seal (compared to the coastal waters surrounding Orkney and the Moray Coast), and thus it is not expected that any short term-local displacement caused by construction related activities would result in any changes to individual vital rates. Therefore, the sensitivity of both seal species to disturbance from other non-piling construction activities is considered to be **Negligible**.

Impact Magnitude

Dredging

11.13.9.7 Harbour porpoise: Dredging at a source level of 184 dB re 1 µPa @ 1 m resulted in avoidance up to 5 km from the dredging site (Verboom 2014). Conversely, Diederichs *et al.* (2010) found much more localised impacts; using Passive Acoustic Monitoring there was short term avoidance (~3 hours) at distances of up to 600 m from the dredging vessel, but no significant long-term effects. Modelling potential impacts of dredging using a case study of the Maasvlatke port expansion (assuming maximum source levels of 192 dB re 1 µPa) predicted a disturbance range of 400 m, while a more conservative approach predicted avoidance of harbour porpoise up to 5 km (McQueen *et al.* 2020).

11.13.9.8 White-beaked dolphin: There is currently no information available on the impacts of dredging for white beaked dolphins. Currently, their hearing range has only been investigated at frequencies above 16 kHz (Nachtigall *et al.* 2008) which is above the typical range for dredging. Localised, temporary avoidance of dredging activities is assumed.

11.13.9.9 Other dolphin species: Increased dredging activity at Aberdeen Harbour was associated with a reduction in bottlenose dolphin presence and, during the initial dredge operations, bottlenose dolphins were absent for five weeks (Pirotta *et al.* 2013). Based on the results of Pirotta *et al.* (2013), subsequent studies have assumed that dredging activities exclude dolphins from a 1 km radius of the dredging site (Pirotta *et al.* 2015a). Dredging operations had no impact on sightings of Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) in South Australia (Bossley *et al.* 2022).

11.13.9.10 Minke whale: In northwest Ireland, construction-related activity (including dredging) has been linked to reduced minke whale presence (Culloch *et al.* 2016). Minke whale distance to construction site increased and relative abundance decreased during dredging and blasting activities in Newfoundland (Borggaard *et al.* 1999).

11.13.9.11 Grey and harbour seal: Based on the generic threshold of behavioural avoidance of pinnipeds (140 dB re1µPa SPL) (Southall *et al.* 2007), acoustic modelling of dredging demonstrated that disturbance could be caused to individuals between 400 m to 5 km from site (McQueen *et al.* 2020).

Drilling

11.13.9.12 Information on the disturbance effects of drilling is limited and the majority of the research available was conducted more than 20 years ago and is focussed on baleen whales (Sinclair *et al.* 2023). For example, drilling and dredging playback experiments observed that 50% of bowhead whales exposed to noise levels of 115 dB re 1 µPa exhibited some form of response, including changes to calling, foraging and dive patterns (Richardson and Wursig 1990). More recent studies of bowhead whales also observed changes in behaviour from increased drilling noise levels, specifically an increase in call rate. However, the call rate plateaued and then declined as noise levels continued to increase, which could be interpreted as the whales aborting their attempt to overcome the masking effects of the drilling noise (Blackwell *et al.* 2017). Playback experiments of drilling and industrial noise have also been undertaken with grey whales at a noise level of 122 dB re 1 µPa. This resulted in a 90% response from the individuals in the form of diverting their migration track (Malme *et al.* 1984). Overall, the literature indicates that the impacts of drilling disturbance on marine mammals may occur at distances of between 10-20 km, and will vary depending on the species (Greene Jr 1986, LGL and Greeneridge 1986, Richardson and Wursig 1990).

11.13.9.13 Whilst information is not available for the species of concern for the Offshore Development Area, it is still considered useful as it suggests that at least some species of cetacean may experience disturbance as a result of drilling. Furthermore, drilling is considered under the umbrella of industrial and construction noise, and has similar properties to dredging, for which more information is available for species relevant to the Offshore Development Area. Therefore, it is considered that drilling could potentially cause disturbance over distances of up to 5-10 km from the noise source based on results for dredging, or potentially up to 20 km based on results from the drilling literature, although this literature is considered slightly outdated.

Other Activities

11.13.9.14 There is a lack of information in the literature on disturbance ranges for other non-piling construction activities such as cable laying, trenching or rock placement. While construction-related activities (acoustic surveys, dredging, rock trenching, pipe laying and rock placement) for an underwater pipeline in northwest Ireland resulted in a decline in harbour porpoise detections, there was a considerable increase in detections after construction-activities ended which suggests that any impact is localised and temporary (Todd *et al.* 2020).

Summary

11.13.9.15 It is expected that any disturbance impact will be primarily driven by the underwater noise generated by the vessel during non-piling construction-related activities, and, as such, it is expected that any impact of disturbance is highly localised (within 5 km). The magnitude of this impact is considered to be **Low** across all marine mammal species since the impact will be of short-term duration (<5 years), will occur intermittently at low intensity and is expected to be of limited spatial extent.

Significance of Impact

11.13.9.16 The sensitivity of marine mammals to disturbance from non-piling construction activities has been assessed as **Negligible** to **Low**. The magnitude of disturbance to all marine mammal species from non-piling construction activities has been assessed as **Low**. Therefore, disturbance from non-piling construction activities is assessed as being of **Negligible** significance, which is **Not Significant** with respect to the EIA Regulations.

Disturbance from Vessels

11.13.9.17 Disturbance to marine mammals by vessels will be driven by a combination of underwater noise and the physical presence of the vessel itself (e.g. Pirotta *et al.* 2015b). It is not simple to disentangle these drivers and thus disturbance from vessels is assessed here in general terms, covering disturbance driven by both vessel presence and underwater noise.

11.13.9.18 Vessel noise levels from construction vessels will result in an increase in non-impulsive, continuous sound in the vicinity of the offshore Salamander Project, typically in the range of 10 - 100 Hz (although higher frequencies will also be produced) (Erbe *et al.* 2019) with an estimated source level of 161 – 168 dB re 1 µPa @ 1m (RMS) for medium and large construction vessels, travelling at a speed of 10 knots **Volume ER.A.4, Annex 4.1: Underwater Noise Modelling Report**.

11.13.9.19 OSPAR (2009) summarise general characteristics of commercial vessel noise. Vessel noise is continuous, and is dominated by sounds from propellers, thrusters and various rotating machinery (e.g., power generation, pumps). In general, support and supply vessels (50-100 m) are expected to have broadband source levels in the range 165-180 dB re 1 µPa, with the majority of energy below 1 kHz (OSPAR 2009). Large commercial vessels (>100 m) produce relatively loud and predominately low frequency sounds, with the strongest energy concentrated below several hundred Hz.

Sensitivity - Harbour Porpoise

11.13.9.20 In a large-scale study of harbour porpoise density in UK waters, increased vessel activity was generally associated with lower harbour porpoise densities. However, in northwest Scottish waters, shipping had little effect on the density of individuals given the low shipping densities in the area (Heinänen and Skov 2015).

11.13.9.21 During the construction of the Beatrice and Moray East Offshore Wind Farms within the Moray Firth, harbour porpoise occurrence decreased with increasing vessel presence, with the magnitude of decrease depending on the distance to the vessel (Benhemma-Le Gall *et al.* 2021). For example, the probability of harbour porpoise occurrence at a mean vessel distance of 2 km decreased by up to 95% from a probability of occurrence of 0.37 when no vessels were present to 0.02 for the highest vessel intensity of 9.8 min per km^2 (the sum of residence times for all vessels present in that hour per kilometre squared). At a mean vessel distance of 3 km, the probability decreased by up to 57% to 0.16 for the highest vessel intensity, and no apparent response was observed at 4 km.

11.13.9.22 Additional studies conducted during offshore wind farm construction demonstrated that harbour porpoise detections in the vicinity of the pile driving location decline prior to a piling event (Brandt *et al.* 2018, Benhemma-Le Gall *et al.* 2021). For example, during a study conducted at seven offshore wind farms in the German Bight, Brandt *et al.* (2018) observed a decline in harbour porpoise detections within 2 km of the construction site, and continued to be reduced for 1 to 2 days after. This was considered to be attributed in part to the increased vessel activity and traffic associated with construction related activities (Brandt *et al.* 2018). During this study, six of the wind farms used noise abatement techniques to reduce source noise levels. However, it is possible that the use of such techniques may require additional vessel presence or extend the construction timeline, thereby increasing the likelihood of a disturbance response (Brandt *et al.* 2018, Graham *et al.* 2019, Thompson *et al.* 2020). Therefore, management efforts to reduce the risk of injury and disturbance from piling activities must also take into consideration potential increases in disturbance from vessel activity (Graham *et al.* 2019, Thompson *et al.* 2020).

11.13.9.23 Behavioural responses of harbour porpoises to vessel noise have also been observed in more controlled conditions. Dyndo *et al.* (2015) conducted an exposure study using four harbour porpoise contained in a semi-natural net pen and exposed to noise from passing vessels. Behavioural responses were observed as a result of low levels of medium to high frequency vessel noise. During 80 high quality recordings of boat noise, porpoising, a stereotypical disturbance behaviour, was observed in 27.5% of cases (Dyndo *et al.* 2015).

11.13.9.24 Data examining the surfacing behaviour of harbour porpoise in relation to vessel traffic in Swansea Bay from land-based surveys found a significant correlation between harbour porpoise sightings and the number of vessels present. When vessels were up to 1 km away, 26% of the interactions observed were considered to be negative (animal moving away or prolonged diving). The proximity of the vessel being an important factor, with the greatest reaction occurring just 200 m from the vessel. The type of vessel was also relevant, as smaller motorised boats (e.g. jet-ski, speed boat, small fishing vessels), were associated with more negative behaviours than larger cargo ships, although this type of vessel was a less common occurrence (Oakley *et al.* 2017). Vessels associated with offshore wind farm construction are typically larger than these types of small, motorised vessels, and, therefore, it would be anticipated that the behavioural response would not be as severe.

11.13.9.25 Telemetry data can also be used to identify fine-scale changes in behaviour. Between 2012-2016, seven harbour porpoises were tagged in a region of high shipping density in the inner Danish waters and Belt seas. Periods of high vessel noise coincided with erratic behaviour including 'vigorous fluking', bottom diving, interrupted foraging, and the cessation of vocalisations. Four out of six of the animals that were exposed to noise levels above 96 dB re 1 µPa (16 kHz third octave levels) produced significantly fewer buzzes with high quantities of vessel noise. In one case, the proximity of a single vessel resulted in a 15 minute cessation in foraging (Wisniewska *et al.* 2018).

11.13.9.26 Behaviour based modelling has indicated the potential for vessel disturbance to have population level effects under certain circumstances. Nabe-Nielsen *et al.* (2014) simulated harbour porpoise response to vessels did not result in further population decline when prey sources recovered fast (after two days), but if prey availability remained low then vessels were estimated to have a significant negative impact on the population. However, whilst this negative trend was estimated, when comparing the theoretical impact of vessel presence versus bycatch, the latter was found to have a greater effect on population size as it causes direct mortality.

11.13.9.27 In conclusion, there is evidence that changes in harbour porpoise behaviour and presence can result from disturbance by vessel presence. Behavioural reactions observed include increased fluking, interrupted foraging, change to vocalisations, prolonged dives and directed movement away from the sound source (Oakley *et al.* 2017, Wisniewska *et al.* 2018). Several studies have also observed an increase in vessel presence to correlate with a decrease in harbour porpoise presence (Brandt *et al.* 2018, Benhemma-Le Gall *et al.* 2021). While disturbance from vessels can result in short term changes to porpoise behaviour, it is unlikely to result in alterations in vital rates in the longer term and no population level impacts are expected (unless there is simultaneously a significant impact to their prey species). Therefore, the sensitivity of harbour porpoise to disturbance from vessel activity assessed as **Low**.

Sensitivity - Bottlenose Dolphins

11.13.9.28 Vessel disturbance has been shown to negatively affect foraging activity. Pirotta *et al.* (2015b) used passive acoustic monitoring to quantify how vessel disturbance affected foraging activity. The results indicated a short-term 49% reduction in foraging activity (though this did not vary with noise level), with animals resuming foraging after the vessel had travelled through the area was associated with vessel presence. The susceptibility to disturbance was variable depending on the location and year, suggesting circumstantial impacts of vessel noise on bottlenose dolphins. The study concluded that the physical presence of vessels, and not just the noise created, plays a large role in disturbance responses (Pirotta *et al.* 2015b). The variability in disturbance from vessels is also observed in Aberdeen harbour, a busy shipping area that is frequently occupied by bottlenose dolphins (Pirotta *et al.* 2013).

11.13.9.29 A study of Indo-Pacific bottlenose dolphin habitat occupancy along the coast of Western Australia found dolphin density to be negatively affected by vessels at one site, but no significant impact at the other (Marley *et al.* 2017a). It is hypothesised that, as the latter habitat is a known foraging site, the quality of the habitat impacts the behavioural response to disturbance. Differences in water depth were also hypothesised as important, as the site that was characterised by changes in dolphin density with vessel activity was shallower than the other location (average depths of 1 m and 13 m respectively). Dolphins have been demonstrated to avoid shallow waters as a predator avoidance response, and similar responses have resulted from vessel disturbance (Lusseau 2006).

11.13.9.30 In the same area of Western Australia, increased vessel presence was also associated with significantly increased swimming speeds for individuals when resting or socialising. In addition, animals exposed to high levels of shipping traffic were found to generally spend more time travelling and less time resting or socialising. Finally, the characteristics of their whistles were found to change with increased broadband exposure, with the greatest variation occurring in the presence of low frequency noise (Marley *et al.* 2017b). These findings are further supported by a study of common bottlenose dolphins in Galveston Ship Channel (Piwetz 2019). The presence of boats was associated with significantly less foraging and socialising activity states. For this population, a significant increase in swimming speeds was observed during the presence of recreational and tourism vessels and shrimp trawlers.

11.13.9.31 Bottlenose dolphins have also been known to exhibit different behavioural responses to different vessel types. In New Zealand, a CATMOD[6] analysis undertaken showed that bottlenose dolphin resting behaviour decreased as the number of tour boats increased (Constantine *et al.* 2004). In a study conducted in Italy, dolphins exhibited an avoidance response to motorboats once disturbance became too great but changed their acoustic behaviour in response to trawler vessels, presumably to compensate for masking (La Manna *et al.* 2013). This study also found that bottlenose dolphins would tolerate vessel presence within certain levels and were more likely to leave an area if disturbance was persistent (La Manna *et al.* 2013). Similarly, high levels of tolerance to vessel disturbance were observed in Aberdeen harbour where vessel traffic is consistently high (Pirotta *et al.* 2013). Therefore, the degree to which an animal will be disturbed is likely linked to their baseline level of tolerance (Bejder *et al.* 2009).

11.13.9.32 New *et al.* (2013) developed a mathematical model simulating the complex interactions of the coastal bottlenose dolphin population in the Moray Firth to determine if an increased rate of disturbance resulting from vessel traffic was biologically significant. The scenario modelled increased vessel traffic from 70 to 470 vessels a year to simulate the potential increase from the proposed Offshore Development. An increase in commercial vessel traffic only is not anticipated to result in a biologically significant increase in disturbance because the dolphins have the ability to compensate for their immediate behavioural response and, therefore, their health and vital rates are unaffected (New *et al.* 2013).

11.13.9.33 In conclusion, vessel disturbance can elicit a variety of responses in bottlenose dolphins including changes to foraging behaviour, swim speed, behavioural state and acoustic behaviour, as well as causing avoidance responses (Constantine *et al.* 2004, La Manna *et al.* 2013, Pirotta *et al.* 2015b, Marley *et al.* 2017a, Marley *et al.* 2017b). However, bottlenose dolphins have been observed to display tolerance to vessel disturbance, particularly in areas where vessel traffic has always been high (Pirotta *et al.* 2013). Furthermore, behavioural changes in bottlenose dolphins are not always considered biologically significant (New *et al.* 2013). The sensitivity of bottlenose dolphins to disturbance from vessel activity is therefore classified as **Low**.

Sensitivity - White-beaked Dolphins

11.13.9.34 There is currently no information pertaining to the effects of vessel disturbance on white-beaked dolphins. As such, the information provided above for bottlenose dolphins have been used as a proxy for the assessment of effects of vessel disturbance on white-beaked dolphin. The sensitivity of white-beaked dolphin to disturbance from vessel activity has therefore been classified as **Low**.

Sensitivity - Minke Whale

11.13.9.35 There are currently limited studies available regarding the effects of vessel disturbance on minke whale. Of the few studies available, minke whale foraging activity has been found to decrease with increased vessel interactions (Christiansen *et al.* 2013), exemplified by shorter dives and changes in movement patterns. In addition, by analysing the respiration rate of minke whales, energy expenditure was estimated to be 28% higher during boat interactions, regardless of swim speed. Swim speed was also found to increase with vessel presence and these combined physiological and behavioural changes are thought to represent a stress response. As noise levels were not measured within the study, behavioural responses were therefore related

[6] http://documentation.sas.com/doc/en/statug/14.3/statug_catmod_overview.htm#:~:text=The%20CATMOD%20procedure%20performs%20categorical,regression%2C%20and%20repeated%20measurement%20analysis

to vessel presence. In addition, when considering the temporal and spatial rates of individuals' exposure over an entire season, there appeared to be no potential for a population-level effect of these acute disturbances (Christiansen *et al.* 2015).

11.13.9.36 Further study by Christiansen and Lusseau (2015) developed a mechanistic model for minke whales to examine the bioenergetic effects of disturbance from whale watching vessels, specifically on foetal growth. The presence of whale watching vessels resulted in an immediate 63.5% reduction in net energy intake. However, the impact of disturbance was considered to be below the threshold value at which whale watching would have a significant impact on foetal growth as the number of interactions with vessels was low during the feeding season and was, therefore, of negligible impact.

11.13.9.37 When considering the impacts of whale watching vessels against those likely to occur from construction vessel activities, they cannot be directly transposed, as disturbance effects from whale watching are direct impacts, whilst those from construction activities are indirect, and the vessel types and underwater noise produced are very different. However, as there are little empirical data on the behavioural plasticity of minke whale as a result of vessel disturbance, the information presented above is used as a proxy to inform this assessment.

11.13.9.38 As Christiansen and Lusseau (2015) reported negligible impacts of whale watching activity on foetal growth and no potential for a population-level effect from acute disturbances (Christiansen *et al*., 2015), it is assumed that the sensitivity of minke whale to disturbance from vessel activity can be classified as **Low**.

<u>Sensitivity - Harbour Seals</u>

11.13.9.39 A telemetry study that included the tagging of 28 harbour seals in the UK found high exposure levels of harbour seals to shipping noise (Jones *et al.* 2017). Twenty individuals may have experienced a temporary threshold shift due to SEL_{cum} exceeding the TTS-threshold for pinnipeds exposed to continuous underwater noise (183 dB re 1 µPa2) proposed by Southall *et al.* (2007). The overlap between seals and vessel activity most frequently occurred within 50 km of the coast, and in proximity to seal haul outs. Despite the distributional overlap and high cumulative sound levels, there was no evidence of reduced harbour seal presence as a result of vessel traffic (Jones *et al.* 2017). The sensitivity of harbour seals to disturbance from vessel activity is therefore classified as **Low**.

<u>Sensitivity - Grey Seals</u>

11.13.9.40 A combined study of grey seal pup tracks in the Celtic Sea and adult grey seals in the English Channel found that no animals were exposed to cumulative shipping noise that exceeded thresholds for TTS (using the Southall *et al.* 2019 thresholds) (Trigg *et al.* 2020). On the northwest coast of Ireland, a study of vessel traffic and marine mammal presence found grey seal sightings decreased with increased vessel activity in the surrounding area, though the effect size was small (Anderwald *et al.* 2013); and the authors noted that relationships between sightings and vessel numbers were weaker than those with environmental variables such as sea state. The sensitivity of grey seals to disturbance from vessel activity is therefore classified as **Low**.

<u>Impact Magnitude</u>

11.13.9.41 It is conservatively anticipated that there will be a maximum of ≤39 vessels on site throughout the Offshore Development Area simultaneously during the construction period (excluding pre-construction surveys) (see **Table 11-5**). It is noted that this total number of simultaneous vessels relates to different activities and phases of construction (e.g. WTG mooring, cable installation); while clusters of vessels will occur around specific activities, the number of vessels within any one cluster will be lower than the maximum simultaneous number on site. It is also noted that the largest single contributor to simultaneous vessels is that of Support Vessels associated with cable installation (up to 12 simultaneous vessels).

11.13.9.42 There are very few studies that indicate a critical level of activity in relation to behavioural disturbance, but an analysis presented in Heinänen and Skov (2015) suggested that harbour porpoise density was significantly lower in areas with vessel transit rates of greater than 80 per day (within a 5 km^2 area). Even considering the existing levels of vessel traffic in the area, the addition of construction traffic during construction activities at the offshore Salamander Project will still be well below this figure.

11.13.9.43 The commitment to the adoption of best practice vessel-handing protocols (e.g., following the Codes of Conduct provided by the WiSe (Wildlife-Safe) Scheme, Scottish Marine Wildlife Watching Code or Guide to Best Practice for Watching Marine Wildlife), which will all be incorporated into a VMP during construction, will minimise the potential for any effects. The magnitude of disturbance from vessel activity is therefore assessed as **Low.**

Impact Significance

11.13.9.44 The sensitivity of marine mammals to disturbance from vessels has been assessed as **Low** for all species. The magnitude of disturbance from vessels to marine mammals has been assessed as **Low** for all other species. Therefore, the effect significance of disturbance from vessels is considered to be of **Negligible** significance**,** which is **Not Significant** with respect to the EIA Regulations.

