Outer Dowsing Offshore Wind

Environmental Statement

Chapter 11 Marine Mammals

Volume 1

Date: September 2025

Document Reference: 6.1.11
Pursuant to APFP Regulation: 5(2)(a)
Revision: 4.0 Tracked

Company:	**Outer Dowsing Offshore Wind**	Asset:	**Whole Asset**
Project:	**Whole Wind Farm**	Sub Project/Package:	Whole Asset
Document Title or Description:	Chapter 11 Marine Mammals		
Internal Document Number:	PP1-ODOW-DEV-CS-REP-0119_04	3rd Party Doc No (If applicable):	N/A

Rev No.	**Date**	**Status / Reason for Issue**	**Author**	**Checked by**	**Reviewed by**	**Approved by**
1.0	March 2024	DCO Application	GoBe/ SMRUC	GoBe	Shepperd & Wedderburn	Outer Dowsing
2.0	March 2025	Examination ES Update: updates to reflect, where relevant: clarifications to date in Examination; correcting errata; additional commitments made through Examination; and changes to status of or addition of cumulative projects.	GoBe/SM RUC	GoBe	Shepperd & Wedderburn	Outer Dowsing
3.0	April 2025	Examination ES Update: updates to reflect, where relevant: corrections to errata and clarifications to date in response to R17 (PD-028)	GoBe	GoBe	Shepperd & Wedderburn	Outer Dowsing
4.0	September 2025	Request for Information Dated 12th August 2025	GoBe	Outer Dowsing	Shepherd and Wedderburn	Outer Dowsing

Table of Contents

Table of Tables

Table of Plates

Table of Figures (Volume 2)

Acronyms & Terminology

Abbreviations / Acronyms

Abbreviation / Acronym	Description
ADD	Acoustic Deterrent Device
AIS	Automatic Identification System
ANS	Artificial Nesting Site
AoS	Area of Search
ASCOBANS	Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas
BEIS	Department for Business, Energy & Industrial Strategy (now the Department for Energy Security and Net Zero (DESNZ))
BND	Bottlenose dolphin
CEA	Cumulative Effects Assessment
CI	Confidence Interval
CIEEM	Chartered Institute of Ecology and Environmental Management
CITES	Convention of International Trade in Endangered Species
CoCP	Code of Construction Practice
COWRIE	Collaborative Offshore Wind Energy Research into the Environment
CSIP	Cetacean Stranding Investigation Programme
CV	Coefficient of Variation
DAERA	Department of Agriculture, Environment and Rural Affairs
DCO	Development Consent Order
DEB	Dynamic Energy Budget
DECC	Department of Energy & Climate Change, now the Department for Energy Security and Net Zero (DESNZ)
Defra	Department for Environment, Food and Rural Affairs
DEPONS	Disturbance Effect on Harbour Porpoise in the North Sea
DESNZ	Department for Energy Security and Net Zero, formerly Department of Business, Energy and Industrial Strategy (BEIS), which was previously Department of Energy & Climate Change (DECC).
DPH	Detection Positive Hours
ECC	Export Cable Corridor (offshore ECC or indicative onshore ECC)
EDR	Effective Deterrence Range
EEA	European Economic Area
EIA	Environment Impact Assessment
EMF	Electromagnetic fields
EPP	Evidence Plan Process
EPS	European Protected Species
EQT	Effective Quiet Threshold
ES	Environmental Statement
ETG	Expert Topic Group
EU	European Union
GS	Grey Seal