11.13.10 Indirect Impacts on Prey

11.13.10.1 Any change in fish abundance and/or distribution as a result of construction is important to assess as, given marine mammals are dependent on fish as prey species, there is the potential for indirect effect on marine mammals. During construction, there is the potential for impacts upon fish species, including:

- Temporary loss of habitat;
- Temporary increase in suspended-solid concentrations and sediment deposition;
- Increased underwater noise levels;
- Direct physical damage and disturbance;
- Seabed disturbances leading to the release of sediment contaminants and /or accidental contamination; and
- Changes to supporting seabed habitats arising from effects on physical processes.

Sensitivity

11.13.10.2 While there may be certain species that comprise the main part of their diet, all marine mammals in this assessment are considered to be generalist feeders and are thus not reliant on a single prey species. Therefore, they are assessed as having a **Low** sensitivity to changes in prey abundance and distribution.

Impact Magnitude

11.13.10.3 Potential impacts on fish and shellfish species have been assessed in **Volume ER.A.3, Chapter 10: Fish and Shellfish**

11.13.10.4 All impacts assessed as part of **Volume ER.A.3, Chapter 10: Fish and Shellfish** for construction activities (including damage or disturbance to sensitive species from underwater noise; temporary habitat loss or disturbance; and temporary increase in suspended sediment concentrations) were assessed as **Negligible** to **Low** in magnitude. As such, indirect impacts on to marine mammals due to impacts on their prey are also assessed as **Low**.

Significance of Impact

11.13.10.5 As the sensitivity of all marine mammals to impacts on prey items has been assessed as Low, and the magnitude of the impact on fish and shellfish have been assessed as Low, the effect is considered to be **Negligible,** which is **Not Significant** with respect to the EIA Regulations**.**

11.14 Impact assessment - Operation and Maintenance Phase

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

- Geophysical surveys;
- Risk of injury resulting from entanglement with mooring lines or cables, including secondary interactions with derelict fishing gears;
- Risk of injury resulting from marine mammal collisions with WTG substructures;
- Operational noise impacts from operational floating WTGs;
- Displacement or barrier effects resulting from the physical presence of the Offshore Array infrastructure; and
- Long-term habitat change due to dynamic cable EMF emissions and indirect impacts on prey items.

11.14.2 Geophysical Surveys

11.14.2.1 The majority of geophysical surveys, in particular SBP use, are anticipated to occur at the pre-construction phase. Nonetheless, some geophysical surveys are anticipated to occur during the operation and maintenance phase in association with asset monitoring surveys.

11.14.2.2 The assessment provided for PTS and disturbance impacts from pre-construction geophysical surveys (**Section 11.13**) is also valid for such activities at the operation and maintenance phase. In both instances, the assessment concluded impacts of **Negligible** significance, which are **Not Significant** with respect to the EIA Regulations.

11.14.2.3 It is noted that impacts at the operation and maintenance phase are anticipated to be lower than the pre-construction phase due to a lower level of activity and very limited use of lower frequency equipment such as SBPs.

11.14.3 Risk of Injury Resulting from Entanglement with Mooring Lines or Cables, including Indirect/Secondary Interactions with Derelict Fishing Gears

11.14.3.1 Many of the newest marine renewable energy technologies, including floating offshore wind, and floating or midwater wave and tidal energy devices, each require mooring lines and/or anchors to ensure they maintain a fixed position within the development area (Copping *et al.* 2020b, Garavelli 2020). In addition, conventional submarine cables, such as those used in fixed foundation offshore wind farms, are unable to be installed for floating renewable energy developments and, as such, the cables (also known as dynamic cables) for floating offshore wind have floating components to enable them to move both with currents in the water column, and the floating structures they are attached to (Taninoki *et al.* 2017). The introduction of these new energy technologies, their mooring structures and their dynamic cables into the marine environment introduces new potential risks of entanglement and thus, injury, to species such as marine mammals.

11.14.3.2 The risks of entanglement of marine mammals within marine renewable technology structures is dependent upon both the physical characteristics of the mooring lines themselves (Harnois *et al.* 2015), and the amount of dynamic cable that is present in the water column. For example, mooring configurations which have taut mooring lines are likely to present a lower risk of entanglement with marine mammals than catenary systems due to greater tension in the mooring line (Benjamins *et al.* 2014, Harnois *et al.* 2015). Similarly, developments with shorter lengths of dynamic cable are also likely to present lower risks of entanglement. Depending on the number of new mooring lines and the length of dynamic cable present in the water column, the risks of derelict fishing gear being caught within marine renewable energy structures can also increase.

11.14.3.3 Four different mooring configurations are currently under consideration for the Offshore Development: catenary, semi-taut, taut and tension (see details in **Volume ER.A.2, Chapter 4: Project Description**). Since the risk of entanglement is higher for catenary moorings, these are considered as the realistic worst-case scenario here. As such, the impact assessment for the risk of injury resulting from entanglement with mooring lines or cables, including secondary interactions with derelict fishing gears for the Offshore Development, is based upon the following project characteristics for a catenary mooring system:

- Each WTG will have a catenary mooring line system with 8 mooring lines per WTG;
- Each WTG mooring line will be a maximum length of 1.65 km, made of rope (material could be polyester, polyethylene, nylon, dyneema fiber and/or aramid fiber) (maximum diameter of 300 mm) and/or chain (maximum diameter of 840 mm);
- A maximum of 3.5 km of dynamic cables will be present within the water column; and
- No dynamic cables will be present within the Offshore ECC.

<u>Sensitivity</u>

11.14.3.4 Marine mammal entanglement in fishing gear (Northridge *et al.* 2010, Song *et al.* 2010, Cassoff *et al.* 2011, Benjamins *et al.* 2012, Moore *et al.* 2013a, Ryan *et al.* 2016, Stelfox *et al.* 2016, MacLennan *et al.* 2021), and now, marine infrastructure projects (Wood and Carter 2008, Benjamins *et al.* 2014, Harnois *et al.* 2015, Maxwell *et al.* 2022) can have significant conservation implications. As a result of entanglement, marine mammals can suffer from injury, and even mortality. Depending on the frequency of entanglements, this can pose risks to survival chances and multiple life-stages, and could lead to population crashes (Musick 1997, van der Hoop *et al.* 2017)

11.14.3.5 For marine renewable energy projects, entanglement can occur when an animal(s) incidentally come into contact with mooring lines and/or dynamic cables in the water column (Benjamins *et al.* 2014, Harnois *et al.* 2015, Maxwell *et al.* 2022). Additionally, derelict fishing gear, particularly nets and gillnets, can unintentionally capture non-target species as bycatch, or if they become caught up in renewable energy technology mooring lines and/or cables, i.e. secondary entanglement (Copping *et al.* 2020a, Garavelli 2020).

11.14.3.6 Of the species most likely the be present within the Offshore Development Area, baleen whale species (such as minke whale and occasionally, humpback whale) are considered the most vulnerable to entanglement with fishing gears (Cassoff et al. 2011, Kot et al. 2012, Benjamins et al. 2014, Ryan et al. 2016, Basran et al. 2019). However, evidence suggests that harbour porpoise (Scheidat et al. 2018, Calderan and Leaper 2019, IJsseldijk et al. 2022), killer whales7,8 and seals (Allen et al. 2012, Moore et al. 2013b) are also susceptible to entanglement, demonstrating that all species of marine mammal are at risk of some form of entanglement (Read et al. 2006).

11.14.3.7 Given the fact that entanglement can potentially result in death, marine mammals are considered to have **High** sensitivity to entanglement risks.

Impact Magnitude

11.14.3.8 Risks of entanglement can be considered as both primary and secondary entanglement risks. Primary entanglement risks are the risk of marine mammals becoming directly entangled with the mooring lines and dynamic cables within the OAA, and secondary entanglement risks is the risk of marine mammals becoming entangled in marine debris which has become caught on the lines and cables within the OAA. Both the magnitude of impact for primary and secondary risks of entanglement are assessed below.

11.14.3.9 To predict the influence of different mooring configurations on primary entanglement risks, Benjamins *et al.* (2014), Harnois *et al.* (2015) used dynamic analysis software to assess the tension characteristics and mooring line curvature of different floating offshore wind mooring types. Both Benjamins *et al*. (2014) and Harnois *et al*. (2015) analyses demonstrated that catenary mooring configurations present the greatest entanglement risk to marine mammals as they have the least taut lines. However, catenary mooring systems are still considered to have too much tension on these lines to generate any loops which could entangle marine mammals, and therefore still present low risks of entanglement to marine mammals (Benjamins *et al.* 2014, Harnois *et al.* 2015, Copping *et al.* 2020b, Garavelli 2020).

11.14.3.10 As the Offshore Development will be utilising large diameter chains and/or ropes to create the mooring system, it is likely that the risks of entanglement in derelict fishing gears shall be greater than those associated with marine mammal entanglement directly in the mooring lines themselves.

11.14.3.11 Although the Offshore Development's final mooring system is yet to be decided, a catenary, semi-taut, taut, or tension mooring system are being proposed. However, each of these designs are unlikely to generate any loops which could entangle marine mammals due to the amount of tension in each of the mooring system lines. Although 3.5 km of dynamic inter-array cables will be present within the water column, these cables are designed to withstand mechanical forces to prevent cable failure and the creation of loops within the system (Young *et al.* 2018). Thus, the risk of primary entanglement is considered to be of **Negligible** magnitude.

11.14.3.12 With respect to secondary entanglement risks, injury and even mortality of marine mammals is difficult to quantify. For example, the prevalence of derelict fishing gears which may become caught on floating offshore wind mooring lines and dynamic cables is likely influenced by the abundance of derelict fishing gears in the area, and the environmental conditions (i.e., sea state, current speed and/or direction) at the

[7] https://www.countryfile.com/wildlife/scotlands-orca-killed-by-rope-entanglement-finds-post-mortem
[8] https://www.bbc.co.uk/news/uk-scotland-north-east-orkney-shetland-58495065

time (Stelfox *et al.* 2016). At a high level, monitoring data reported by EMODNET[9] suggest a moderate to low relative density of fishing-related items among seabed litter in the waters off north-east Scotland compared to elsewhere in European waters. If derelict fishing gears become caught on floating offshore wind mooring lines and dynamic cables, the risk of marine mammal entanglement then becomes dependent upon the characteristics of the gear itself (Winn *et al.* 2008, Wood and Carter 2008, Northridge *et al.* 2010, Benjamins *et al.* 2014, Knowlton *et al.* 2015, Stelfox *et al.* 2016). For example, in Scotland, the most frequent type of entanglement involves long lengths of 10-15 mm diameter polypropylene ropes (which are rarely under tension), such as those used in creel fishing (MacLennan *et al.* 2021). Off the north-east coast of Scotland, creel fishing is largely restricted to inshore waters, and fishing effort with passive gears in general being much higher around Orkney and the west coast of Scotland relative to eastern Scotland (Scottish Government data presented on NMPI).

11.14.3.13 Although the risks of secondary entanglement are greater than that of primary entanglement, as a part of the embedded mitigations, mooring lines and floating 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 marine mammal entanglement risk and appropriate actions taken to remove if deemed necessary. Despite the anticipated very low probability of indirect/secondary entanglement of marine mammals occurring at the Salamander Project, and the presence of embedded mitigation, this potential impact is conservatively assessed as **Low** magnitude given the limited number of operational floating wind farm and associated data.

Significance of Impact

11.14.3.14 As the sensitivity of all marine mammals to entanglement has been assessed as **High**, and the magnitude of the impact of primary entanglement (entanglement with WTG mooring lines/dynamic cables) has been assessed as **Negligible**, the effect of primary entanglement is considered to be of **Negligible** significance, which is **Not Significant** with respect to the EIA Regulations.

11.14.3.15 When considering the magnitude of the impact of indirect/secondary entanglement (entanglement with fisheries debris caught in WTG mooring lines or dynamic cables), this has been assessed as **Low**. As such, the effect of indirect/secondary entanglement is considered to be of **Minor** significance**,** which is **Not Significant** with respect to the EIA Regulations.

11.14.4 Risk of Injury Resulting from Marine Mammal Collisions with Wind Turbine Generator Substructures

11.14.4.1 The risk of marine mammal collisions with moving vessels have long been discussed in the impact assessments of renewable energy developments (with the risks potentially injurious and/or fatal). However, much of the recent research that focuses on collision risk examines marine mammals in the vicinity of new marine renewable energy structures and has a predominant focus on tidal turbines (Copping *et al.* 2020a, Copping *et al.* 2020b, Garavelli 2020). No collisions of marine mammals have ever been observed with tidal turbines or other marine renewable energy infrastructure (such as monopiles) (Copping *et al.* 2020b);

[9] https://emodnet.ec.europa.eu/en/map-week-%E2%80%93-seabed-litter-%E2%80%93-fishing-related-items-density

nonetheless, as the development of floating offshore wind farm technology increases, there is a need to assess the possibility of marine mammal collisions with these new offshore floating WTG substructures.

Sensitivity

11.14.4.2 The risks of marine mammals colliding with floating WTG substructures is likely based on the individual's ability to perceive newly introduced infrastructure and the individual's behaviour within a new development area. In addition, the risks of marine mammals colliding with floating WTG substructures would also be species dependent.

11.14.4.3 For example, both grey and harbour seals have demonstrated associations with offshore wind turbines (fixed foundation) and subsea pipelines in the UK, Denmark and the Netherlands (McConnell *et al.* 2012, Russell *et al.* 2014). In the UK, individual seals were shown to regularly enter the Sheringham Shoal wind farm, demonstrating grid-like directed navigational movements between structures and area-restricted search behaviours which are characteristic of foraging (Russell *et al.* 2014). In the Netherlands, individual seals followed subsea pipelines during foraging efforts (Russell *et al.* 2014). This demonstrates the ability of both grey and harbour seals to perceive newly introduced infrastructure into the marine landscape. Thus, seals are unlikely to collide with newly introduced floating WTG substructures at the sea surface and sustain injuries. Likewise, seals have been shown to haul out and rest on accessible parts of oil and gas semi-submerged structures (Delefosse *et al.* 2018, Delefosse *et al.* 2020), again highlighting their ability to detect and make use of the structures, rather than be susceptible to collision with it. The sensitivity of seals to collisions with floating WTG substructure is assessed as **Negligible**.

11.14.4.4 Similarly, echolocating odontocetes (such as harbour porpoise, bottlenose dolphins and white-beaked dolphins) use the echoes of their outgoing sounds to locate and identify objects in their path (Brinkløv *et al.* 2022). Various experiments have shown that dolphins and porpoises can perform complex biosonar target discrimination tasks of man-made objects (Au and Hastings 2008) and have the ability to discriminate between prey items based on the returning echoes of their echolocation clicks (Au *et al.* 2009, Yovel and Au 2010). This demonstrates the ability that dolphin species and harbour porpoise are likely to have the ability to perceive newly introduced infrastructure into the marine landscape. As such, dolphins and porpoise are unlikely to collide with newly introduced floating WTG substructures at the sea surface and sustain injuries. The sensitivity of dolphins and porpoise to collisions with floating WTG substructure is assessed as **Negligible.**

11.14.4.5 Baleen whales, such as minke whale and humpback, use a unique prey-acquisition strategy: lunge feeding, to engulf entire patches of large plankton or schools of fish (Goldbogen *et al.* 2012, Potvin *et al.* 2012, Friedlaender *et al.* 2014, Potvin *et al.* 2021, Smith *et al.* 2022). During these behaviours, baleen whales may not perceive the structures around them, increasing their chances of a collision with a moving and/or static object (such as with vessels[10, 11] and structures within marinas[12]). Although these events are rare, this may also occur with floating WTG substructures, especially in instances where individuals have accepted that the foraging rewards outweigh the perceived risks (in this instance, collision risks) around them (Pitcher *et al.* 1988, Szesciorka *et al.* 2023). Baleen whales colliding with static and/or moving objects during lunge feeding

[10] https://outsider.com/outdoors/news-outdoors/humpback-whale-collides-boat-feeding-footage/
[11] https://www.nbcnews.com/news/us-news/whale-lands-boat-massachusetts-coast-insane-moment-caught-video-rcna39781
[12] https://www.earthtouchnews.com/oceans/whales-and-dolphins/whale-surprises-locals-with-out-of-nowhere-lunge-in-busy-marina/

have not resulted in any known injuries and/or mortalities; however, this does not preclude from sustaining injuries during the collision with a floating WTG substructure. Given the paucity of information available on the risks of baleen whale collisions with floating WTG substructures, the sensitivity of baleen whales, such as minke whale, to collisions with WTG substructure is conservatively assessed as **Low**.

Impact Magnitude

11.14.4.6 The magnitude of impact of marine mammal collision with floating WTG substructures is likely dependent on both the species present within the OAA, and the size of the WTG substructures. Approximately 19,600 m^2 of structure (per substructure) of plan sea surface area will be occupied by the substructure when considering the full OAA (seven floating WTGs and their substructures, totalling 137,200 m^2 of structure within the water column). The draught range of each substructure, however, shall vary depending on the substructure type. For semi-submersibles, there is a draught range of 10 – 24 m during operations, and 15 – 40 m for tension leg platforms.

11.14.4.7 The area of the substructure present in the water column is the area where there is the greatest potential for interaction. However, given that the number of floating WTG substructures present in the OAA shall not exceed seven, and that their presence within the marine landscape is predictable, it is unlikely that marine mammal collisions shall be a common occurrence.

11.14.4.8 As aforementioned, seals, dolphins and porpoise are likely to have the ability to perceive newly introduced infrastructure in the marine landscape. In addition, seals have been shown to habituate to the presence of marine infrastructure. Therefore, irrespective of the size of floating WTG substructures, seals, dolphins and porpoise are unlikely to sustain any injuries as a result of collision. The magnitude of impact is assessed as **Negligible.**

11.14.4.9 For baleen whales, such as minke whale, the risk of collisions with floating WTG substructures is greater than that of seals, dolphins and porpoise due to the nature of their lunge feeding behaviours. While minke whales are known to occur in the region, their density is low and the area has not been reported as supporting aggregations of feeding animals such as those observed off the southern coast of the Moray Firth. Therefore, there is considered to be a low potential for interactions between minke whales and WTG substructures. Overall, the risk of baleen whale collisions with floating WTG substructures is considered to be of **Low** magnitude.

Significance of Impact

11.14.4.10 The sensitivity of porpoise, dolphins and seals to collisions with WTG substructures has been assessed as **Negligible**. When considering the magnitude of the impact of porpoise, dolphin or seal collisions with WTG substructure, these were assessed as **Negligible**. As such, the effect is considered to be of **Negligible** significance, which is **Not Significant** with respect to the EIA Regulations.

11.14.4.11 The sensitivity of minke whales to collisions with WTG substructures has been assessed as **Low**, and the magnitude of this effect is considered to be **Low**. As such, the effect is considered to be of **Negligible** significance, which is **Not Significant** with respect to the EIA Regulations.

11.14.5 Operational Noise Impacts from Operational Floating Wind Turbine Generators

11.14.5.1 Research of underwater noise impacts from offshore wind farms on marine life has in the past concentrated on the construction phase, with a particular focus on pile driving (Bailey *et al.* 2010, Hastie *et al.* 2015, Graham *et al.* 2019, Thompson *et al.* 2020, Graham *et al.* 2023) and UXO clearance (Robinson *et al.* 2020, Cook and Banda 2021, GoBe 2021, Robinson *et al.* 2022).

11.14.5.2 However, with the introduction of new floating WTG technologies and the expansion of offshore wind farms into deeper waters, the operational noise of floating offshore wind farms has received increased attention (Tougaard *et al.* 2020, Stöber and Thomsen 2021, Thomsen *et al.* 2021, Risch *et al.* 2023).

11.14.5.3 Operational underwater noise is expected to be similar between fixed and floating offshore wind turbines, as above water structures where most noise will be generated (e.g., tower, nacelle, turbine, and rotors) are comparable between these two forms of energy generation (Risch *et al.* 2023). However, recent estimates of cumulative underwater noise from fixed offshore wind turbine arrays have highlighted that contributions from increasingly large arrays can change local soundscapes (Tougaard *et al.* 2020); similar relationships between array size and cumulative operational noise generation are to be expected for floating arrays, but have not yet been assessed.

Sensitivity

11.14.5.4 Most of the acoustic energy produced by operational floating offshore wind farms is below 200 Hz (Risch *et al.* 2023) and there appears to be a continued decrease in energy levels above 300 Hz[13]. Therefore, the primary acoustic energy from operational floating WTGs at Salamander is likely to be below the region of greatest sensitivity for most marine mammal species considered here (porpoise, dolphins and seals) (Southall *et al.* 2019).

11.14.5.5 Therefore, most marine mammals (porpoise, dolphins, and seals) have been assessed as having a **Negligible** sensitivity to operational floating WTG noise.

11.14.5.6 As there is more energy at lower frequencies (<200 Hz) it is more precautionary to assess minke whales as having a **Low** sensitivity to operational noise from operational floating WTGs.

Impact Magnitude

11.14.5.7 Characterisation of operational underwater noise from floating WTGs has recently been undertaken by Risch *et al.* (2023), whereby the operational underwater noise and mooring noise from two floating offshore wind farms currently deployed off the Scottish east coast were modelled. Data were collected at the Kincardine floating wind farm from November – January 2021/2022 and at the Hywind Scotland Offshore Wind Farm from May to June 2022. In addition, F-POD autonomous echolocation click detectors were used for monitoring harbour porpoise activity in the vicinity of the turbine arrays.

11.14.5.8 Source levels for operational noise (25 Hz – 25 kHz) increased with wind speed at both recording locations. At a wind speed of 15 m/s, source levels were found to be about 3 dB higher at Kincardine as compared to Hywind Scotland (i.e., 148.8 compared to 145.4 dB re 1 µPa) (Risch *et al.* 2023). However, most turbine operational noise is concentrated below 200 Hz and median one-third octave band levels in this frequency range were between 95 and 100 dB re 1 µPa at about 600 m from the closest turbine (Risch *et al.* 2023). These noise levels are above expected ambient noise levels due to wave and wind conditions (Wenz 1962) but were similar to those measured for operational noise from fixed offshore wind turbines at comparable distances (Tougaard *et al.* 2020, Stöber and Thomsen 2021, Risch *et al.* 2023).

11.14.5.9 As the Salamander OWF is also located within the North Sea, it is anticipated that ambient noise levels shall be similar to those in which underwater noise generation was assessed as part of the Kincardine and Hywind

[13] See Figures 14 - 16 in Risch *et al*. (2023) https://tethys.pnnl.gov/sites/default/files/publications/Rischetal.pdf

Scotland projects (~ 100 dB[14]). **Volume ER.A.4, Annex 4.1: Underwater Noise Modelling Report** predicts that the sound output of the largest turbine considered is expected to be 145 dB SPL_{RMS} at 10 m distance and 122 dB SPL_{RMS} at 100 m. As such, the operational noise source levels for Salamander are anticipated to be similar to those for Kincardine and/or Hywind Scotland (25 Hz – 20 kHz, 145.4 – 148.8 dB re 1 µPa (6 – 8 MW turbines)).

11.14.5.10 At Kincardine and Hywind Scotland locations, daily patterns of harbour porpoise occurrence were similar for both wind farm arrays (Risch *et al.* 2023). Recorded porpoise detections were lower at the recording site closest to the turbine compared to the site further away (600 m compared to 1,500 m at Kincardine, and 300 m compared to 2,400 m at Hywind Scotland) (Risch *et al.* 2023). Thus, reduced presence of harbour porpoise may be expected at Salamander closer to the floating WTG structures. It is important to note, however, that these results are preliminary, and although they might indicate longer term displacement and/or reduced vocalisation behaviours of harbour porpoises closer to floating offshore wind structures (Risch *et al.* 2023), data are limited and further investigation across a larger spatial scale and longer timeframe using a distributed sound source analysis (Risch *et al.* 2023) is required to better understand the spatio-temporal scale of potential displacement.

11.14.5.11 Whilst mooring lines at floating offshore wind farms are designed to be permanently in tension and, therefore, should not go slack even in extreme conditions (Statoil 2015), it is considered that mooring lines associated with floating OWFs have the potential to produce ‘pinging’ noises during the operational phase of the development. Mooring line ‘pinging’ refers to impulsive noises generated by the sudden re-tension in a cable following a period of slackness resulting from large amplitude and/or high-frequency surface motions (Liu 1973).

11.14.5.12 Data are available for the Hywind Demonstrator project in Norway for a single WTG where noise measurements were taken in water depths of 200 m at 91 m off the seabed (approximately mid-depth) at 150 m from the installation (Martin *et al.* 2011). During the 2-month monitoring period, up to 23 ‘pings’ were identified per day. Of these, less than 10 ‘snaps’ per day exceeded an SPL_{peak} of 160 dB re 1 µPa.

11.14.5.13 By contrast, analysis of sounds recorded at both Kincardine and Hywind Scotland did not reveal distinct impulsive ‘pinging’ sounds; instead, a range of ‘transient sounds’ were reported that can be described as “bangs”, “creaks” and “rattles” which acoustic analysis classified as non-impulsive sound sources (Burns et al. 2022). Burns et al. (2022) showed that these sounds had a broadband energy (10 – 48 kHz) and were short in duration (~ 1 second). However, it was concluded that these transient sounds could not be considered as impulsive, and therefore the application of non-impulsive frequency weighted noise threshold values for determining auditory injury risk to marine mammals is appropriate (Risch et al. 2023). Using the NMFS (2018) thresholds for TTS-onset from non-impulsive noise sources, Burns et al. (2022) determined that a high-frequency cetacean (porpoise) would need to remain within 50 m of an operational turbine (assuming the wind speed was 15 knots) for 24 hours to reach the TTS-onset threshold.

11.14.5.14 It is important to note that the aforementioned examples of Hywind (Norway), Hywind Scotland and Kincardine floating wind farms all involve catenary moored systems, which is just one of the mooring options being considered for the Salamander Project. Taut or tensioned mooring arrangements are expected to have significantly lower instances of ‘pinging’.

[14] https://moat.cefas.co.uk/pressures-from-human-activities/underwater-noise/ambient-noise/

11.14.5.15 Given the types of noise recorded at existing floating OWFs, and the small scale of the Salamander Project, it is expected that disturbance from operational noise would be of **Negligible** magnitude.

Significance of Impact

11.14.5.16 When considering the sensitivity of marine mammals to operational WTG noise, porpoise, dolphins and seals were assessed as **Negligible**, whilst minke whale were assessed as **Low**. Given that the magnitude of impact of operational WTG noise was assessed as **Negligible**, the significance of the effect is considered to be of **Negligible** significance**,** which is **Not Significant** with respect to the EIA Regulations.

11.14.6 Displacement or Barrier Effects resulting from the Physical Presence of the Offshore Array Infrastructure

11.14.6.1 The physical presence of array infrastructure at the OAA has the potential to either displace marine mammals through an effective loss of habitat, and/or create barrier effects, whereby the regular movements of a particular species are impacted by the presence of the wind farm (Onoufriou *et al.* 2021). Barrier effects can also be present in the form of a reduction of access to areas which were once used by marine mammals for particular behaviours.

Sensitivity

11.14.6.2 As floating offshore wind farms are a relatively new development in the UK, the implications of barrier effects on marine mammals, and thus, their sensitivity to barrier effects is based on the evidence presented for fixed-foundation offshore wind farms.

11.14.6.3 At present, there are no accounts of barrier effects being caused by fixed-foundation offshore wind farms or other marine infrastructure (such as oil and gas platforms). For example, Vallejo *et al.* (2017) found no difference in the occurrence of harbour porpoise during the pre-construction and operational phases of the Robin Rigg offshore wind farm. Similarly, Todd *et al.* (2009) showed that harbour porpoise were present around an oil and gas platform, and were thought to be foraging around it. With respect to pinnipeds, in the UK, individual seals were shown to regularly enter the Sheringham Shoal wind farm, demonstrating grid-like directed navigational movements between structures and area-restricted search behaviours which are characteristic of foraging (Russell *et al.* 2014). Further research by Russell *et al.* (2016a) also demonstrated that while seals may exhibit short-term avoidance of offshore wind farm sites during pile driving activities (i.e., construction), once operational, seals would pass through the wind farm site.

11.14.6.4 These accounts, coupled with the fact there are further observations of seals actively foraging (Russell *et al.* 2014, Arnould *et al.* 2015, Farr *et al.* 2021) and regular sightings and acoustic detections of dolphins porpoise (Bonizzoni *et al.* 2013, Todd *et al.* 2016, Delefosse *et al.* 2018, Clausen *et al.* 2021) around marine infrastructure suggests that barrier effects do not persist for pinnipeds and odontocetes. Instead, these structures could function as fish aggregation devices (i.e., reef structures), introducing the potential for positive associations between predators and the prey aggregating infrastructure (Degraer *et al.* 2020).

11.14.6.5 However, for more migratory species, which are reliant on the utilisation of key pathways or seasonal habitats, barrier effects could be more persistent as a result of the increased presence of marine infrastructure. In Scotland, minke whales are the migratory species most likely to be impacted by obstructions from marine infrastructure. Although it is unclear how human activity may influence whale migrations, Braithwaite *et al.* (2015) suggested that should the total distance travelled by an individual during migration be increased (representing displacement), the increased energetic costs associated with this change could have implications on both adult and calf survival. However, as the annual movement patterns of minke whales are not fully understood, it is difficult to ascertain whether marine infrastructure projects cause minke whales to deviate away from their optimal migration strategies.

11.14.6.6 Although the Salamander OWF is less likely to introduce reef structures to the marine environment compared to fixed foundations (given the reduced amount of fixed permanent structure), the literature shows that pinnipeds and odontocetes have been shown to adapt their behaviour and actively forage within offshore wind farm arrays (e.g. Scheidat *et al.* 2011, Russell *et al.* 2014). To date, no displacement or barrier effects on minke whales have been reported. As such, all marine mammal species are considered to have a **Negligible** sensitivity to displacement from the Offshore Development during the O&M phase.

Impact Magnitude

11.14.6.7 When considering the scale of the planned infrastructure (maximum seven WTGs), the Offshore Development is unlikely to prevent the functional habitat use of any individuals across the site. As demonstrated at offshore wind farms of a much larger scale than Salamander, marine mammals have the ability to utilise marine substructures for foraging opportunities and have the ability to navigate between the same structures (e.g. Scheidat *et al.* 2011, Russell *et al.* 2014).

11.14.6.8 Although it has been reported that marine mammals may benefit from the introduction of subsea infrastructure (which can act as an artificial reef), the occurrence of this cannot yet be confirmed for newer, floating WTG technologies. However, even if floating WTG technologies do not create the same foraging opportunities as fixed-foundation marine substructures, displacement and barrier effects should still not occur given the small scale of the Salamander Project.

11.14.6.9 In addition, throughout the Offshore ECC, the Offshore Export Cable(s) will be buried or will include remedial cable protection where burial is not possible (only cabling within the OAA includes a proportion of dynamic cabling). Therefore, this infrastructure is not anticipated to limit the passage of animals across the Offshore ECC.

11.14.6.10 As such, the magnitude of impacts is assessed as **Negligible**.

Significance of Impact

11.14.6.11 The sensitivity of all marine mammals to displacement and barrier effects were assessed as **Negligible**. In addition, the magnitude of the impact was also assessed as **Negligible**. As such, the effect is considered to be of **Negligible** significance**,** which is **Not Significant** with respect to the EIA Regulations.

11.14.7 Long-term Habitat Change due to Dynamic Cable Electromagnetic Field Emissions and Indirect Impacts on Prey Items

11.14.7.1 Any change in fish abundance and/or distribution as a result of operations is important to assess as, given marine mammals are dependent on fish as prey species, there is the potential for indirect effects on marine mammals. During operational and maintenance activities, there is the potential for impacts upon fish species, including:

- Long-term loss of habitat;
- Temporary increase in suspended-solid concentrations and sediment deposition;
- Increased hard substrate and structural complexity;
- Electromagnetic field (EMF) impacts;
- Direct physical damage and disturbance;

- Seabed disturbances leading to the release of sediment contaminants and /or accidental contamination; and
- Changes to supporting seabed habitats arising from effects on physical processes.

Sensitivity

11.14.7.2 While there may be certain species that comprise the main part of their diet, all marine mammals in this assessment are considered to be generalist feeders and are thus not reliant on a single prey species. Therefore, they are assessed as having a **Low** sensitivity to changes in prey abundance and distribution.

Impact Magnitude

11.14.7.3 Potential impacts of EMFs on fish and shellfish species have been assessed in **Volume ER.A.3, Chapter 10: Fish and Shellfish**Ecology. The assessment has concluded that the overall adverse impacts to fish species from the operational and maintenance phases of Salamander will be of Negligible (Non-significant) impacts and thus the predicted magnitude of impact on marine mammals is of **Negligible** magnitude.

Significance of Impact

11.14.7.4 As the sensitivity of all marine mammals to impacts on prey items has been assessed as **Low**, and the magnitude of the impact on marine mammals have been assessed as **Negligible,** the effect is considered to be **Negligible,** which is **Not Significant** with respect to the EIA Regulations.

11.15 Impact Assessment – Decommissioning Phase

11.15.1.1 The draft Decommissioning Programme will be updated during the Project's lifespan and the final methods chosen for decommissioning shall be dependent on the technologies, guidance and best practice available at the time. As such, the numbers of vessels and/or plant required for each activity is therefore not available at this stage. Indicative activities may include (see **Volume ER.A.2 Chapter 4: Project Description** for further details):

- A variety of surveys which may include geophysical surveys and visual inspections via ROV
- Similar types and numbers of vessels as used during the construction phase
- WTGs and floating substructures disconnected from moorings and towed to port
- Recovery of mooring lines and anchors
- Cutting of any anchor piles approximately 1 m below seabed
- Recovery and removal of dynamic portion of array cables
- Removal of buried cables by reversing burial process and recovery to vessel, with potential diver/ROV support
- Burial of cut cable ends
- Recovery of scour protection / rock protection by dredger or grab (current assumption is to leave *in situ*)

11.15.1.2 The potential impacts on marine mammals arising from decommissioning of Salamander are listed in **Section 11.8**. Under the decommissioning phase, the following potential impacts have been assessed:

- Auditory injury (PTS) from decommissioning activities;
- Disturbance from decommissioning activities and vessels; and
- Indirect impacts on prey.

11.15.1.3 Decommissioning activities shall include removal of offshore structures above the seabed in reverse order to the construction sequence. The effects of these activities on marine mammals are considered to be similar to, or less than those occurring during construction. For example, there shall be no piling activities and as such, the effects of underwater noise on marine mammals during decommissioning is considered to be no greater than those described for the construction phase.

11.15.2 Auditory Injury (Permanent Threshold Shift) from Decommissioning Activities

Sensitivity

11.15.2.1 As the effects of underwater noise on marine mammals during decommissioning are considered to be no greater than those described for the construction phase, it is conservative to assume that the sensitivity of marine mammals to PTS from decommissioning activities is with the same as the sensitivity of marine mammals to PTS from piling. As such, the sensitivity of minke whale is assessed as **Medium,** and the sensitivity of all other marine mammals is assessed as **Low**.

Impact Magnitude

11.15.2.2 The final methods chosen for decommissioning shall be dependent on the technologies, guidance and best practice available at the time. The numbers of vessels and/or plant required for each activity is therefore not available at this stage.

11.15.2.3 Auditory injury is a permanent effect from which an animal cannot recover. As the exact methods to be used for decommissioning are to be decided, the impact from PTS and disturbance levels of decommissioning activities cannot be accurately determined at this time. However, it is anticipated that with the implementation of embedded mitigation in the form of a Decommissioning Program and a MMMP specific to decommissioning activities, the magnitude of the impacts on individuals are not anticipated to alter population trajectory over a generational scale Therefore, the magnitude of the impacts on individuals are not anticipated to alter population trajectory over a generational scale. Therefore, the magnitude is **Low** for all species.

Significance of Impact

11.15.2.4 As the sensitivity of minke whale to auditory injury from decommissioning activities has been assessed as **Medium,** and the magnitude of the impact has been assessed as **Low**, the effect is considered to be of **Minor** significance, which is **Not Significant** with respect to the EIA Regulations**.**

11.15.2.5 As the sensitivity of all other marine mammals to auditory injury from decommissioning activities has been assessed as **Low**, and the magnitude of the impact has been assessed as **Low**, the effect is considered to be of **Negligible** significance, which is **Not Significant** with respect to the EIA Regulations**.**

11.15.3 Disturbance from Decommissioning Activities and Vessels

Sensitivity

11.15.3.1 Decommissioning activities and associated vessel activity is considered to be comparable or less intense than vessel activity and other construction activity during the construction phase. Therefore, it is conservative to assume that the sensitivity of marine mammals to disturbance during decommissioning activities and vessel activities during the decommissioning phase to be the same as the sensitivity of marine mammals to disturbance from vessel and other construction activities disturbance during the construction phase. As such, the sensitivity of all marine mammals is assessed as **Low**[15].

Impact Magnitude

11.15.3.2 The magnitude and characteristics of vessel noise varies depending on ship type, ship size, mode of propulsion, operational factors, and speed. Vessels of varying size produce different frequencies, typically between 10-100 Hz (although higher frequencies may also be produced) (Sinclair *et al.* 2023), and generally becoming lower in frequency with increasing size. The distance at which animals may react is difficult to predict and behavioural responses can vary a great deal depending on context. Porpoise displacement has been observed up to 4 km from construction vessels (Benhemma-Le Gall *et al.* 2021) and it is expected that other cetacean species will be displaced to a similar extent.

11.15.3.3 There is little information available as to what level of vessel activity can result in disturbance to marine mammals. However, Heinänen and Skov (2015) suggested that harbour porpoise density was significantly lower in areas with vessel transit rates of greater than 20,000 ships/year (80/day) within an area of 5 km^2. For both the construction and decommissioning phases, it is anticipated that a maximum of 12 vessels will be on site simultaneously in a 5 km^2 area.

11.15.3.4 When considering the magnitude of impact, the impacts of vessel disturbance are likely to be similar to those during the construction phase. As such, when considering the impact of disturbance from vessel noise, this is predicted to be of local spatial extent, short-term and reversible, and unlikely to cause impacts in which the population trajectory would be altered. The magnitude of disturbance from vessel activity during decommissioning is therefore assessed as **Low**.

Significance of Impact

11.15.3.5 The sensitivity of marine mammals to disturbance from vessels has been assessed as **Low**. The magnitude of disturbance from vessels to marine mammals has been assessed as **Low** for all other species. Therefore, the significance of impact of disturbance from vessels is considered to be of **Negligible** significance, which is **Not Significant** with respect to the EIA Regulations.

[15] It is noted that the sensitivity of seals to other construction activities is assessed as Negligible; however, their sensitivity to vessel disturbance during the construction phase is assessed as Low and, therefore, the more precautionary of these two is adopted for sensitivity to decommissioning activities and vessels.

11.15.4 Indirect Impacts on Prey

Sensitivity

11.15.4.1 While there may be certain species that comprise the main part of their diet, all marine mammals in this assessment are considered generalist feeders and are thus not reliant on a single prey species. Therefore, they are assessed as having a **Low** sensitivity to changes in prey abundance and distribution.

Impact Magnitude

11.15.4.2 During decommissioning activities, there is the potential for impacts upon fish species, including:

- Temporary physical loss and disturbance;
- Temporary increases in suspended sediment concentration and sediment deposition;
- Seabed disturbances leading to the release of sediment contaminants and/or accidental contamination; and
- Additional underwater noise and vibration.

11.15.4.3 The assessment provided in **Volume ER.A.3, Chapter 10: Fish and Shellfish Ecology** indicates that the overall adverse impacts to fish species from the decommissioning phase of Salamander will be of Negligible significance. Therefore, the magnitude of impact on marine mammals is anticipated to be **Negligible**.

Significance of Impact

11.15.4.4 As the sensitivity of all marine mammals to impacts on prey items has been assessed as Low, and the magnitude of the impact on marine mammals have been assessed as **Negligible**, the significance of the effect is considered to be **Negligible**, which is **Not Significant** with respect to the EIA Regulations**.**

11.16 Summary of Impact Assessment

11.16.1.1 A summary of the impacts and effects identified for the Marine Mammal assessment is outlined in **Table 11-38**.