Abbreviation / Acronym	Description
GT R4 Ltd	The Applicant. The special project vehicle created in partnership between Corio Generation, Gulf Energy Development and TotalEnergies
HF	High Frequency
HP	Harbour Porpoise
HRA	Habitat Regulations Assessment
HS	Harbour Seal
IAMMWG	The Inter Agency Marine Mammal Working Group
ICES	International Council for the Exploration of the Sea
IPC	Infrastructure Planning Commission
IROPI	Imperative Reasons of Over-riding Public Interest
JCP	Joint Cetacean Protocol
JNCC	Joint Nature Conservation Committee
kJ	Kilojoule
LF	Low Frequency
LSE	Likely Significant Effect
LWT	Lincolnshire Wildlife Trust
MDS	Maximum Design Scenario
MHWS	Mean High Water Springs
MMMP	Marine Mammal Mitigation Protocol
MMO	Marine Management Organisation
MMOb	Marine Mammal Observer
MPA	Marine Protected Area
MPCP	Marine Pollution Contingency Plan
MU	Management Unit
MW	Mega Watt
MWH	Minke whale
NMFS	National Marine Fisheries Centre
NOAA	National Oceanographic Atmospheric Administration
NPS	National Policy Statement
NSIP	Nationally Significant Infrastructure Project
NW	Northwest
ODOW	Outer Dowsing Offshore Wind, trading name of GT R4 Limited
OP	Offshore Platform
OPRED	Offshore Petroleum Regulator for Environment and Decommissioning
ORBA	Offshore Restricted Build Area
ORCP	Offshore Reactive Compensation Platform
ORJIP	Offshore Renewables Joint Industry Programme
OSPAR	Oslo/Paris convention (for the Protection of the Marine Environment of the North-East Atlantic)
OSS	Offshore Substation
OWF	Offshore Wind Farm
PAM	Passive Acoustic Monitoring
PCW	Phocid Carnivore in Water
PEIR	Preliminary Environmental Information Report

Abbreviation / Acronym	Description
PEMP	Project Environment Management Plan
PTEC	Perpetuus Tidal Energy Centre
PTS	Permanent Threshold Shift
RIAA	Report to Inform Appropriate Assessment
RMS	Root Mean Squared
SAC	Special Area of Conservation
SAFESIMM	Statistical Algorithms for Estimating the Sonar Influence on Marine Megafauna
SCANS	Small Cetaceans in European Atlantic waters and the North Sea
SCOS	Special Committee on Seals
SEL	Sound Exposure Level
SIP	Site Integrity Plan
SMRU	Sea Mammal Research Unit
SNCB	Statutory Nature Conservation Bodies
SNS	Southern North Sea
SPA	Special Protection Area
SPL	Sound Pressure Level
SSC	Suspended Sediment Concentration
SSSI	Sites of Special Scientific Interest
SW	Southwest
TCE	The Crown Estate
TTS	Temporary Threshold Shift
TWT	The Wildlife Trust
UWN	Underwater Noise
UXO	Unexploded Ordnance
VHF	Very High Frequency
VMP	Vessel Management Plan
WTG	Wind Turbine Generator
ZoI	Zone of Influence

Terminology

Term	Definition
The Applicant	GTR4 Limited (a joint venture between Corio Generation (and its affiliates), TotalEnergies and Gulf Energy Development), trading as Outer Dowsing Offshore Wind
AfL array area	The area of the seabed awarded to GT R4 Ltd. through an Agreement for Lease (AfL) for the development of an offshore windfarm, as part of The Crown Estate's Offshore Wind Leasing Round 4.
Array area	The area offshore within which the generating station (including wind turbine generators (WTG) and inter array cables), offshore accommodation platforms, offshore transformer substations and associated cabling will be positioned, including the ORBA.
Baseline	The status of the environment at the time of assessment without the development in place.
Biodiversity Net Gain	An approach to development that leaves biodiversity in a measurably improved state than it was previously. Where a development has an impact on biodiversity, developers are encouraged to provide an increase in appropriate natural habitat and ecological features over and above that being affected, to ensure that the current loss of biodiversity through development will be halted and ecological networks can be restored.
Cable Circuit	A number of electrical conductors necessary to transmit electricity between two points bundled as one cable or taking the form of separate cables, and may include one or more auxiliary cables (normally fibre optic cables).
Connection Area	An indicative search area for the NGSS.
Cumulative effects	The combined effect of the Project acting additively with the effects of other developments, 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 Project.
Deemed Marine Licence (dML)	A marine licence set out in a Schedule to the Development Consent Order and deemed to have been granted under Part 4 (marine licensing) of the Marine and Coastal Access Act 2009.
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for a Nationally Significant Infrastructure Project (NSIP).
Early Adopters Programme (EAP)	A process launched in April 2023 by the Planning Inspectorate, and adopted by seven NSIP projects including Outer Dowsing Offshore Wind, to trial potential components of a future enhanced pre-application service for applications decided under procedures set out in the Planning Act 2008 (PA2008).
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 sensitivity of the receptor, in accordance with defined significance criteria.
EIA Directive	European Union 2011/92/EU (as amended by Directive 2014/52/EU).
EIA Regulations	Infrastructure Planning (Environmental Impact Assessment) Regulations 2017
Environmental Impact Assessment (EIA)	A statutory process by which certain planned 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 EIA Regulations, including the publication of an Environmental Statement (ES).