Table 11-38 Summary of Impacts and Effects for Marine Mammals

Salamander Project Activity and Impact	Project Aspect	Embedded Mitigation	Receptor	Sensitivity	Magnitude	Significance of Effect	Additional Mitigation	Residual Significance of Effect	Significance of Effect in EIA Terms
Construction Impacts									
Auditory Injury (PTS) from pre-construction geophysical surveys	Offshore ECC and OAA	Co16	All marine mammals	Negligible to Low	Negligible	Negligible	No additional mitigation measures have been identified for this effect above and beyond the embedded mitigation listed in **Section 11.11** as it was concluded that the effect was Not Significant.	Negligible	Not Significant
Disturbance from pre-construction geophysical surveys	Offshore ECC and OAA	NA	All marine mammals	Negligible to Low	Negligible	Negligible	No additional mitigation measures have been identified for this effect as it was concluded that the effect was Not Significant.	Negligible	Not Significant

Salamander Project Activity and Impact	Project Aspect	Embedded Mitigation	Receptor	Sensitivity	Magnitude	Significance of Effect	Additional Mitigation	Residual Significance of Effect	Significance of Effect in EIA Terms
Auditory Injury (PTS) from UXO clearance	Offshore ECC and OAA	Co16	Porpoise, dolphins and seals	Low	Negligible with UXO MMMP	Negligible	No additional mitigation measures have been identified for this effect above and beyond the embedded mitigation listed in **Section 11.11** as it was concluded that the effect was Not Significant.	Negligible	Not Significant
			Minke whale	Medium					
Disturbance from UXO clearance (26km EDR, 5km EDR and TTS)	Offshore ECC and OAA	NA	All marine mammals	Low	Low	Negligible	No additional mitigation measures have been identified for this effect as it was concluded that the effect was Not Significant.	Negligible	Not Significant
Auditory Injury (PTS) from piling of anchors	OAA	Co16	Porpoise, dolphins and seals	Low	Negligible with Piling MMMP	Negligible	No additional mitigation measures have been identified for this effect	Negligible	Not Significant

Salamander Project Activity and Impact	Project Aspect	Embedded Mitigation	Receptor	Sensitivity	Magnitude	Significance of Effect	Additional Mitigation	Residual Significance of Effect	Significance of Effect in EIA Terms
			Minke whale	Medium			above and beyond the embedded mitigation listed in **Section 11.11** as it was concluded that the effect was Not Significant.		
Disturbance from piling of anchors	OAA	NA	Harbour porpoise	Low	Negligible	Negligible	No additional mitigation measures have been identified for this effect as it was concluded that the effect was Not Significant.	Negligible	Not Significant
			Bottlenose dolphin	Low	Negligible				
			White-beaked dolphin	Low	Low				
			Minke whale	Low	Low				
			Harbour seal	Medium	Negligible				
			Grey seal	Negligible	Negligible				

Salamander Project Activity and Impact	Project Aspect	Embedded Mitigation	Receptor	Sensitivity	Magnitude	Significance of Effect	Additional Mitigation	Residual Significance of Effect	Significance of Effect in EIA Terms
Auditory Injury (PTS) from other construction activities	Offshore ECC and OAA	NA	Porpoise, dolphins and seals	Low	Negligible	Negligible	No additional mitigation measures have been identified for this effect as it was concluded that the effect was Not Significant.	Negligible	Not Significant
			Minke whale	Medium					
Disturbance from other construction activities	Offshore ECC and OAA	Co11	Porpoise, dolphins and minke whale	Low	Low	Negligible	No additional mitigation measures have been identified for this effect above and beyond the embedded mitigation listed in **Section 11.11** as it was concluded that the effect was Not Significant.	Negligible	Not Significant
			Seals	Negligible					
Disturbance from vessels	Offshore ECC and OAA	Co11	All marine mammals	Low	Low with VMP	Negligible	No additional mitigation measures have been identified for this effect above and beyond the embedded mitigation listed in **Section 11.11** as it was concluded that the effect was Not Significant.	Negligible	Not Significant

Salamander Project Activity and Impact	Project Aspect	Embedded Mitigation	Receptor	Sensitivity	Magnitude	Significance of Effect	Additional Mitigation	Residual Significance of Effect	Significance of Effect in EIA Terms
Indirect impacts on prey	Offshore ECC and OAA	NA	All marine mammals	Low	Low	Negligible	No additional mitigation measures have been identified for this effect as it was concluded that the effect was Not Significant.	Negligible	Not Significant
Operational Impacts									
Auditory Injury (PTS) from pre-construction geophysical surveys	Offshore ECC and OAA	Co16	All marine mammals	Negligible to Low	Negligible	Negligible	No additional mitigation measures have been identified for this effect above and beyond the embedded mitigation listed in **Section 11.11** as it was concluded that the effect was Not Significant.	Negligible	Negligible
Disturbance from pre-construction geophysical surveys	Offshore ECC and OAA	NA	All marine mammals	Negligible to Low	Negligible	Negligible	No additional mitigation measures have been identified for this effect as it was concluded that the effect was Not Significant.	Negligible	Not Significant

Salamander Project Activity and Impact	Project Aspect	Embedded Mitigation	Receptor	Sensitivity	Magnitude	Significance of Effect	Additional Mitigation	Residual Significance of Effect	Significance of Effect in EIA Terms
Risk of injury resulting from entanglement (Direct/Primary)	OAA	NA	All marine mammals	High	Negligible	Negligible	No additional mitigation measures have been identified for this as it was concluded that the effect was Not Significant.	Negligible	Not Significant
Risk of injury resulting from entanglement (Indirect/Secondary)	OAA	Co17	All marine mammals	High	Low	Minor	No additional mitigation measures have been identified for this effect above and beyond the embedded mitigation listed in **Section 11.11** as it was concluded that the effect was Not Significant.	Minor	Not Significant
Risk of injury resulting from marine mammal collisions with WTG substructures	OAA	NA	Porpoise, dolphins and seals	Negligible	Negligible	Negligible	No additional mitigation measures have been identified for this effect as it was concluded that the effect was Not Significant.	Negligible	Not Significant
			Minke whale	Low	Low				
Operational noise impacts from	OAA	NA	Porpoise, dolphins and seals	Negligible	Negligible	Negligible	No additional mitigation measures have been identified for this effect as	Negligible	Not Significant

Salamander Project Activity and Impact	Project Aspect	Embedded Mitigation	Receptor	Sensitivity	Magnitude	Significance of Effect	Additional Mitigation	Residual Significance of Effect	Significance of Effect in EIA Terms
operational floating WTGs			Minke whale	Low			it was concluded that the effect was Not Significant.		
Displacement or barrier effects resulting from the physical presence of Offshore Array infrastructure	Offshore ECC and OAA	NA	All marine mammals	Negligible	Negligible	Negligible	No additional mitigation measures have been identified for this effect as it was concluded that the effect was Not Significant.	Negligible	Not Significant
Long-term habitat change due to dynamic cable EMF emissions and indirect impacts on prey	Offshore ECC and OAA	NA	All marine mammals	Low	Negligible	Negligible	No additional mitigation measures have been identified for this effect as it was concluded that the effect was Not Significant.	Negligible	Not Significant
Decommissioning									
Auditory injury (PTS) from	Offshore ECC and OAA	Co16	Porpoise, dolphins and seals	Low	Low	Negligible	No additional mitigation measures have been identified for this effect	Negligible	Not Significant

Salamander Project Activity and Impact	Project Aspect	Embedded Mitigation	Receptor	Sensitivity	Magnitude	Significance of Effect	Additional Mitigation	Residual Significance of Effect	Significance of Effect in EIA Terms
decommissioning activities			Minke whale	Medium			above and beyond the embedded mitigation listed in **Section 11.11** as it was concluded that the effect was Not Significant.		
Disturbance from decommissioning activities and vessels	Offshore ECC and OAA	Co11	Porpoise	Medium	Low	Negligible	No additional mitigation measures have been identified for this effect above and beyond the embedded mitigation listed in **Section 11.11** as it was concluded that the effect was Not Significant.	Negligible	Not Significant
			Dolphins, minke whale and seals	Low					
Indirect impacts on prey	Offshore ECC and OAA	NA	All marine mammals	Low	Negligible	Negligible	No additional mitigation measures have been identified for this effect as it was concluded that the effect was Not Significant.	Negligible	Not Significant

11.17 Mitigation and Monitoring

11.17.1.1 The significance of effects for all impacts assessed during construction, O&M and decommissioning are **Not Significant** in EIA terms (**Table 11-38**). Therefore, no additional mitigation to that already identified in **Section 11.11: Embedded Mitigation**, are considered necessary. Therefore, no significant adverse residual effects have been predicted in respect of marine mammals which warrant additional mitigation measures.

11.18 Cumulative Effect Assessment

11.18.1.1 A Cumulative Effects Assessment (CEA) has been made based on existing and proposed developments in the Study Area. The approach to the CEA is described in **Volume ER.A.4, Annex 6.2: Cumulative Effects Assessment Technical Annex**. Cumulative effects are defined as those effects on a receptor that may arise when the development is considered together with other projects.

11.18.1.2 As noted in **Volume ER.A.4, Annex 6.2: Cumulative Effects Assessment Technical Annex**, 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.

11.18.2 Screening Projects

11.18.2.1 The projects and plans selected as relevant to the assessment of impacts to marine mammals are based upon an initial screening exercise undertaken on a long list. Each project, plan or activity has been considered and screened in or out based on effect–receptor pathway, data confidence and the temporal and spatial scales involved. In order to create the CEA long list, a Zone of Influence (ZOI) has been applied to screen in relevant offshore projects. The ZOI for marine mammals is the species-specific MU.

11.18.2.2 The CEA methodology and long list are described in **Volume ER.A.4, Annex 6.2: Cumulative Effects Assessment Technical Annex.** The long list of projects, plans and activities was used to generate a list of projects initially screened into the marine mammal CEA. The long list of projects was screened to remove all projects that have:

- No data available;
- No timeline available;
- No conceptual effect-receptor pathway;
- No physical effect-receptor overlap; and
- No temporal overlap (when considering the potential for disturbance from underwater noise).

11.18.2.3 From publicly available information, expected construction timelines were obtained for offshore wind farm projects only. Therefore, these were the only projects considered quantitatively in this CEA.

11.18.3 Screening Impacts

11.18.3.1 Certain impacts assessed for the Offshore Development alone are not considered in the marine mammal CEA due to:

- The highly localised nature of the impacts relative to the ranging patterns of marine mammal species[16];
- Management and mitigation measures in place at the Offshore Development and on other projects will reduce the risk occurring; and
- Where the potential significance of the impact from the Offshore Development alone has been assessed as negligible.

11.18.3.2 The impacts excluded from the marine mammal CEA for these reasons are:

- Auditory injury (PTS): where PTS may result from activities such as pile driving and UXO clearance, suitable mitigation will be put in place to reduce injury risk to marine mammals to negligible levels
- Disturbance from geophysical surveys: it is expected that disturbance impacts will be minimal, highly localised and over a limited duration (Negligible significance);
- Disturbance from UXOs: it is expected that going forward, most, if not all, UXO clearance will be conducted using low-order deflagration techniques, and therefore disturbance impacts will be minimal, highly localised and over an extremely short duration (Negligible significance);
- Disturbance from other construction activities: highly localised and negligible significance;
- Collision with vessels: it is expected that all offshore energy projects will employ a VMP or follow best practice guidance to reduce the already low risk of collisions with marine mammals (Negligible significance);
- Disturbance from vessels: it is expected that all offshore energy projects will employ a VMP or follow best practice guidance to reduce the risk of disturbance to marine mammals (Negligible significance);
- Changes in water quality: highly localised and negligible significance;
- Changes in prey availability: highly localised and negligible significance;
- Barrier effects/operational noise: highly localised and negligible significance;
- Long-term habitat change due to cable EMF and indirect impacts on prey: highly localised and negligible significance; and
- Injury from Primary/Direct entanglement with cables or mooring lines: negligible significance.

11.18.3.3 Therefore, the impacts that are considered in the marine mammal CEA are as follows:

- The potential for disturbance from underwater noise during construction (piling) of offshore wind farm developments. In addition to this, it has been precautionarily assumed that seismic airgun surveys associated with oil and gas projects have the potential to occur within the marine mammal MUs, though information on planned projects is limited. Given the potential disturbance impacts that these surveys could result in, it is recommended that they are included illustratively in marine mammal CEAs for underwater noise disturbance. The CEA time period considered for disturbance from underwater noise from construction activities is 2023-2031

[16] Given the wide-ranging behaviour of all marine mammal species considered here, it is not expected that highly localised impacts would result in a significant effect.

inclusive. This allows for the quantification of impacts to the MUs prior to the construction of the Salamander Project (since the baseline was collated), during the potential construction window for the Salamander Project (piling in 2028) and immediately after piling activities.

- The potential for indirect/secondary entanglement with mooring lines and dynamic cables (i.e. via derelict fishing gear) at floating offshore wind projects. The CEA time period considered here is the entire O&M phase of the Offshore Development.

11.18.4 Cumulative Effects Assessment Disturbance from Underwater Noise

Cumulative Effects Assessment Short List

11.18.4.1 **Table 11-39** shows the projects included in the marine mammal CEA short list for the impact of disturbance from underwater noise, for which a quantitative assessment was conducted. In total, 25 offshore wind farm projects and 1 seismic survey project were included in addition to the Salamander Project. It is acknowledged that the Blyth Demonstrator Phase 2 floating offshore windfarm is scheduled for construction in 2024; however, this project has been screened out of this CEA due to the project planning to exclusively use drag embedment anchors for mooring of WTGs, and the EIAR did not identify any impacts to marine mammals associated with installation of piles.

Table 11-39 Marine Mammal Cumulative Effects Assessment Short List. OWF = fixed foundation, FOWF = floating, Environmental Impact Assessment Report Y/N denotes whether a quantitative impact assessment for piling is available, blue cells denote years in which piling activities are expected / could occur, orange cells denote years in which seismic surveys are expected. Projects screened into/out of species-specific assessments are denoted by y/n for HP (harbour porpoise), BND (bottlenose dolphin), WBD (white-beaked dolphin), MW (minke whale), GS (grey seal) and HS (harbour seal)

Project	Type	EIAR	2023	2024	2025	2026	2027	2028	2029	2030	2031	HP	BND	WBD	MW	GS	HS
Salamander	FOWF	Y										y	y	y	y	y	y
Green Volt	FOWF	Y										y	y	y	y	y	y
Pentland	FOWF	Y										y	y	y	y	n	n
Seagreen Alpha and Bravo	OWF	Y										y	y	y	y	y	y
Moray West	OWF	Y										y	y	y	y	n	n
Berwick Bank	OWF	Y										y	y	y	y	y	y
Inch Cape	OWF	Y										y	y	y	y	y	y
Neart Na Gaoithe	OWF	Y										y	y	y	y	y	y
East Anglia ONE N	OWF	Y										y	y	y	y	n	n
East Anglia Three	OWF	Y										y	y	y	y	n	n
East Anglia Two	OWF	Y										y	y	y	y	n	n
Hornsea Four	OWF	Y										y	y	y	y	n	n
Hornsea Three	OWF	Y										y	y	y	y	n	n
Norfolk Vanguard E	OWF	Y										y	y	y	y	n	n
Norfolk Vanguard W	OWF	Y										y	y	y	y	n	n
Rampion 2	OWF	Y										y	n	y	y	n	n
Dogger Bank C	OWF	Y										y	y	y	y	n	n
Dudgeon Extension	OWF	Y										y	y	y	y	n	n
Sheringham Extension	OWF	Y										y	y	y	y	n	n
Sofia	OWF	Y										y	y	y	y	n	n
Muir Mhòr	*FOWF*	*N*										y	y	y	y	y	y
MarramWind	*FOWF*	*N*										y	y	y	y	n	n
Caledonia	*FOWF*	*N*										y	y	y	y	n	n
Cenos	*OWF*	*N*										y	y	y	y	y	y
Seismic Airgun Survey	*SS*	*N*										y	y	y	y	y	y

Method: Pile driving at offshore Wind Farms

11.18.4.2 For all offshore wind farm projects that had a quantitative impact assessment for pile driving available (Preliminary Environmental Information Report (PEIR) or EIAR chapter), the maximum number of animals predicted to be disturbed was obtained from the Salamander Project assessment and used in this CEA for that specific project. It is noted that different quantitative impact assessments used different methods to assess disturbance from pile driving activities. Some used a dose-response function, while others used an EDR approach, or used TTS as a proxy for disturbance. Therefore, the number of animals predicted to be disturbed by each project is not directly comparable. However, consent is granted to projects based on the values presented in their EIAR and thus these values are considered the most suitable to take forward in this quantitative CEA, despite the inconsistency in methods across projects.

11.18.4.3 For all projects that have no quantitative impact assessment available (PEIR or EIAR chapter), a 26 km EDR was assumed for fixed foundation projects, and a 15 km EDR for floating projects. For all cetacean species, the density was assumed to be that of the SCANS III block in which the OAA is located. For seals, the density was assumed to be the average habitat preference at sea usage estimate throughout the array area for each project.

Method: Seismic Surveys

11.18.4.4 The potential number of seismic surveys that could be undertaken is unknown. Therefore, it has been assumed that one seismic survey could be conducted within the UK portion of the North Sea at any one time. It has been assumed that the EDR for seismic surveys is 12 km as per the advice provided in JNCC (2020). It is considered that this approach is sufficiently precautionary (i.e., it is unlikely that this number of seismic surveys will be occurring concurrently, less so concurrently with the Offshore Development construction).

11.18.4.5 It is acknowledged that seismic surveys are a moving sound source and not a point source. Therefore, data on shooting statics provided in Stone (in prep) were used to provide an indicative distance travelled while shooting. The mean distance travelled per day while shooting for 3D seismic surveys between 2011 and 2020 was 116 km. Therefgore, it has been assumed that a seismic survey vessel travelling 116 km of survey line while shooting in a single 24 hour period will impact an area of 3,236 km² per day.

11.18.4.6 To estimate the number of cetaceans predicted to be disturbed from seismic surveys in the UK portion of North Sea, the average density across each species-specific MU was calculated:

- For harbour porpoise: abundance in UK MU (159,632)/area of UK MU (296,391 km^2) = 0.54 porpoise/km^2
- For bottlenose dolphins: average density in GNS MU = 0.003 dolphins/km^2
- For white-beaked dolphins: abundance in UK MU (34,025)/area of UK MU (697,876 km^2) = 158 dolphins/km^2
- For minke whales: abundance in UK MU (10,228)/area of UK MU (697,876 km^2) = 0.01 whales/km^2

11.18.4.7 To estimate the number of harbour and grey seals predicted to be disturbed by a seismic survey in East Scotland, the average habitat preference at-sea usage estimate throughout the MU was used (this is highly conservative since seals are generally in higher densities closer to shore, whereas seismic surveys tend not to occur close to shore).

Precaution in the Cumulative Effects Assessment

11.18.4.8 It should be noted that there are significant levels of precaution / conservatism within this CEA, resulting in the estimated effects being highly precautionary. The main areas of precaution / conservatism in the assessment include:

- The approach of summing across concurrent activities assumes that there is no spatial overlap in the impact footprints between individual activities, which is highly conservative considering the close proximity of many of the OWF projects;
- The inclusion of projects with a high degree of uncertainty; for example, those lacking consent, an EIAR, PEIR, and/or scoping report. In such instances, realistic worst-case scenarios are assumed in the absence of other information;
- The exact timing of pile driving for each development is unknown, therefore it has been assumed that these activities could occur at any point throughout the construction window. This has resulted in piling activities occurring over multiple consecutive years with associated estimated disturbance levels far greater than would occur in reality;
- The timelines presented in PEIR and EIAR chapters are realistic worst-case scenarios and the true period of piling activity will likely be shorter;
- The assumption that all fixed foundation OWF developments will install pile-driven monopile foundations. The project envelope for most of these developments includes options for pin-piles or monopiles, alongside options for non-piled foundations. As a realistic worst-case assumption monopiles have been assumed; however, a portion of these projects may instead use jacket foundations with pin-piles, which will have a much lower recommended effective deterrence range (15 km instead of 26 km, equating to a 66% smaller area) (JNCC 2020), and will therefore disturb far fewer animals;
- In the absence of project-specific assessments of the number of disturbed animals, EDRs based on those recommended for harbour porpoise have been applied; these can be considered precautionary for other species of marine mammal, which have not been reported to respond as strongly to relevant underwater noise as harbour porpoise; and,
- The assumption that the extent of the disturbance effects remains constant throughout the construction of each wind farm. Passive acoustic monitoring during pin piling at the Beatrice wind farm in the Moray Firth showed a 50% probability of harbour porpoise response (a significant reduction in detection relative to baseline) within 7.4 km at the first location piled, with decreasing response levels over the construction period (excluding pre-construction surveys), to a 50% probability of response within 1.3 km by the final piling location (Graham *et al.* 2019).

Cumulative Effects Assessment Underwater Noise Disturbance: Harbour Porpoise

Sensitivity

11.18.4.9 Harbour porpoise have been assessed as having a **Low** sensitivity to disturbance from pile driving activities. The same has been assumed here for disturbance from seismic airgun surveys as both sound sources are classified as low frequency broadband pulsed (LFBP) noise.

Magnitude

11.18.4.10 **Table 11-40** outlines the number of harbour porpoise predicted to be disturbed at each project in each year. The data have been split by whether a quantitative impact assessment is available. There is considerably more certainty in the number of animals predicted to be disturbed from project specific quantitative impact assessments. Therefore, the CEA results focus on projects with a quantitative impact assessment, while acknowledging that other projects are planned/expected.

11.18.4.11 Between 2023 and 2025, relatively low levels of disturbance to harbour porpoise in the North Sea MU from pile driving activities are predicted (10,024 porpoise in 2025, assuming concurrent construction at Moray West, Dogger Bank C, Sofia and Sheringham Shoal Extension) (**Table 11-40**). Construction of offshore wind farms is expected to increase dramatically in the second half of the 2020's to achieve the target installed capacity by 2030. Therefore, between 2026 and 2029 significantly more projects are expected to construct with potentially overlapping construction years, resulting in significantly higher predicted disturbance impacts to harbour porpoise in the North Sea MU.

11.18.4.12 Focusing on those projects for which a quantitative impact assessment is already available, there is expected to be disturbance to 50,416 harbour porpoise in 2028 (14.5% MU, 31.6% UK MU), assuming pile driving of anchors at Salamander occurs concurrently with pile driving at East Anglia One North, East Anglia Two, Hornsea Four, Hornsea Three, Norfolk Vanguard East, Rampion 2, Dudgeon Extension and Sheringham Shoal Extension (**Table 11-40**). Of this, Salamander is predicted to contribute 24% of the disturbance impact.

11.18.4.13 Including projects with no quantitative impact assessment available yet increases this slightly to 52,666 harbour porpoise (15.1% MU, 32.7% UK MU) (**Table 11-40**). Of this, Salamander is predicted to contribute 23% of the disturbance impact.

11.18.4.14 It is expected that disturbance from pile driving across multiple projects is likely to occur at a moderate frequency or intensity, affecting a moderate proportion of the harbour porpoise population which has the potential to cause short- to medium-term changes in the population from baseline conditions[17]. Therefore, the magnitude has been assessed as **Medium**.

[17] Note: no population modelling has been conducted for this CEA due to a lack of detailed information on potential piling schedules across projects.

Table 11-40 Harbour porpoise Cumulative Effects Assessment: potential disturbance from underwater noise

Project	Type	EIAR	2023	2024	2025	2026	2027	2028	2029	2030	2031
Salamander	FOWF	Y						11958			
Green Volt	FOWF	Y				5208	5208				
Pentland	FOWF	Y				323					
Seagreen Alpha and Bravo	OWF	Y					1103				
Moray West	OWF	Y	1609	1609							
Berwick Bank	OWF	Y				2822	2822				
Inch Cape	OWF	Y			556	556					
Neart Na Gaoithe	OWF	Y	1177								
East Anglia ONE N	OWF	Y					1289	1289			
East Anglia Three	OWF	Y			3828						
East Anglia Two	OWF	Y						1551	1551		
Hornsea Four	OWF	Y					6417	6417	6417		
Hornsea Three	OWF	Y				19396	19396	19396			
Norfolk Vanguard E	OWF	Y						2676	2676		
Norfolk Vanguard W	OWF	Y							1678		
Rampion 2	OWF	Y					630	630			
Dogger Bank C	OWF	Y		4302	4302	4302	4302				
Dudgeon Extension	OWF	Y				5161	5161	5161			
Sheringham Extension	OWF	Y			1338	1338	1338	1338			
Sofia	OWF	Y		2035							
Muir Mhòr	*FOWF*	*N*							*423*		
MarramWind	*FOWF*	*N*									*423*
Caledonia	*FOWF*	*N*						*107*			
Cenos	*FOWF*	*N*				*423*	*423*				
Seismic Airgun Survey	*SS*	*N*	*1743*	*1743*	*1743*	*1743*	*1743*	*1743*	*1743*	*1743*	*1743*
RESULTS FOR PROJECTS WITH A QUANTITATIVE IMPACT ASSESSMENT AVAILABLE											
TOTAL			*2,786*	*7,946*	*10,024*	*39,106*	*47,666*	*50,416*	*12,322*	*0*	*0*
% MU			*0.8%*	*2.3%*	*2.9%*	*11.3%*	*13.8%*	*14.5%*	*3.6%*	*0.0%*	*0.0%*
% UK MU			*1.7%*	*5.0%*	*6.3%*	*24.5%*	*29.9%*	*31.6%*	*7.7%*	*0.0%*	*0.0%*
Salamander contribution to total			*0%*	*0%*	*0%*	*0%*	*0%*	*24%*	*0%*	*0%*	*0%*
RESULTS FOR ALL PROJECTS											
TOTAL			*4,529*	*9,689*	*11,767*	*42,121*	*50,681*	*52,266*	*14,488*	*1,743*	*2,166*
% MU			*1.3%*	*2.8%*	*3.4%*	*12.2%*	*14.6%*	*15.1%*	*4.2%*	*0.5%*	*0.6%*
% UK MU			*2.8%*	*6.1%*	*7.4%*	*26.4%*	*31.7%*	*32.7%*	*9.1%*	*1.1%*	*1.4%*
Salamander contribution to total			*0%*	*0%*	*0%*	*0%*	*0%*	*23%*	*0%*	*0%*	*0%*

Impact Significance

11.18.4.15 The sensitivity of harbour porpoise to disturbance from piling activities has been assessed as **Low**, and the magnitude of the cumulative impact has been assessed as **Medium**. Therefore, the cumulative effect of disturbance from underwater noise is considered to be of **Minor** significance, which is **Not Significant** with respect to the EIA Regulations.

Cumulative Effects Assessment Underwater Noise Disturbance: Minke Whale

Sensitivity

11.18.4.16 Minke whales have been assessed as having a **Low** sensitivity to disturbance from pile driving activities. The same has been assumed here for disturbance from seismic airgun surveys as both sound sources are classified as low frequency broadband pulsed (LFBP) noise.

Magnitude

11.18.4.17 **Table 11-41** outlines the number of minke whales predicted to be disturbed at each project in each year. The data have been split by whether a quantitative impact assessment is available. There is considerably more certainty in the number of animals predicted to be disturbed from project-specific quantitative impact assessments. Therefore, the CEA results focus on projects with a quantitative impact assessment, while acknowledging that other projects are planned/expected.

11.18.4.18 There are several projects included in the CEA for minke whales where the available EIAs predicted no impact to minke whales (East Anglia One North, East Anglia Three, East Anglia Two, Norfolk Vanguard East, Norfolk Vanguard West, Dudgeon Extension and Sheringham Shoal Extension). This is because the baseline characterisations for these projects found very low densities, or no minke whales in the area, and they were scoped out of quantitative impact assessment.

11.18.4.19 Focusing on those projects for which a quantitative impact assessment is already available, there is expected to be a maximum disturbance to 1,250 minke whales in 2026 (6.2% MU, 12.2% UK MU) – two years before piling occurs at Salamander (**Table 11-41**).

11.18.4.20 In 2028, when Salamander is anticipated to be piling, there is expected to be disturbance to 863 minke whales (4.3% MU, 8.4% UK MU), assuming pile driving of anchors at Salamander occurs concurrently with pile driving at Hornsea Four, Hornsea Three and Rampion 2 (**Table 11-41**). Of this, Salamander is predicted to contribute 70% of the disturbance impact.

11.18.4.21 Including projects with no quantitative impact assessment available yet increases this 2028 total slightly to 918 minke whales (4.6% MU, 9.0% UK MU) (**Table 11-41**). Of this, Salamander is predicted to contribute 66% of the disturbance impact.

11.18.4.22 It is important to note that minke whales are seasonally present in the North Sea, and as such, these disturbance levels are representative of the realistic worst-case impacts during the summer months when minke whales are substantially more abundant. Impacts outside of the summer months will have significantly less of an impact to minke whales.

11.18.4.23 It is expected that disturbance from pile driving across multiple projects is likely to occur at a moderate frequency or intensity, affecting a moderate proportion of the minke whale population which has the potential to cause short- to medium-term changes in the population from baseline conditions[18]. Therefore, the magnitude has been assessed as **Medium**.

[18] Note: no population modelling has been conducted for this CEA due to a lack of detailed information on potential piling schedules across projects.

Table 11-41 Minke whale Cumulative Effects Assessment: potential disturbance from underwater noise

Project	Type	EIAR	2023	2024	2025	2026	2027	2028	2029	2030	2031
Salamander	FOWF	Y						603			
Green Volt	FOWF	Y				265	265				
Pentland	FOWF	Y				40					
Seagreen Alpha and Bravo	OWF	Y					71				
Moray West	OWF	Y	30	30							
Berwick Bank	OWF	Y				132	132				
Inch Cape	OWF	Y			543	543					
Neart Na Gaoithe	OWF	Y	77								
Hornsea Four	OWF	Y					46	46	46		
Hornsea Three	OWF	Y				208	208	208			
Rampion 2	OWF	Y					6	6			
Dogger Bank C	OWF	Y		62	62	62	62				
Sofia	OWF	Y		36							
Muir Mhòr	*FOWF*	*N*							*28*		
MarramWind	*FOWF*	*N*									*28*
Caledonia	*FOWF*	*N*						*7*			
Cenos	*FOWF*	*N*				*23*	*23*				
Seismic Airgun Survey	*SS*	*N*	*48*	*48*	*48*	*48*	*48*	*48*	*48*	*48*	*48*
RESULTS FOR PROJECTS WITH A QUANTITATIVE IMPACT ASSESSMENT AVAILABLE											
		TOTAL	**107**	**128**	**605**	**1250**	**790**	**863**	**46**	**0**	**0**
		% MU	**0.5%**	**0.6%**	**3.0%**	**6.2%**	**3.9%**	**4.3%**	**0.2%**	**0%**	**0.0%**
		% UK MU	**1.0%**	**1.2%**	**5.9%**	**12.2%**	**7.7%**	**8.4%**	**0.4%**	**0%**	**0.0%**
		Salamander contribution to total	**0%**	**0%**	**0%**	**0.0%**	**0%**	**70%**	**0%**	**0%**	**0.0%**
RESULTS FOR ALL PROJECTS											
		TOTAL	155	176	653	1,321	861	918	122	48	76
		% MU	0.8%	0.9%	3.2%	6.6%	4.3%	4.6%	0.6%	0.2%	0.4%
		% UK MU	1.5%	1.7%	6.3%	12.9%	8.4%	9.0%	1.2%	0.5%	0.7%
		Salamander contribution to total	0%	0%	0%	0.0%	0%	66%	0%	0%	0%

Impact Significance

11.18.4.24 The sensitivity of minke whales to disturbance from piling activities has been assessed as **Low**, and the magnitude of the cumulative impact has been assessed as **Medium**. Therefore, the cumulative effect of disturbance from underwater noise is considered to be of **Minor** significance, which is **Not Significant** with respect to the EIA Regulations.

Cumulative Effects Assessment Underwater Noise Disturbance: Bottlenose Dolphin

Sensitivity

11.18.4.25 Bottlenose dolphins have been assessed as having a **Low** sensitivity to disturbance from pile driving activities. The same has been assumed here for disturbance from seismic airgun surveys as both sound sources are classified as low frequency broadband pulsed (LFBP) noise.

Magnitude

11.18.4.26 **Table 11-45** outlines the number of bottlenose dolphins predicted to be disturbed at each project in each year. The data have been split by whether a quantitative impact assessment is available. There is considerably more certainty in the number of animals predicted to be disturbed from project-specific quantitative impact assessments. Therefore, the CEA results focuses on projects with a quantitative impact assessment, while acknowledging that other projects are planned/expected.

11.18.4.27 There are several projects included in the CEA for bottlenose dolphins where the available EIAs predicted no impact to bottlenose dolphins (East Anglia One North, East Anglia Three, East Anglia Two, Hornsea Three, Norfolk Vanguard East, Norfolk Vanguard West, Sofia, Dogger Bank C, Dudgeon Extension and Sheringham Shoal Extension). This is because the baseline characterisations for these projects found very low densities or no bottlenose dolphins in the area, and they were scoped out of quantitative impact assessment.

11.18.4.28 For most projects that did include bottlenose dolphins in the quantitative impact assessment, the predicted number of animals disturbed were not divided between the two MUs. Only two projects assessed in this CEA (Salamander and Pentland) assessed impacts to both the CES and GNS MUs separately. A total of four projects assessed the number of animals disturbed using a combined CES & GNS MU approach (including Salamander), whilst the remainder of the projects predicted the number of animals disturbed in either the CES MU or the GNS MU alone.

11.18.4.29 For projects with an EIAR available:

- The maximum impact to the CES MU alone is predicted to be in 2026 when Pentland, Berwick bank and Inch Cape are expected to be piling (**Table 11-42**). The assessment predicted disturbance to 132 bottlenose dolphins (58.9% CES MU) if all three projects pile on the same day (which is very highly unlikely). The impact to the CES MU alone in 2028 (when Salamander is expected to be piling) is from Salamander alone, predicting disturbance to 25 dolphins per piling day (11.2% CES MU).
- The maximum impact to the GNS MU alone is predicted to be in 2028 (when Salamander is expected to be piling), when only Salamander is piling, resulting in disturbance to 25 dolphins per piling day (11.2% CES MU) (**Table 11-43**).
- The maximum impact to the combined CES and GNS MUs is predicted to be in 2026 when Green Volt, Pentland, Berwick Bank and Inch Cape are expected to be piling (**Table 11-44**). The assessment predicted disturbance to 338 bottlenose dolphins (15.0% combined MU) if all projects pile on the same day (which is very highly unlikely). The impact to the combined GNS and CES MUs in 2028 (when Salamander is expected to be piling) is predicted to be 98 dolphins (4.4% combined MU) if Salamander and Hornsea Four both pile on the same day.

11.18.4.30 For projects with no quantitative impact assessment yet available, a combined CES and GNS MU approach was taken. The greatest number of bottlenose dolphins expected to be disturbed across all projects screened into the CEA is in 2026, with 369 individuals (16.4% combined MUs) anticipated to be disturbed across five offshore wind farm projects alongside an illustrative seismic airgun survey (**Table 11-45**).

11.18.4.31 It is expected that disturbance from pile driving across multiple projects is likely to occur at a moderate frequency or intensity, affecting a moderate proportion of the bottlenose dolphin population which has the potential to cause short- to medium-term changes in the population from baseline conditions[19]. Therefore, the magnitude has been assessed as **Medium**.

[19] Note: no population modelling has been conducted for this CEA due to a lack of detailed information on potential piling schedules across projects.

Table 11-42 Bottlenose dolphin Cumulative Effects Assessment: potential disturbance to the Coastal East Scotland Management Unit alone from underwater noise for projects with an Environmental Impact Assessment Report

Project	Type	EIAR	2023	2024	2025	2026	2027	2028	2029	2030	2031
Salamander	FOWF	Y						25			
Pentland	FOWF	Y				6					
Seagreen Alpha and Bravo	OWF	Y					3				
Moray West	OWF	Y	14	14							
Berwick Bank	OWF	Y				107	107				
Inch Cape	OWF	Y			19	19					
Neart Na Gaoithe	OWF	Y	2								
TOTAL			*16*	*14*	*19*	*132*	*110*	*25*	*0*	*0*	*0*
% MU (224)			*7.1%*	*6.3%*	*8.5%*	*58.9%*	*49.1%*	*11.2%*	*0.0%*	*0.0%*	*0.0%*
Salamander contribution to total			*0%*	*0%*	*0%*	*0%*	*0%*	*100%*	*0%*	*0%*	*0%*

Table 11-43 Bottlenose dolphin Cumulative Effects Assessment: potential disturbance to the Greater North Sea Management Unit alone from underwater noise for projects with an Environmental Impact Assessment Report

Project	Type	EIAR	2023	2024	2025	2026	2027	2028	2029	2030	2031
Salamander	FOWF	Y						59			
Pentland	FOWF	Y				2					
TOTAL			*0*	*0*	*0*	*2*	*0*	*59*	*0*	*0*	*0*
% MU			*0.0%*	*0.0%*	*0.0%*	*0.1%*	*0.0%*	*2.9%*	*0.0%*	*0.0%*	*0.0%*
% UK MU			*0.0%*	*0.0%*	*0.0%*	*0.1%*	*0.0%*	*3.1%*	*0.0%*	*0.0%*	*0.0%*
Salamander contribution to total			*0%*	*0%*	*0%*	*0%*	*0%*	*100%*	*0%*	*0%*	*0%*

Table 11-44 Bottlenose dolphin Cumulative Effects Assessment: potential disturbance to the combined Coastal East Scotland and Greater North Sea Management Units from underwater noise for projects with an Environmental Impact Assessment Report

Project	Type	EIAR	2023	2024	2025	2026	2027	2028	2029	2030	2031
Salamander	FOWF	Y						84			
Green Volt	FOWF	Y				204	204				
Pentland	FOWF	Y				8					
Seagreen Alpha and Bravo	OWF	Y					3				
Moray West	OWF	Y	14	14							
Berwick Bank	OWF	Y				107	107				
Inch Cape	OWF	Y			19	19					
Neart Na Gaoithe	OWF	Y	2								
Hornsea Four	OWF	Y					14	14	14		
TOTAL			*16*	*14*	*19*	*338*	*328*	*98*	*14*	*0*	*0*
% MU			*0.7%*	*0.6%*	*0.8%*	*15.0%*	*14.6%*	*4.4%*	*0.6%*	*0.0%*	*0.0%*
% UK MU			*0.8%*	*0.7%*	*0.9%*	*16.0%*	*15.6%*	*4.6%*	*0.7%*	*0.0%*	*0.0%*
Salamander contribution to total			*0%*	*0%*	*0%*	*0%*	*0%*	*86%*	*0%*	*0%*	*0%*

Table 11-45 Bottlenose dolphin Cumulative Effects Assessment: potential disturbance from underwater noise, assuming combined Coastal East Scotland and Greater North Sea Management Units and the inclusion of projects both with, and without, an Environmental Impact Assessment Report

Project	Type	EIAR	2023	2024	2025	2026	2027	2028	2029	2030	2031
Salamander	FOWF	Y						84			
Green Volt	FOWF	Y				204	204				
Pentland	FOWF	Y				8					

Project	Type	EIAR	2023	2024	2025	2026	2027	2028	2029	2030	2031
Seagreen Alpha and Bravo	OWF	Y					3				
Moray West	OWF	Y	14	14							
Berwick Bank	OWF	Y				107	107				
Inch Cape	OWF	Y			19	19					
Neart Na Gaoithe	OWF	Y	2								
Hornsea Four	OWF	Y					14	14	14		
Muir Mhòr	FOWF	N							21		
MarramWind	FOWF	N									21
Caledonia	FOWF	N						3			
Cenos	FOWF	N				21	21				
Seismic Airgun Survey	SS	N	10	10	10	10	10	10	10	10	10
RESULTS FOR ALL PROJECTS											
TOTAL			26	24	29	369	359	111	45	10	31
% MU			1.2%	1.1%	1.3%	16.4%	16.0%	4.9%	2.0%	0.4%	1.4%
% UK MU			1.2%	1.1%	1.4%	17.5%	17.0%	5.3%	2.1%	0.5%	1.5%
Salamander contribution to total			0%	0%	0%	0%	0%	76%	0%	0%	0%

Impact significance

11.18.4.32 The sensitivity of bottlenose dolphins to disturbance from piling activities has been assessed as **Low**, and the magnitude of the cumulative impact has been assessed as **Medium**. Therefore, the cumulative effect of disturbance from underwater noise is considered to be of **Minor** significance, which is **Not Significant** with respect to the EIA Regulations.

Cumulative Effects Assessment Underwater Noise Disturbance: White-beaked Dolphin

Sensitivity

11.18.4.33 White-beaked dolphins have been assessed as having a **Low** sensitivity to disturbance from pile driving activities. The same has been assumed here for disturbance from seismic airgun surveys as both sound sources are classified as low frequency broadband pulsed (LFBP) noise.

Magnitude

11.18.4.34 **Table 11-46** outlines the number of white-beaked dolphins predicted to be disturbed at each project in each year. The data have been split by whether a quantitative impact assessment is available. There is considerably more certainty in the number of animals predicted to be disturbed from project specific quantitative impact assessments. Therefore, the CEA results focuses on projects with a quantitative impact assessment, while acknowledging that other projects are planned/expected.

11.18.4.35 There are several projects included in the CEA for white-beaked dolphins where the available EIAs predicted no impact to white-beaked dolphins (Moray West, East Anglia One North, East Anglia Three, East Anglia Two, Norfolk Vanguard East, Norfolk Vanguard West, Rampion 2, Dudgeon Extension and Sheringham Shoal Extension). This is because the baseline characterisations for these projects found very low densities, or no white-beaked dolphins in the area, and they were scoped out of quantitative impact assessment.

11.18.4.36 Focusing on those projects for which a quantitative impact assessment is already available, there is expected to be disturbance to 5,800 white-beaked dolphins in 2028 (13.2% MU, 17.0% UK MU), assuming pile driving of anchors at Salamander occurs concurrently with pile driving at East Anglia One North, East Anglia Two, Hornsea Four, Hornsea Three, Norfolk Vanguard East, and Rampion 2, (**Table 11-46**). Of this, Salamander is predicted to contribute 98% of the disturbance impact.

11.18.4.37 Including projects with no quantitative impact assessment available yet increases this slightly to 5,973 white-beaked dolphins (13.6% MU, 17.6% UK MU) (**Table 11-41**). Of this, Salamander is predicted to contribute 96% of the disturbance impact.

11.18.4.38 It is expected that disturbance from pile driving across multiple projects is likely to occur at a moderate frequency or intensity, affecting a moderate proportion of the white-beaked dolphin population which has the potential to cause short- to medium-term changes in the population from baseline conditions[20]. Therefore, the magnitude has been assessed as **Medium**.

Table 11-46 White-beaked dolphins Cumulative Effects Assessment: potential disturbance from underwater noise

Project	Type	EIAR	2023	2024	2025	2026	2027	2028	2029	2030	2031
Salamander	FOWF	Y						5697			
Green Volt	FOWF	Y				1665	1665				
Pentland	FOWF	Y				337					
Seagreen Alpha and Bravo	OWF	Y					448				
Berwick Bank	OWF	Y				830	830				

[20] Note: no population modelling has been conducted for this CEA due to a) a lack of detailed information on potential piling schedules across projects and b) iPCoD model for white-beaked dolphins.

Project	Type	EIAR	2023	2024	2025	2026	2027	2028	2029	2030	2031
Inch Cape	OWF	Y			51	51					
Neart Na Gaoithe	OWF	Y	478								
Hornsea Four	OWF	Y					85	85	85		
Hornsea Three	OWF	Y				18	18	18			
Dogger Bank C	OWF	Y		21	21	21					
Sofia	OWF	Y		3							
Muir Mhòr	FOWF	N							172		
MarramWind	FOWF	N									172
Caledonia	FOWF	N						15			
Cenos	FOWF	N				172	172				
Seismic Airgun Survey	SS	N	158	158	158	158	158	158	158	158	158
RESULTS FOR PROJECTS WITH A QUANTITATIVE IMPACT ASSESSMENT AVAILABLE											
TOTAL			**478**	**24**	**72**	**2,922**	**3,046**	**5,800**	**85**	**0**	**30**
% MU			**1.1%**	**0.1%**	**0.2%**	**6.6%**	**6.9%**	**13.2%**	**0.2%**	**0.0%**	**0.0%**
% UK MU			**1.4%**	**0.1%**	**0.2%**	**8.6%**	**9.0%**	**17.0%**	**0.2%**	**0.0%**	**0.0%**
Salamander contribution to total			**0%**	**0%**	**0%**	**0%**	**0%**	**98%**	**0%**	**0%**	**0%**
RESULTS FOR ALL PROJECTS											
TOTAL			636	182	230	3,596	3,720	5,973	415	158	330
% MU			1.4%	0.4%	0.5%	8.2%	8.5%	13.6%	0.9%	0.4%	0.8%
% UK MU			1.9%	0.5%	0.7%	10.6%	10.9%	17.6%	1.2%	0.5%	1.0%
Salamander contribution to total			0%	0%	0%	0%	0%	95%	0%	0%	0%

Impact Significance

11.18.4.39 The sensitivity of white-beaked dolphins to disturbance from piling activities has been assessed as **Low**, and the magnitude of the cumulative impact has been assessed as **Medium**. Therefore, the cumulative effect of disturbance from underwater noise is considered to be of **Minor** significance, which is **Not Significant** with respect to the EIA Regulations.

Cumulative Effects Assessment Underwater Noise Disturbance: Harbour Seal

Sensitivity

11.18.4.40 Harbour seals have been assessed as having a **Medium** sensitivity to disturbance from pile driving activities. The same has been assumed here for disturbance from seismic airgun surveys as both sound sources are classified as low frequency broadband pulsed (LFBP) noise.

Magnitude

11.18.4.41 The harbour seal CEA screened in only those projects within the East Scotland MU, therefore the number of projects included is significantly less than presented for cetacean species.

11.18.4.42 **Table 11-47** outlines the number of harbour seals predicted to be disturbed at each project in each year. The data have been split by whether a quantitative impact assessment is available (the Green Volt ES and Seagreen Alpha and Bravo ES concluded no piling impacts to harbour seals and so these have been screened out). There is considerably more certainty in the number of animals predicted to be disturbed from project-specific quantitative impact assessments. Therefore, the CEA results focuses on projects with a quantitative impact assessment, while acknowledging that other projects are planned/expected.

11.18.4.43 Focusing on those projects for which a quantitative impact assessment is already available, there is expected to be disturbance to 20 harbour seals in 2026 (5.5% MU). Assuming pile driving of anchors occurs at Salamander in 2028, it is predicted that 3 harbour seals will be disturbed (0.8% MU) (**Table 11-47**). Of this, Salamander is predicted to contribute 100% of the disturbance impact.

11.18.4.44 It is expected that disturbance from pile driving across multiple projects could occur at low frequency or intensity, with temporary impacts to only a small proportion of the population, such that there is unlikely to be a population level effect[21]. Therefore, the magnitude has been assessed as **Low**.

Table 11-47 Harbour seal Cumulative Effects Assessment: potential disturbance from underwater noise

Project	Type	ES?	2023	2024	2025	2026	2027	2028	2029	2030	2031
Salamander	FOWF	Y						3			
Berwick Bank	OWF	Y				3	3				
Inch Cape	OWF	Y			17	17					
Neart Na Gaoithe	OWF	Y	8								
Muir Mhòr	*FOWF*	*N*							*3*		
Cenos	*FOWF*	*N*				*3*	*3*				
Seismic Airgun Survey	*SS*	*N*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*	*15*

[21] Note: no population modelling has been conducted for this CEA due to a lack of detailed information on potential piling schedules across projects.

Project	Type	ES?	2023	2024	2025	2026	2027	2028	2029	2030	2031
RESULTS FOR PROJECTS WITH A QUANTITATIVE IMPACT ASSESSMENT AVAILABLE											
		TOTAL	**8**	**0**	**17**	**20**	**3**	**3**	**0**	**0**	**0**
		% MU	**2.2%**	**0.0%**	**4.7%**	**5.5%**	**0.8%**	**0.8%**	**0.0%**	**0.0%**	**0.0%**
		Salamander contribution to total	**0%**	**0%**	**0%**	**0%**	**0%**	**100%**	**0%**	**0%**	**0%**
RESULTS FOR ALL PROJECTS											
		TOTAL	*23*	*15*	*32*	*38*	*21*	*18*	*18*	*15*	*15*
		% MU	*6.3%*	*4.1%*	*8.8%*	*10.4%*	*5.8%*	*4.9%*	*4.9%*	*4.1%*	*4.1%*
		Salamander contribution to total	*0%*	*0%*	*0%*	*0%*	*0%*	*17%*	*0%*	*0%*	*0%*

Impact Significance

11.18.4.45 The sensitivity of harbour seals to disturbance from piling activities has been assessed as **Medium**, and the magnitude of the cumulative impact has been assessed as **Low**. Therefore, the cumulative effect of disturbance from underwater noise is considered to be of **Minor** significance, which is **Not Significant** with respect to the EIA Regulations.

Cumulative Effects Assessment Underwater Noise Disturbance: Grey Seal

Sensitivity

11.18.4.46 Grey seals have been assessed as having a **Negligible** sensitivity to disturbance from pile driving activities. The same has been assumed here for disturbance from seismic airgun surveys as both sound sources are classified as low frequency broadband pulsed (LFBP) noise.

Magnitude

11.18.4.47 The grey seal CEA screened in only those projects within the East Scotland MU, therefore the number of projects included is significantly less than presented for cetacean species.

11.18.4.48 **Table 11-48** outlines the number of grey seals predicted to be disturbed at each project in each year. The data have been split by whether a quantitative impact assessment is available. There is considerably more certainty in the number of animals predicted to be disturbed from project-specific quantitative impact assessments. Therefore, the CEA results focuses on projects with a quantitative impact assessment, while acknowledging that other projects are planned/expected.

11.18.4.49 Focusing on those projects for which a quantitative impact assessment is already available, there is expected to be disturbance to 2,524 grey seals in 2026 (23.4% East Scotland MU). Assuming pile driving of anchors at Salamander occurs in 2028, 1,395 grey seals are anticipated to be disturbed (**Table 11-48**; 12.9% MU). In 2028, Salamander is predicted to contribute 100% of the disturbance impact.

11.18.4.50 It is expected that disturbance from pile driving across multiple projects is likely to occur at a moderate frequency or intensity, affecting a moderate proportion of the grey seal population which has the potential to cause short- to medium-term changes in the population from baseline conditions[22]. Therefore, the magnitude has been assessed as **Medium**.

[22] Note: no population modelling has been conducted for this CEA due to a) a lack of detailed information on potential piling schedules across projects and b) iPCoD model for white-beaked dolphins.

Table 11-48 Grey seal Cumulative Effects Assessment: potential disturbance from underwater noise

Project	Type	EIAR	2023	2024	2025	2026	2027	2028	2029	2030	2031
Salamander	FOWF	Y						1395			
Green Volt	FOWF	Y				336	336				
Seagreen Alpha and Bravo	OWF	Y					42				
Berwick Bank	OWF	Y				1358	1358				
Inch Cape	OWF	Y			830	830					
Neart Na Gaoithe	OWF	Y	821								
Muir Mhòr	*FOWF*	*N*							*95*		
Cenos	*FOWF*	*N*				*95*	*95*				
Seismic Airgun Survey	*SS*	*N*	*434*	*434*	*434*	*434*	*434*	*434*	*434*	*434*	*434*
RESULTS FOR PROJECTS WITH A QUANTITATIVE IMPACT ASSESSMENT AVAILABLE											
TOTAL			821	0	830	2,524	1,736	1,395	0	0	0
% MU			7.6%	0%	7.7%	23.4%	16.1%	12.9%	0.0%	0.0%	0.0%
Salamander contribution to total			0%	0%	0%	0%	0%	100%	0%	0%	0%
RESULTS FOR ALL PROJECTS											
TOTAL			*1,255*	*434*	*1,264*	*3,053*	*2,265*	*1,829*	*529*	*434*	*434*
% MU			*11.6%*	*4.0%*	*11.7%*	*28.3%*	*21.0%*	*17.0%*	*4.9%*	*4.0%*	*4.0%*
Salamander contribution to total			*0%*	*0%*	*0%*	*0%*	*0%*	*76%*	*0%*	*0%*	*0%*

Impact Significance

11.18.4.51 The sensitivity of grey seals to disturbance from piling activities has been assessed as **Negligible**, and the magnitude of the cumulative impact has been assessed as **Medium**. Therefore, the cumulative effect of disturbance from underwater noise is considered to be of **Negligible** significance, which is **Not Significant** with respect to the EIA Regulations.

11.18.5 Cumulative Effects Assessment: Indirect/Secondary Entanglement

11.18.5.1 In addition to the Salamander Project, a total of nine floating offshore wind farms were included in the marine mammal CEA short list for the impacts of indirect / secondary entanglement. **Table 11-49** These include those floating projects considered for underwater construction noise (Table 11-39) in addition to two currently operational floating projects. As for the Project alone, only a qualitative assessment for cumulative entanglement risks is conducted at this time, as floating offshore wind technologies remain in their infancy and the impacts of indirect/secondary entanglement as a result of the presence of floating offshore wind arrays are still relatively unknown.

Table 11-49 Floating Offshore Wind Projects included in the qualitative Cumulative Effects Assessment for indirect/secondary entanglement risks.

Project	ES / EIAR available?
Hywind Scotland Pilot Park*	Yes
Kincardine Offshore Wind Farm*	Yes
Salamander	yes
Green Volt	yes

Project	ES / EIAR available?
Pentland	yes
Muir Mhòr	no
MarramWind	no
Caledonia	no
Cenos	no

** Operational projects*

11.18.5.2 Risks of entanglement can be considered as both primary and secondary entanglement risks. Primary entanglement risks are the risk of marine mammals becoming directly entangled with the mooring lines and dynamic cables within the floating offshore wind array areas, and secondary entanglement risks are the risks of marine mammals becoming entangled in marine debris which has become caught on the lines and cables within floating offshore wind array areas. Injury from primary entanglement was not screened into this CEA as it was assessed as of negligible significance at a Salamander Project level.

11.18.5.3 Although the risks of indirect/secondary entanglement have often been assessed as greater than that of primary entanglement, it is still unclear what the risk levels of indirect / secondary entanglement within floating offshore wind array areas actually are. The level of risk will be influenced by the number of WTGs, along with the type of mooring structure utilised by a specific floating offshore wind farm, which is often dictated by the oceanographic and geological conditions at the project site location. Given that there are few floating offshore wind farm projects in operation across the UK and globally, it is difficult to ascertain which floating array mooring structures are likely to contribute to increased secondary entanglement risks, if any. The density and type of derelict fishing gear in the area will also influence the probability of entanglement. As noted in **Section 11.14.3**, available evidence indicates a moderate to low relative density of fishing-related items among seabed litter in offshore waters off the east coast of Scotland (where the majority of relevant projects occur (**Table 11-49**)) compared to elsewhere in European waters, in addition to low relative creel fishing effort.

11.18.5.4 As entanglement can potentially result in death, marine mammal sensitivity to indirect/secondary entanglement is assessed as **High.** As is planned for the Salamander Project, it is anticipated that as a part of the embedded mitigations of most early floating offshore wind farm projects, mooring lines and dynamic inter-array cables will be inspected during the operation and maintenance phase to confirm the structural integrity of the cable systems. During these inspections, the presence of marine debris can be identified and subsequent actions can be taken to remove any such debris, where required. At a Project-alone level, a low magnitude was conservatively assessed for indirect/secondary entanglement of marine mammals. Considering the anticipated presence of embedded mitigation and low probability of impact, at a cumulative level, indirect/secondary entanglement of marine mammals is also assessed as of **Low** magnitude.

11.18.5.5 As the sensitivity of all marine mammals to secondary/indirect entanglement has been assessed as **High**, and the magnitude of the impact of secondary / indirect has been assessed as **Low**, the cumulative effect of secondary/indirect entanglement is considered to be of **Minor** significance, which is **Not Significant** with respect to the EIA Regulations.

11.19 Assessment of Impacts Cumulatively with the Onshore Development

11.19.1.1 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.

11.19.1.2 The main components of the Onshore Development which have the potential to disturb receptors of Marine Mammals include trenchless operations at the Landfall.

11.19.1.3 The impacts associated with trenchless operations at the Landfall with potential to impact Marine Mammal receptors (i.e. below MHWS) have been assessed in **Section 11.13**.

11.19.1.4 It is not anticipated that there will be any additional impacts from the Onshore Development on Marine Mammal receptors as all other activities from the Onshore Development are fully terrestrial.

11.20 Transboundary Effects

11.20.1.1 Transboundary effects are defined as effects that extend into other European Economic Area (EEA) states. These may occur from the Salamander Project alone, or cumulatively with other plans or projects. This assessment will consider the potential for transboundary effects based on the significance of effect outcomes for the Salamander Project.

11.20.1.2 There may be behavioural disturbance or displacement of marine mammals from the Offshore Development as a result of underwater noise. Behavioural disturbance resulting from underwater noise during construction could occur over large ranges (tens of kilometres) and therefore there is the potential for transboundary effects to occur where subsea noise arising from the Offshore Development could extend into waters of other EEA states. However, given the location of the Offshore Development relative to the nearest waters of other states – over 160 km to the UK/Norway median line – the potential for disturbance of animals in waters of other EEA states is considered to be small.

11.20.1.3 In addition, any transboundary impacts that do occur as a result of the Offshore Development are predicted to be short-term and intermittent, with the recovery of marine mammal populations to affected areas following the completion of construction activities. For example, disturbance to prey species from loss of fish spawning and nursery habitat and suspended sediments and deposition may occur. However, the effects of reduction in prey availability are predicted to be limited in extent to within a few kilometres from Salamander and are therefore not predicted to extend into the waters of other EEA states. Therefore, the impact of a reduction in prey ability will not lead to a significant effect.

11.20.1.4 Therefore, the magnitude of the impact has been assessed as **Negligible.** The sensitivity of receptors to behavioural disturbance from various project activities, has been assessed as varying by species between **Negligible** and **Medium** (see summary in **Table 11-38**). Therefore, the significance of all impacts leading to transboundary effects is concluded to be **Negligible** so **Not Significant** in terms of the EIA regulations.

11.21 Inter-related Effects

11.21.1.1 The following assessment considers the potential for inter-related effects to arise across the three project phases (i.e. project lifetime effects during construction, operations and maintenance, and decommissioning), as well as the interaction of multiple effects on a receptor (i.e. receptor-led effects).

11.21.1.2 Inter-relationships are considered to be the impacts and associated effects of different aspects of the proposal on the same receptor. It is important to note, however, that the inter-related effects assessment considers only effects produced by the elements of the Offshore Development and not from other projects, which are considered within **Section 11.18**. In addition, the significance of the inter-related effects incorporates qualitative and, where reasonably possible, quantitative assessments undertaken above. The following assessment does not assign significance of effect for inter-related effects; rather, any inter-related effects that may be of greater significance than the individual effects acting in isolation on a given receptor are identified and discussed.

11.21.1.3 A description of the likely inter-related effects and receptor-led effects arising from the Offshore Development on marine mammals is provided below, and each discussed in turn.

11.21.1.4 A description of the likely inter-related effects arising from the Offshore Development on marine mammals is provided below, and each discussed in turn.

Disturbance from Underwater Noise

11.21.1.5 Disturbance to marine mammals from underwater noise shall be present throughout each of the construction, operations and maintenance, and decommissioning phases of the Salamander project. This results in a potential project lifetime, inter-related effect.

11.21.1.6 Disturbance to marine mammals shall primarily be caused by piling activities, should piled foundations be used during the construction phase, but shall also be present as a result of:

- During construction:
  - Geophysical surveys;
  - UXO clearance;
  - Vessel activity;
  - Construction activities such as dredging and/or drilling;
- During operations & maintenance:
  - Operational floating WTGS;
  - Geophysical surveys;
  - Vessel activity;
- During decommissioning:
  - Removal of structure;
  - Geophysical surveys; and
  - Vessel activity.

11.21.1.7 The implementation of a UXO MMMP for UXO clearances, a piling MMMP for piling activities, and a VMP, shall ensure that impacts related to disturbance as a result of underwater noise shall remain **Negligible** to **Low** in magnitude, and therefore **Not Significant** across all three phases of the Salamander Project. For each of the potentially noisy activities, across each project phase, the impacts were assessed as being of **Negligible** significance (which is **Not Significant** with respect to the EIA Regulations). It is also noted that while some level of disturbance may occur over the lifetime of the Salamander Project, the magnitude of such disturbance over a longer time period will be far less than during the construction phase.

11.21.1.8 As such, the significance of the inter-related effects of each project phase are not anticipated to increase beyond those already assessed, and the inter-related effects associated with disturbance from underwater noise are assessed as **Negligible** which is **Not Significant** with respect to the EIA Regulations.

Disturbance from Vessel Activity in the Salamander Offshore Array Area

11.21.1.9 The risk of marine mammal disturbance as a result of vessels will be present throughout each of the construction, operations and maintenance, and decommissioning phases of the Salamander Project. This results in a potential project lifetime, inter-related effect.

11.21.1.10 However, the risk of disturbance from vessels to marine mammals was assessed as being of negligible significance (which is **Not Significant** with respect to the EIA Regulations) throughout each of the construction, operations & maintenance, and decommissioning phases of the Salamander Project. In addition, the implementation of a VMP shall ensure that impacts related to vessel activity shall remain low in magnitude, and therefore **Not Significant** across all three phases of the Salamander Project.

11.21.1.11 As such, the significance of the inter-related effects of each project phase are not anticipated to increase beyond those already assessed, and the inter-related effects associated with vessel disturbance are assessed as **Negligible (Not Significant)**.

Changes to Marine Mammal Prey Species

11.21.1.12 Impacts and changes to marine mammal prey species have been assessed as part of each of the construction, operations and maintenance, and decommissioning phases of the Salamander Project. Thus, there is the potential for project lifetime, inter-related effects associated with impacts on marine mammal prey items.

11.21.1.13 However, the impacts on marine mammal prey items was assessed as being of negligible significance (which is **Not Significant** with respect to the EIA Regulations) throughout each of the construction, operations & maintenance, and decommissioning phases of the Salamander Project.

11.21.1.14 As such, the significance of the inter-related effects of each project phase are not anticipated to increase beyond those already assessed, and the inter-related effects associated with indirect impacts on marine mammal prey items are assessed as **Negligible (Not Significant)**.

11.21.2 Receptor-led effects assessment

11.21.2.1 Receptor-led effects occur as a result of the inter-related effects acting in combination with one another over the same spatial and temporal scales. Where this occurs, the spatial or temporal interaction of effects from multiple pathways potentially create a more significant effect on a receptor than if just assessed in isolation.

11.21.2.2 A description of the likely receptor-led effects arising from the Offshore Development on marine mammals is provided below, and each discussed in turn.

Combination of Disturbance from Underwater Noise, the Presence of Vessels and Indirect Impacts on Marine Mammal Prey Items

11.21.2.3 When acting in combination with one another, the greatest potential for spatial and temporal interactions arising from the Offshore Development are associated with underwater noise impacts and the presence of vessels. Each of the individual impacts (i.e., disturbance from piling activities and disturbance from vessel activity) were assessed as being of **Negligible** (**Not Significant**) due to the implementation of embedded mitigation measures.

11.21.2.4 Although piling activities and vessel presence within the Offshore Development Area could occur at the same time, it is noted that in some instances, the presence of vessels prior to piling is likely to disturb some marine mammal species (Benhemma-Le Gall *et al.* 2023), and thus limit the amount of disturbance and/or displacement some marine mammal species may experience as a result of piling activities. In addition, underwater noise arising from piling activities has the potential to disturb animals to an extent which reduces the potential for vessel interactions.

11.21.2.5 As such, the significance of the receptor-led effects is not anticipated to increase beyond those already assessed, and are assessed as **Negligible (Not Significant)**.

11.21.3 Summary

11.21.3.1 The effects to marine mammals from the above impacts have been assessed as Negligible non-significant. Overall, no inter-relationships have been identified where an accumulation of residual impacts on marine mammals and the relationship between those impacts gives rise to a need for additional mitigation beyond the embedded mitigation already considered. The impact of inter-relationships between marine mammals and disturbance from underwater noise, vessel disturbance, and changes to prey species has been assessed as **Not Significant**.

11.22 Conclusion and Summary

11.22.1.1 This chapter has assessed the potential effects on marine mammal receptors arising from the Offshore Development of the Salamander Project. The range of potential impacts and associated effects considered has been informed by scoping responses, as well as reference to existing policy and guidance. The impacts considered include those brought about directly (e.g., underwater noise impacts during construction, operation and decommissioning of the Offshore Development), as well as indirectly (e.g., impacts on prey species). Potential impacts considered in this chapter, alongside any mitigation and residual effects, are summarised in **Table 11-38**.

11.22.1.2 The impacts on relevant receptors from all stages of the Salamander Project were assessed, including impacts from underwater noise (geophysical surveys, piling, UXO clearance and other construction activities), vessel disturbance, and indirect impacts on prey species.

11.22.1.3 Throughout the construction, operation and decommissioning phases, all impacts assessed were found to have either negligible, or minor effects on marine mammal receptors within the Study Area (i.e., **Not Significant** in EIA terms). The assessment of cumulative impacts from the Salamander Project and other developments and activities, including offshore wind farms, concluded that the effects of any cumulative impacts would be of **Negligible** to **Minor** (**Not Significant)** in EIA terms.

11.23 References

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11.24 Appendix 1: Limitations and Assumptions

11.24.1.1 There are uncertainties relating to the underwater noise modelling and impact assessment for Salamander, which are apply across all comparable applications of the approaches described here. Broadly, these relate to predicting exposure of animals to underwater noise, predicting the response of animals to underwater noise, and predicting potential population consequences of disturbance from underwater noise.

11.24.1.2 The following limitations and assumptions have been identified for the Marine Mammal chapter:

- Permanent threshold shift (PTS) onset assumptions: whereby the proportion of the marine mammal management units impacted by construction, operational, and decommissioning activities; the ability to predict the exposure of animals to underwater noise, as well as in predicting the response to that exposure; and, the prediction of the cumulative PTS impact ranges all have uncertainties.
- Uncertainties relating to the ability to predict the responses of animals to underwater noise and the number of animals potentially exposed to levels of noise that may cause.
- Uncertainty associated with the prediction of response for marine mammal receptors to underwater noise arising from piling and other construction activities.
- Uncertainty associated with the duration of the impact(s).
- Limitations associated with temporary threshold shifts (TTS).
- Limitations in population modelling to assess population level consequences of disturbance.

11.24.1.3 Further detail of such uncertainty is set out below.

11.24.1 PTS-onset Limitations and Assumptions

11.24.1.1 There are no empirical data on the threshold for auditory injury in the form of PTS onset for marine mammals. Therefore, PTS onset thresholds are estimated based on extrapolating from TTS onset thresholds. For pulsed noise, such as piling, NOAA have set the onset of TTS at the lowest level that exceeds natural recorded variation in hearing sensitivity (6 dB), and assumes that PTS occurs from exposures resulting in 40 dB or more of TTS measured approximately four minutes after exposure.

Proportion impacted

11.24.1.2 It is important to note that it is expected that only 18-19% of animals are predicted to actually experience PTS at the PTS-onset threshold level. This was the approach adopted by Donovan *et al.* (2017) to develop their dose response function implemented into the SAFESIMM (Statistical Algorithms For Estimating the Sonar Influence on Marine Megafauna) model, based on the data presented in Finneran *et al.* (2005). Therefore, where PTS-onset ranges are provided, it is not expected that all individuals within that range will experience PTS. The number of animals predicted to be within PTS-onset ranges are precautionary, as this assessment assumes that all animals within the PTS-onset range are impacted.

Exposure to noise

11.24.1.3 There are uncertainties relating to the ability to predict the exposure of animals to underwater noise, as well as in predicting the response to that exposure. These uncertainties relate to a number of factors: the ability to predict the level of noise that animals are exposed to, particularly over long periods of time; the ability to predict the numbers of animals affected, and the ability to predict the individual and ultimately population consequences of exposure to noise. These are explored in further detail in the paragraphs below.

11.24.1.4 The propagation of underwater noise is relatively well understood and modelled using standard methods. However, there are uncertainties regarding the amount of noise actually produced by each pulse at source and how the pulse characteristics change with range from the source. There are also uncertainties regarding the position of receptors in relation to received levels of noise, particularly over time, and understanding how the position of receptors in the water column may affect received level. Noise monitoring is not always carried out at distances relevant to the ranges predicted for effects on marine mammals, so effects at greater distances remain un-validated in terms of actual received levels. The extent to which ambient noise and other anthropogenic sources of noise may mask signals from the offshore wind farm construction are not specifically addressed. The dose-response functions for porpoise include behavioural responses at noise levels down to 120 dB SEL_{ss} which may be indistinguishable from ambient noise at the ranges these levels are predicted.

Cumulative PTS

11.24.1.5 The cumulative sound exposure level (SEL_{cum}) is energy based and is a measure of the accumulated sound energy an animal is exposed to over an exposure period. An animal is considered to be at risk of experiencing "cumulative PTS" if the SEL_{cum} exceeds the energy based threshold. The calculation of SEL_{cum} is undertaken with frequency-weighted sound levels, using species group-specific weighing functions to reflect the hearing sensitivity of each functional hearing group. To assess the risk of cumulative PTS, it is necessary to make assumptions on how animals may respond to noise exposure, since any displacement of the animal relative to the noise source will affect the sound levels received. For this assessment, it was assumed that animals would flee from the pile foundation at the onset of piling. A fleeing animal model was therefore used to determine the cumulative PTS impact ranges, to determine the minimum distance to the pile site at which an animal can start to flee, without the risk of experiencing cumulative PTS.

11.24.1.6 There is much more uncertainty associated with the prediction of the cumulative PTS impact ranges than with those for the instantaneous PTS. One reason is that the sound levels an animal receives, and which are cumulated over a whole piling sequence are difficult to predict over such long periods of time, as a result of uncertainties about the animal's (responsive) movement in terms of its changing distance to the sound source and the related speed, and its position in the water column.

11.24.1.7 Another reason is that the prediction of the onset of PTS (which is assumed to be at the SEL_{cum} threshold values provided by Southall *et al.* (2019) is determined with the assumptions that:

- The amount of sound energy an animal is exposed to within 24 hours will have the same effect on its auditory system, regardless of whether it is received all at once (i.e., with a single bout of sound) or in several smaller doses spread over a longer period (called the equal-energy hypothesis); and
- The sound keeps its impulsive character, regardless of the distance to the sound source.

11.24.1.8 However, in practice:

- there is a recovery of a threshold shift caused by the sound energy if the dose is applied in several smaller doses (e.g., between pulses during pile driving or in piling breaks) leading to an onset of PTS at a higher energy level than assumed with the given SEL_{cum} threshold; and
- pulsed sound loses its impulsive characteristics while propagating away from the sound source, resulting in a slower shift of an animal's hearing threshold than would be predicted for an impulsive sound.

11.24.1.9 Both assumptions, therefore, lead to a conservative determination of the impact ranges and are discussed in further detail in the sections below.

11.24.1.10 Modelling the SEL_{cum} impact ranges of PTS with a 'fleeing animal' model, as is typical in noise impact assessments, are subject to both above-mentioned uncertainties and the result is a highly precautionary prediction of impact ranges. As a result of these and the uncertainties on animal movement, model parameters, such as swim speed, are generally highly conservative and, when considered across multiple parameters, this precaution is compounded therefore the resulting predictions are very precautionary and very unlikely to be realised.

Equal energy hypothesis

11.24.1.11 The equal-energy hypothesis assumes that exposures of equal energy are assumed to produce equal amounts of noise-induced threshold shift, regardless of how the energy is distributed over time. However, a continuous and an intermittent noise exposure of the same SEL will produce different levels of TTS (Ward 1997). Ward (1997) highlights that the same is true for impulsive noise, giving the example of simulated gun fires of the same SEL_{cum} exposed to human, where 30 impulses with an SPL_{peak} of 150 dB re 1m Pa result in a TTS of 20 dB, while 300 impulses of a respectively lower SPL_{peak} did not result in any TTS.

11.24.1.12 Finneran (2015) showed that several marine mammal studies have demonstrated that the temporal pattern of the exposure does in fact affect the resulting threshold shift (e.g., Kastak *et al.* 2005, Mooney *et al.* 2009, Finneran *et al.* 2010, Kastelein *et al.* 2013a). Intermittent noise allows for some recovery of the threshold shift in between exposures, and therefore recovery can occur in the gaps between individual pile strikes and in the breaks in piling activity, resulting in a lower overall threshold shift, compared to continuous exposure at the same SEL. Kastelein *et al.* (2013a) showed that, for seals, the threshold shifts observed did not follow the assumptions made in the guidance regarding the equal-energy hypothesis. The threshold shifts observed were more similar to the hypothesis presented in Henderson *et al.* (1991) whereby hearing loss induced due to noise does not solely depend upon the total amount of energy, but on the interaction of several factors such as the level and duration of the exposure, the rate of repetition, and the susceptibility of the animal. Therefore, the equal-energy hypothesis assumption behind the SEL_{cum} threshold is not valid, and as such, models will overestimate the level of threshold shift experienced from intermittent noise exposures.

11.24.1.13 Another detailed example is the study of (Kastelein *et al.* 2014), where a harbour porpoise was exposed to a series of 1-2 kHz sonar down-sweep pulses of 1-second duration of various combinations, with regard to received sound pressure level, exposure duration and duty cycle (% of time with sound during a broadcast) to quantify the related threshold shift. The porpoise experienced a 6 – 8 dB lower TTS when exposed to sound with a duty cycle of 25% compared to a continuous sound. A one second silent period in between pulses resulted in a 3 to 5 dB lower TTS compared to a continuous sound (**Figure 11-21**).

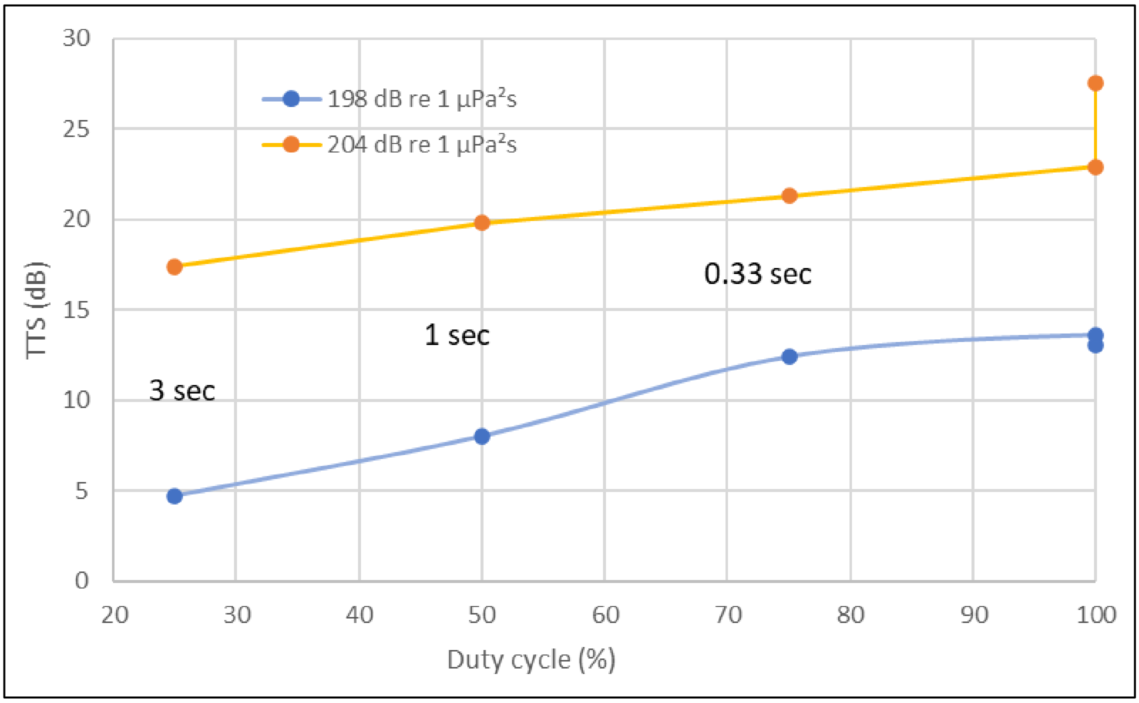

Figure 11-21 Temporary threshold shift elicited in a harbour porpoise by a series of 1-2 kHz sonar down-sweeps of 1 second duration with varying duty cycle and a constant SEL_{cum} of 198 and 204 dB re1 µPa²s, respectively. Also labelled is the corresponding 'silent period' in-between pulses. Data from Kastelein *et al.* (2014).

11.24.1.14 Kastelein *et al.* (2015b) showed that the 40 dB hearing threshold shift (the PTS-onset threshold) for harbour porpoise is expected to be reached at different SEL_{cum} levels depending on the duty cycle: for a 100% duty cycle, the 40 dB hearing threshold shift is predicted to be reached at a SEL_{cum} of 196 dB re 1 µPa²s, but for a 10% duty cycle, the 40 dB hearing threshold shift is predicted to be reached at a SEL_{cum} of 206 dB re 1 µPa²s (thus resulting in a 10 dB re 1 µPa²s difference in the threshold).

11.24.1.15 Pile strikes are relatively short signals; the signal duration of pile strikes may range between 0.1 seconds (De Jong and Ainslie 2008) and approximately 0.3 seconds (Dähne *et al.* 2017) measured at a distance of 3.3 km to 3.6 km. Duration will however increase with increasing distance from the pile site.

11.24.1.16 For the pile driving at the Offshore Development, the soft start is 3 blows/min and the ramp-up is 30 blows/min. Assuming a signal duration of around 0.5 seconds for a pile strike, the soft start has been an 2.5% duty cycle (0.5 seconds pulse followed by 19.5 seconds silence) and the ramp-up has been a 25% duty cycle (0.5 second pulse followed by 1.5 second silence). In the study of Kastelein *et al.* (2014), a silent period of 3 seconds corresponds to a duty cycle of 25%. The reduction in TTS at a duty cycle of 25% is 5.5 – 8.3 dB. Assuming similar effects to the hearing system of marine mammals in the OAA, the PTS-onset threshold would be expected to be around 2.4 dB higher than that proposed by Southall *et al.* (2019) and used in the current assessment, as reasoned in the following section.

11.24.1.17 Southall *et al.* (2009) calculates the PTS-onset thresholds based on the assumption that a TTS of 40 dB will lead to PTS, and that an animal's hearing threshold will shift by 2.3 dB per dB SEL received from an impulsive sound. This means, if the same SEL elicits a ≥5.5 dB lower TTS at 25% duty cycle compared to 100% duty cycle, to elicit the same TTS as a sound of 100% duty cycle, a ≥2.4 dB higher SEL is needed with a

25% duty cycle than with a 100% duty cycle. The threshold at which PTS-onset is likely is therefore, expected to be a minimum of 2.4 dB higher than the PTS-onset threshold proposed by Southall *et al.* (2019).

11.24.1.18 If a 2 or 3 dB increase in the PTS-threshold is assumed, then this can make a significant difference to the maximum predicted impact range for cumulative PTS. **Table 11-50** summarises the difference in the predicted PTS impact ranges using the current and adjusted thresholds. In summary, if the threshold accounts for recovery in hearing between pulses, the PTS impact ranges for the East location decreases from 9.1 km for harbour porpoise to 4.4 km (+2 dB) or 2.6 km (+3 dB). For minke whale the PTS impact ranges for the East location decreases from 26.1 km to 17.0 km (+2 dB) or 12.9 km (+3 dB).

11.24.1.19 Therefore, accounting for recovery in hearing between pulses by increasing the PTS onset threshold by 2 or 3 dB significantly decreases the predicted PTS-onset impact ranges (**Table 11-50**). This approach to modelling cumulative PTS is in development and has not yet been fully assessed or peer reviewed. Therefore, the Salamander Project impact assessment will present the cumulative PTS impact ranges using the current Southall *et al.* (2019) PTS-onset impact threshold. While more research needs to be conducted to understand the exact magnitude of this effect in relation to pile driving sound, this study proves a significant reduction in the risk of PTS even through short silent periods for TTS recovery as found in pile driving.

Table 11-50 Difference in predicted cumulative Permanent Threshold Shift impact ranges if recovery between pulses is accounted for and the Permanent Threshold Shift-onset threshold is increased by 2 or 3 dB[23]

Threshold		Max impact range (km)	Reduction in impact range (km)
Minke whale			
PTS	**183 SEL_{cum}**	**26.1**	**-**
PTS + 2 dB	**185 SEL_{cum}**	**17.0**	**9.1**
PTS + 3 dB	**186 SEL_{cum}**	**12.9**	**13.2**
Harbour porpoise			
PTS	**155 SEL_{cum}**	**9.1**	**-**
PTS + 2 dB	**157 SEL_{cum}**	**4.4**	**4.7**
PTS + 3 dB	**158 SEL_{cum}**	**2.6**	**6.5**

Impulsive characteristics

11.24.1.20 Southall *et al.* (2019) calculated the PTS-onset thresholds based on the assumption that an animal's hearing threshold will shift by 2.3 dB per dB SEL received from an impulsive sound, but only 1.6 dB per dB SEL when the sound received is non impulsive. The PTS-onset threshold for non-impulsive sound is, therefore, higher than for impulsive sound, as more energy is needed to cause PTS with non-impulsive sound compared to impulsive sound. Consequently, an animal subject to both types of sound has been at risk of PTS at an SEL_{cum} that lies somewhere between the PTS onset thresholds of impulsive and non-impulsive sound.

[23] Note: PTS-onset impact ranges for dolphins are seals were <0.1 km so are not considered here

11.24.1.21 Southall *et al.* (2019) acknowledges that, as a result of propagation effects, the sound signal of certain sound sources (e.g., impact piling) loses its impulsive characteristics and could potentially be characterised as non-impulsive beyond a certain distance. The changes in noise characteristics with distance generally result in exposures becoming less physiologically damaging with increasing distance as sharp transient peaks become less prominent (Southall *et al.* 2007). The Southall *et al.* (2019) updated criteria proposed that, while keeping the same source categories, the exposure criteria for impulsive and non-impulsive sound should be applied based on the signal features likely to be perceived by the animal rather than those emitted by the source. Methods to estimate the distance at which the transition from impulsive to non-impulsive noise are currently being developed (Southall *et al.* 2019).

11.24.1.22 Using the criteria of signal duration[24], rise time[25], crest factor[26] and peak pressure[27] divided by signal duration[28], Hastie *et al.* (2019) estimated the transition from impulsive to non-impulsive characteristics of impact piling noise during the installation of offshore wind turbine foundations at the Wash and in the Moray Firth. Hastie *et al.* (2019) showed that the noise signal experienced a high degree of change in its impulsive characteristics with increasing distance. Southall *et al.* (2019) state that mammalian hearing is most readily damaged by transient sounds with rapid rise-time, high peak pressures, and sustained duration relative to rise-time. Therefore, of the four criteria used by Hastie *et al.* (2019), the rise-time and peak pressure may be the most appropriate indicators to determine the impulsive/non-impulsive transition.

11.24.1.23 Based on this data it is expected that the probability of a signal being defined as "impulsive" (using the criteria of rise time being less than 25 milliseconds) reduces to only 20% between ~2 and 5 km from the source. Predicted PTS impact ranges based on the impulsive noise thresholds may therefore be overestimates in cases where the impact ranges lie beyond this. Any animal present beyond that distance when piling starts will only be exposed to non-impulsive noise, and therefore impact ranges should be based on the non-impulsive thresholds.

11.24.1.24 It is acknowledged that the Hastie *et al.* (2019) study is an initial investigation into this topic, and that further data are required in order to set limits to the range at which impulsive criteria for PTS are applied.

11.24.1.25 Since the Hastie *et al.* (2019) study, Martin *et al.* (2020) investigated the sound emission of different sound sources to test techniques for distinguishing between the sound being impulsive or non-impulsive. For impulsive sound sources, they included impact pile driving of four 4-legged jacket foundation installed at around 20 m water depth (at the Block Island Wind Farm in the USA). For the impact piling sound, they recorded sound at four distances between ~500 m and 9 km, recording the sound of 24 piling events. To investigate the impulsiveness of the sound, they used three different parameters and suggested the use of kurtosis[29] to further investigate the impulsiveness of sound. Hamernik *et al.* (2007) showed a positive correlation between the magnitude of PTS and the kurtosis value in chinchillas, with an increase in PTS for a kurtosis value from 3 up to 40 (which in reverse also means that PTS decreases for the same SEL with decreasing kurtosis below 40). Therefore, Martin *et al.* (2020) argued that:

[24] Time interval between the arrival of 5% and 95% of total energy in the signal.
[25] Measured time between the onset (defined as the 5th percentile of the cumulative pulse energy) and the peak pressure in the signal.
[26] The decibel difference between the peak sound pressure level (i.e., the peak pressure expressed in units of dB re 1 µPa) of the pulse and the root-mean-square sound pressure level calculated over the signal duration.
[27] The greatest absolute instantaneous sound pressure within a specified time interval.
[28] Time interval between the arrival of 5% and 95% of total energy in the signal.
[29] Kurtosis is a measure of the asymmetry of a probability distribution of a real-valued variable.

- Kurtosis of 0-3 = continuous sinusoidal signal (non-impulsive);
- Kurtosis of 3-40 = transition from non-impulsive to impulsive sound; and
- Kurtosis of 40 = fully impulsive.

11.24.1.26 For the evaluation of their data, Martin *et al.* (2020) used unweighted as well as LF-Cetacean (C) and VHFC weighted sound, based on the species-specific weighting curves in Southall *et al.* (2019) to investigate the impulsiveness of sound. Their results for pile driving are shown in **Figure 11-22**. For the unweighted and LFC weighted sound, the kurtosis value was >40 within 2 km from the piling site. Beyond 2 km, the kurtosis value decreased with increasing distance. For the VHFC weighted sound, kurtosis factor is more inconclusive with the median value >40 for the 500 m and 9 km measuring stations, and at 40 for the stations in between. However, the variability of the kurtosis value for the VHF-C weighted sound increased with distance

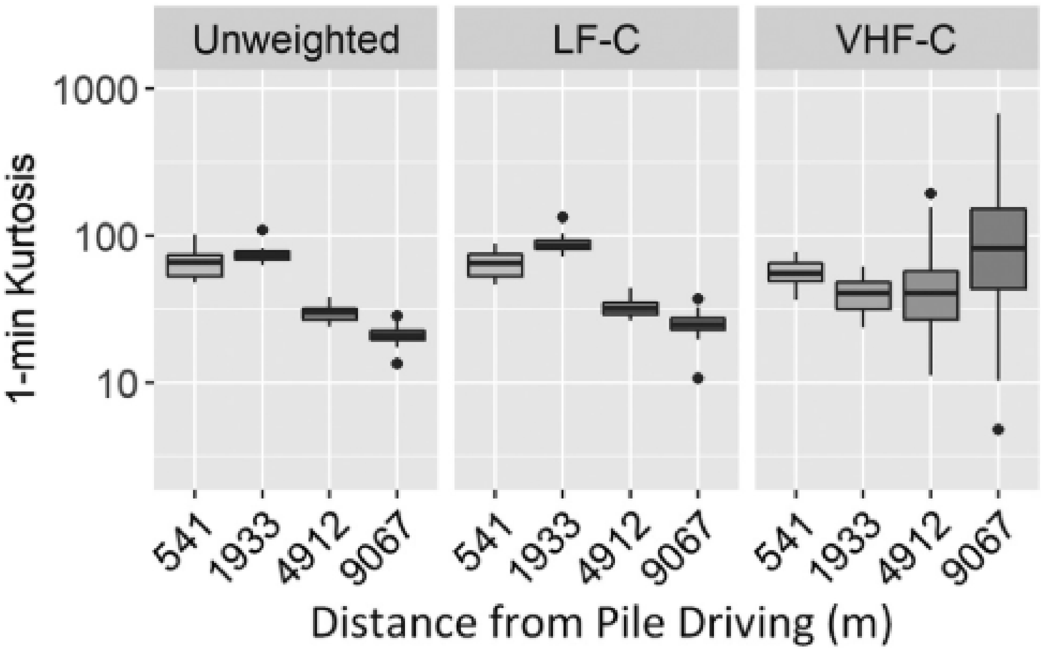

Figure 11-22 The range of kurtosis weighted by LF-C and VHF-C Southall *et al.* (2019) auditory frequency weighting functions for 30 min of impact pile driving data measured in 25 m of water at the Block Island Wind Farm. Boxplots show the median value (horizontal lines), interquartile range (boxes) and outlier values (dots). Figure from Martin *et al.* (2020)

11.24.1.27 From these data, Martin et al. (2020) conclude that the change to non-impulsiveness "is not relevant for assessing hearing injury because sounds retain impulsive character when SPLs are above EQT [effective quiet threshold[30]]" (i.e., the sounds they recorded retain their impulsive character while being at sound levels that can contribute to auditory injury).

11.24.1.28 However, despite Martin *et al*.'s conclusions, **Figure 11-22** shows (for unweighted and LF-C weighted sound) that piling sound loses its impulsiveness with increasing distance from the piling site - the kurtosis value decreases with increasing distance and therefore the sound loses its harmful impulsive characteristics. Based on this study and the study by Hastie *et al.* (2019), we argue that the predicted PTS impact ranges based on the impulsive noise thresholds will over-estimate the risk of PTS-onset in cases and at ranges where the likelihood increases that an animal is exposed to sound with much reduced impulsive characteristics.

11.24.1.29 There are points that need consideration before adopting kurtosis as an impulsiveness measure, with the recommended threshold value of 40. Firstly, this value was experimentally obtained for chinchillas that were exposed to noise for a five-day period under controlled conditions. Caution may need to be taken to directly

[30] From Martin *et al.* (2020): The proposed effective quiet threshold (EQT) is the 1-min auditory frequency weighted SPL that accumulates to this 1-min SEL, which numerically is 18dB below the 1-min SEL [because $10 \cdot \log_{10}(1\ \text{min}/1\ \text{s})$dB¼17.7dB]. Thus, the proposed level for effective quiet is equivalently a 1-min SPL that is 50dB below the numeric value of the auditory frequency-weighted Southall *et al.,* (2019) daily SEL TTS threshold for non-impulsive sources.,

adopt this threshold-value (and the related dose-response of increasing PTS with increasing kurtosis between 3 and 40) to marine mammals in the wild, especially given that the PTS guidance considers time periods of up to 24 hours. Secondly, kurtosis is recommended to be computed over at least 30 seconds, which means that it is not a specific measure that can be used for single blows of a piling sequence. Instead, kurtosis has been recommended to evaluate steady-state noise in order to include the risk from embedded impulsive noise (Goley *et al.* 2011). Metrics used by Hastie *et al.* (2019) computed for each pile strike (e.g. risetime) may be more suitable to be included in piling impact assessments, as, for each single pile strike, the sound exposure levels received by an animal are considered. It is currently unknown which metric is the most useful and how they correlate with the magnitude of auditory injury in (marine) mammals.

11.24.1.30 Southall (2021) points out that "*at present there are no properly designed, comparative studies evaluating TTS for any marine mammal species with various noise types, using a range of impulsive metrics to determine either the best metric or to define an explicit threshold with which to delineate impulsiveness*". Southall (2021) proposes that the presence of high-frequency noise energy could be used as a proxy for impulsiveness, as all currently used metrics have in common that a high frequency spectral content result in high values for those metrics. This suggestion is an interim approach: "*the range at which noise from an impulsive source lacks discernible energy (relative to ambient noise at the same location) at frequencies ≥ 10 kHz could be used to distinguish when the relevant hearing effect criteria transitions from impulsive to non-impulsive*".

11.24.1.31 Southall (2021), however, notes that: "it should be recognised that the use of impulsive exposure criteria for receivers at greater ranges (tens of kilometres) is almost certainly an overly precautionary interpretation of existing criteria".

11.24.1.32 Considering that an increasing proportion of the sound emitted during a piling sequence will become less impulsive (and thereby less harmful) while propagating away from the sound source, and this effect starts at ranges below 5 km in all above mentioned examples, the cumulative PTS-onset threshold for animals starting to flee at 5 km should be higher than the Southall (2021) threshold adopted for this assessment (i.e., the risk of experiencing PTS becomes lower), and any impact range estimated beyond this distance should be considered as an unrealistic over-estimate, especially when they result in very large distances.

11.24.1.33 For the purpose of presenting a precautionary assessment, the quantitative impact assessment for the Salamander Project is based on fully impulsive thresholds, but the potential for overestimation should be noted.

Cumulative PTS Conclusion

11.24.1.34 Given the evidence presented above it is considered that the calculated SEL_{cum} PTS-onset impact ranges are highly precautionary and that the true extent of effects (impact ranges and numbers of animals experiencing PTS) will likely be considerably less than that assessed here.

11.24.2 Density Limitations and Assumptions

11.24.2.1 There are uncertainties relating to the ability to predict the responses of animals to underwater noise and the number of animals potentially exposed to levels of noise that may cause an impact is uncertain. Given the high spatial and temporal variation in marine mammal abundance and distribution in any area of the sea, it is difficult to predict how many animals may be present within the range of noise impacts. All methods for determining at sea abundance and distribution suffer from a range of biases and uncertainties. This is described in further detail in the **Volume ER.A.4, Annex 11.1: Marine Mammal Baseline Report**.

11.24.3 Predicting Response Limitations and Assumptions

11.24.3.1 In addition, there are limited empirical data available to inform predictions of the extent to which animals may experience auditory damage or display responses to noise. The current methods for prediction of behavioural responses are based on received sound levels, but it is likely that factors other than noise levels alone will also influence the probability of response and the strength of response (e.g., previous experience, behavioural and physiological context, proximity to activities, characteristics of the sound other than level, such as duty cycle and pulse characteristics). However, at present, it is impossible to adequately take these factors into account in a predictive sense. This assessment makes use of the monitoring work that has been carried out during the construction of the Beatrice Offshore Wind Farm and therefore uses the most recent and site-specific information on disturbance to harbour porpoise because of pile driving noise.

11.24.3.2 There is also a lack of information on how observed effects (e.g. short-term displacement around impact piling activities) manifest themselves in terms of effects on individual fitness, and ultimately population dynamics (see the above section on marine mammal sensitivity to disturbance and the recent expert elicitation conducted for harbour porpoise and both seal species) in order to attempt to quantify the amount of disturbance required before vital rates are impacted.

11.24.4 Duration of Impact Limitations and Assumptions

11.24.4.1 The duration of disturbance is another uncertainty. Studies at Horns Rev 2 demonstrated that porpoises returned to the area between one and three days after piling (Brandt *et al.* 2011) and monitoring at the Dan Tysk Wind Farm as part of the Disturbance Effects on the Harbour Porpoise Population in the North Sea (DEPONS) project found return times of around 12 hours (van Beest *et al.* 2015). Two studies at Alpha Ventus demonstrated, using aerial surveys, that the return of porpoises was about 18 hours after piling (Dähne *et al.* 2013). A recent study of porpoise response at the Gemini wind farm in the Netherlands, also part of the DEPONS project, found that local population densities recovered between two and six hours after piling (Nabe-Nielsen *et al.* 2018). An analysis of data collected at the first seven offshore wind farms in Germany has shown that harbour porpoise detections were reduced between one and two days after piling (Brandt *et al.* 2018).

11.24.4.2 Analysis of data from monitoring of marine mammal activity during piling of jacket pile foundations at Beatrice Offshore Wind Farm (Graham *et al.* 2017b, Graham *et al.* 2019) provides evidence that harbour porpoise were displaced during pile driving but return after cessation of piling, with a reduced extent of disturbance over the duration of the construction period (excluding pre-construction surveys). This suggests that the assumptions adopted in the current assessment are precautionary as animals are predicted to remain disturbed at the same level for the entire duration of the pile driving phase of construction.

11.24.5 TTS Limitations and Assumptions

11.24.5.1 It is recognised that TTS is a temporary impairment of an animal's hearing ability with potential consequences for the animal's ability to escape predation, forage and/or communicate, supporting the statement of Kastelein *et al.* (2012c) that *"the magnitude of the consequence is likely to be related to the duration and magnitude of the TTS".* An assessment of the impact based on the TTS thresholds as currently given in Southall *et al.* (2019) or the former NMFS (2016) guidelines and Southall *et al.* (2007) guidance would lead to a substantial overestimation of the potential impact of TTS. Furthermore, the prediction of TTS impact ranges, based on the SEL thresholds, are subject to the same inherent uncertainties as those for PTS, and in fact the uncertainties may be considered to have a proportionately larger effect on the prediction of TTS. These concepts are explained in detail below based on the thresholds detailed by Southall *et al.* (2019), as these are based upon the most up-to-date scientific knowledge.

11.24.5.2 It is SMRU Consulting's expert opinion that basing any impact assessment on the impact ranges for TTS using current TTS thresholds would overestimate the potential for an ecologically significant effect. This is because the species-specific TTS thresholds in Southall *et al.* (2019) describe those thresholds at which the onset of TTS is observed, which is, per their definition, a 6 dB shift in the hearing threshold, usually measured four minutes after sound exposure, which is considered as *"the minimum threshold shift clearly larger than any day-to-day or session-to-session variation in a subject's normal hearing ability", and which "is typically the minimum amount of threshold shift that can be differentiated in most experimental conditions".* The time hearing recovers back to normal (the recovery time) for such small threshold shifts is expected to be less than an hour, and, therefore, unlikely to cause any major consequences for an animal.

11.24.5.3 A large shift in the hearing threshold near to values that may cause PTS may however require multiple days to recover (Finneran 2015). For TTS induced by steady-state tones or narrowband noise, Finneran (2015) describes a logarithmic relationship between recovery rate and recovery time, expressed in dB/decade (with a decade corresponding to a ratio of 10 between two time intervals, resulting in steps of 10, 100, 1000 minutes and so forth). For an initial shift of 5 to 15 dB above hearing threshold, TTS reduced by 4 to 6 dB per decade for dolphins, and 4 to 13 dB per decade for harbour porpoise and harbour seals. Larger initial TTS tend to result in faster recovery rates, although the total time it takes to recover is usually longer for larger initial shifts (summarised in Finneran 2015). While the rather simple logarithmic function fits well for exposure to steady-state tones, the relationship between recovery rate and recovery time might be more complex for more complex broadband sound, such as that produced by pile driving noise.

11.24.5.4 For small threshold shifts of 4 to 5 dB caused by pulsed noise, Kastelein *et al.* (2016) demonstrated that porpoises recovered within one hour from TTS. While the onset of TTS has been experimentally validated, the determination of a threshold shift that would cause a longer-term recovery time and is therefore potentially ecologically significant, is complex and associated with much uncertainty.

11.24.5.5 The degree of TTS and the duration of recovery time that may be considered severe enough to lead to any kind of energetic or fitness consequences for an individual, is currently undetermined, as is how many individuals of a population can suffer this level of TTS before it may lead to population consequences. There is currently no set threshold for the onset of a biologically meaningful TTS, and this threshold is likely to be well above the TTS-onset threshold, leading to smaller impact ranges (and consequently much smaller impact areas, considering a squared relationship between area and range) than those obtained for the TTS-onset threshold. One has to bear in mind that the TTS-onset thresholds as recommended first by Southall *et al.* (2007) and further revised by Southall *et al.* (2019) were determined as a means to be able to determine the PTS-onset thresholds and represents the smallest measurable degree of TTS above normal day to day variation. A direct determination of PTS-onset thresholds would lead to an injury of the experimental animal and is therefore considered as unethical. Guidelines such as National Academies of Sciences Engineering and Medicine (2017) and Southall *et al.* (2007) therefore rely on available data from humans and other terrestrial mammals that indicate that a shift in the hearing threshold of 40 dB may lead to the onset of PTS.

11.24.5.6 For pile driving for offshore wind farm foundations, the TTS and PTS-onset thresholds for impulsive sound are the appropriate thresholds to consider. These consist of a dual metric, a threshold for the peak sound pressure associated with each individual hammer strike, and one for the SEL_{cum}, for which the sound energy over successive strokes is summated. The SEL_{cum} is based on the assumption that each unit of sound energy an animal is exposed to leads to a certain amount of threshold shift once the cumulated energy raises above the TTS-onset threshold. For impulsive sound, the threshold shift that is predicted to occur is 2.3 dB per dB noise received; for non-impulsive sound this rate is smaller (1.6 dB per dB noise) (Southall *et al.* 2007). Please see the section above for further details on the limitations of SEL_{cum} thresholds (the same limitations apply to TTS as PTS).

11.24.5.7 Modelling the SEL_{cum} impact ranges of PTS with a 'fleeing animal' model (as is typical during in noise impact assessments) are subject to both of these precautions. Modelling the SEL_{cum} TTS impact ranges will inherit the same uncertainties, however, over a longer period of time, and over greater ranges as the TTS impact ranges are expected to be larger than those of PTS. Therefore, these uncertainties and conservativisms will have a relatively larger effect on predictions of TTS ranges.

11.24.5.8 It is also important to bear in mind that the quantification of any impact ranges in the environmental assessment process, is done to inform an assessment of the potential magnitude and significance of an impact. Because the TTS thresholds are not universally used to indicate a level of biologically meaningful impact of concern per se but are used to enable the prediction of where PTS might occur, it would be very challenging to use them as the basis of any assessment of impact significance.

11.24.5.9 All the data that exists on auditory injury in marine mammals is from studies of TTS and not PTS. SMRU Consulting agrees with the studies' conclusion that we may be more confident in our prediction of the range at which any TTS may occur. However, this is not necessarily very useful for the impact assessment process. We accept that scientific understanding of the degree of exposure required to elicit TTS may be more empirically based than our ability to predict the degree of sound required to elicit PTS, it does not automatically follow that our ability to determine the consequences of a stated level of TTS for individuals is any more certain than our ability to determine the consequences of a stated level of PTS for individuals. It could even be argued that we are more confident in our ability to predict the consequences of a permanent effect than we are to predict the consequences of a temporary effect of variable severity and uncertain duration.

11.24.5.10 It is important to consider that predictions of PTS and TTS are linked to potential changes in hearing sensitivity at particular hearing frequencies, which for piling noise are generally thought to occur in the 2-10 kHz range and are not considered to occur across the whole frequency spectrum. Studies have shown that exposure to impulsive pile driving noise induces TTS in a relatively narrow frequency band in harbour porpoise and harbour seals (reviewed in Finneran 2015), with statistically significant TTS occurring at 4 and 8 kHz (Kastelein *et al.* 2016) and centred at 4 kHz. Our understanding of the consequences of PTS within this frequency range to an individual's survival and fecundity is limited, and therefore our ability to predict and assess the consequences of TTS of variable severity and duration is even more difficult to do.

TTS Conclusion

11.24.5.11 TTS is not presented in this impact assessment (except for when used as a proxy for disturbance in the UXO clearance assessment – see **Section 11.9.6**).

11.24.6 Population Modelling Limitations and Assumptions

11.24.6.1 There is a lack of empirical data on the way in which changes in behaviour and hearing sensitivity may affect the ability of individual marine mammals to survive and reproduce. Therefore, in the absence of empirical data, the iPCoD framework uses the results of an expert elicitation process conducted according to the protocol described in Donovan *et al.* (2016) to predict the effects of disturbance and PTS on survival and reproductive rate. The process generates a set of statistical distributions for these effects and then simulations are conducted using values randomly selected from these distributions that represent the opinions of a "virtual" expert. This process is repeated many 100s of times to capture the uncertainty among experts.

11.24.6.2 There are several precautions built into the iPCoD model and this specific scenario that mean that the results are considered to be highly precautionary and likely over-estimate the true population level effects. These include:

- The fact that the model assumes a minke whales and bottlenose dolphins will not forage for 24 hours after being disturbed[31],
- The lack of density dependence in the model (meaning the population will not respond to any reduction in population size), and
- The level of environmental and demographic stochasticity in the model.

Duration of disturbance: minke whales and bottlenose dolphins

11.24.6.3 The iPCoD model for minke whale and bottlenose dolphin disturbance was last updated following the expert elicitation in 2013 (Harwood *et al.* 2014a). When this expert elicitation was conducted, the experts provided responses on the assumption that a disturbed individual would not forage for 24 hours. However, the most recent expert elicitation in 2018 highlighted that this was an unrealistic assumption for harbour porpoises (generally considered to be more responsive than minke whales and bottlenose dolphins), and was amended to assume that disturbance resulted in 6 hours of non-foraging time (Booth *et al.* 2019). Unfortunately, neither minke whale nor bottlenose dolphins were included in the updated expert elicitation for disturbance, and thus the iPCoD model still assumes 24 hours of non-foraging time for both minke whales and bottlenose dolphins. This is unrealistic considering what we now know about marine mammal behavioural responses to pile driving. A recent study estimated energetic costs associated with disturbance from sonar, where it was assumed that 1 hour of feeding cessation was classified as a mild response, 2 hours of feeding cessation was classified as a strong response and 8 hours of feeding cessation was classified as an extreme response (Czapanskiy *et al.* 2021). Assuming 24 hours of feeding cessation for both minke whales and bottlenose dolphins in the iPCoD model is significantly beyond that which is considered to be an extreme response, and is therefore considered to be unrealistic and will over-estimate the true disturbance levels expected from the Offshore Development.

Lack of density dependence

11.24.6.4 Density dependence is described as "the process whereby demographic rates change in response to changes in population density, resulting in an increase in the population growth rate when density decreases and a decrease in that growth rate when density increases" (Harwood *et al.* 2014a). The iPCoD scenario run assumes no density dependence, since there is insufficient data to parameterise this relationship. Essentially, what this means is that there is no ability for the modelled impacted population to increase in size back up to carrying capacity following disturbance. At a recent expert elicitation, conducted for the purpose of modelling population impacts of the Deepwater Horizon oil spill (Schwacke *et al.* 2021), experts agreed that there would likely be a concave density dependence on fertility, which means that in reality, it would be expected that the impacted population would recover to carrying capacity (which is assumed to be equal to the size of un-impacted population – i.e., it is assumed the un-impacted population is at carrying

[31] In the updated expert elicitation in 2018, the duration of disturbance for harbour porpoise, harbour seals and grey seals was assumed to be 6 hours (Booth *et al.* 2019). Unfortunately, minke whales were not included in the updated expert elicitation so the duration of disturbance remains 12 hours, as used in the original expert elicitation in 2013.

capacity) rather than continuing at a stable trajectory that is smaller than that of the un-impacted population.

Environmental and demographic stochasticity

11.24.6.5 The iPCoD model attempts to model some of the sources of uncertainty inherent in the calculation of the potential effects of disturbance on marine mammal population. This includes demographic stochasticity and environmental variation. Environmental variation is defined as "*the variation in demographic rates among years as a result of changes in environmental conditions*" (Harwood *et al.* 2014a). Demographic stochasticity is defined as "*variation among individuals in their realised vital rates as a result of random processes*" (Harwood *et al.* 2014a).

11.24.6.6 The iPCoD protocol describes this in further detail: "Demographic stochasticity is caused by the fact that, even if survival and fertility rates are constant, the number of animals in a population that die and give birth will vary from year to year because of chance events. Demographic stochasticity has its greatest effect on the dynamics of relatively small populations, and we have incorporated it in models for all situations where the estimated population within an MU is less than 3000 individuals. One consequence of demographic stochasticity is that two otherwise identical populations that experience exactly the same sequence of environmental conditions will follow slightly different trajectories over time. As a result, it is possible for a "lucky" population that experiences disturbance effects to increase, whereas an identical undisturbed but "unlucky" population may decrease" (Harwood et al. 2014a).

11.24.6.7 This is clearly evidenced in the outputs of iPCoD where the un-impacted (baseline) population size varies greatly between iterations, not as a result of disturbance but simply as a result on environmental and demographic stochasticity. In the example provided in **Figure 11-23**, after 25 years of simulation, the un-impacted population size varies between 176 (lower 2.5%) and 418 (upper 97.5%). Thus, the change in population size resulting from the impact of disturbance is significantly smaller than that driven by the environmental and demographic stochasticity in the model.

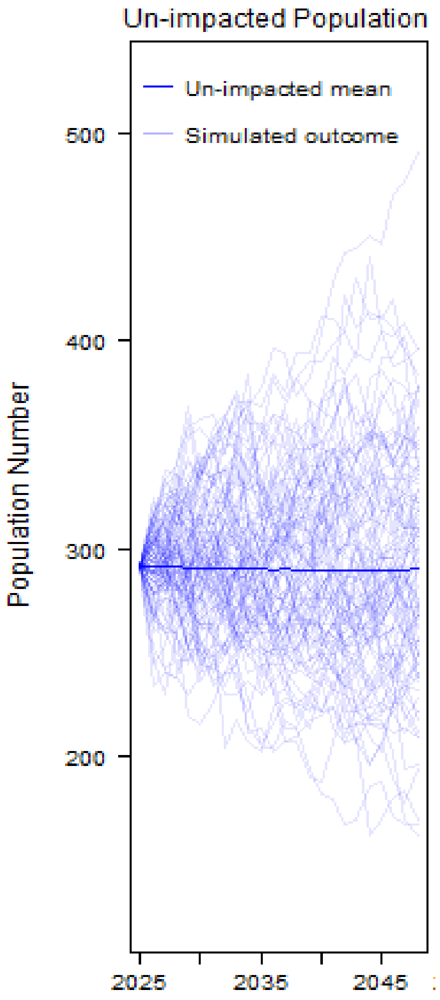

Figure 11-23 Simulated un-impacted (baseline) population size over the 25 years modelled

Summary

11.24.6.8 All of the precautions built into the iPCoD model mean that the results are considered to be highly precautionary. Despite these limitations and uncertainties, this assessment has been carried out according to best practice and using the best available scientific information. The information provided is therefore considered to be sufficient to carry out an adequate assessment, though a level of precaution around the results should be taken into account when drawing conclusions.

11.24.6.9 In addition to this, it is noted that iPCoD is not available for white-beaked dolphins.