Term	Definition
Environmental Statement (ES)	The suite of documents that detail the processes and results of the EIA.
Evidence Plan	A voluntary process of stakeholder consultation with appropriate Expert Topic Groups (ETGs) that discusses and, where possible, agrees the detailed approach to the Environmental Impact Assessment (EIA) and information to support Habitats Regulations Assessment (HRA) for those relevant topics included in the process, undertaken during the pre-application period.
Export cables	High voltage cables which transmit power from the Offshore Substations (OSS) to the Onshore Substation (OnSS) via the Offshore Reactive Compensation Platform (ORCP).
Cable ducts	A duct is a length of underground piping which is used to house the Cable Circuits.
Grid connection cable	Cable which connects the project Onshore Substation (OnSS) with the National Grid Substation.
Habitats Regulations Assessment (HRA)	A process which helps determine likely significant effects and (where appropriate) assesses adverse impacts on the integrity of European conservation sites and Ramsar sites. The process consists of up to four stages of assessment: screening, appropriate assessment, assessment of alternative solutions and assessment of imperative reasons of over-riding public interest (IROPI) and compensatory measures.
Haul Road	The track within the onshore ECC which the construction traffic would use to facilitate construction.
High Voltage Alternating Current (HVAC)	High voltage alternating current is the bulk transmission of electricity by alternating current (AC), whereby the flow of electric charge periodically reverses direction.
High Voltage Direct Current (HVDC)	High voltage direct current is the bulk transmission of electricity by direct current (DC), whereby the flow of electric charge is in one direction.
Impact	An impact to the receiving environment is defined as any change to its baseline condition, either adverse or beneficial.
Indicative Working Width	The indicative working width within the Onshore Export Cable Corridor (ECC), required for the construction of the onshore cable route.
Inter-array cables	Cable which connects the wind turbines to each other and to the offshore substation(s).
Interlink cables	Cable which connects the Offshore Substations (OSS) to one another
Intertidal	The area between Mean High Water Springs (MHWS) and Mean Low Water Springs (MLWS)
Joint bays	An excavation formed with a buried concrete slab at sufficient depth to enable the jointing of high voltage power cables.
Landfall	The location at the land-sea interface where the offshore export cables and fibre optic cables will come ashore.
Link boxes	Underground metal chamber placed within a plastic and/or concrete pit where the metal sheaths between adjacent export cable sections are connected and earthed.
Maximum Design Scenario	The project design parameters, or a combination of project design parameters that are likely to result in the greatest potential for change in relation to each impact assessed
Mitigation	Mitigation measures are commitments made by the Project to reduce and/or eliminate the potential for significant effects to arise as a result of the Project.

Term	Definition
	Mitigation measures can be embedded (part of the project design) or secondarily added to reduce impacts in the case of potentially significant effects.
National Grid Onshore Substation (NGSS)	The National Grid substation and associated enabling works to be developed by the National Grid Electricity Transmission (NGET) into which the Project's 400kV Cables would connect.
National Policy Statement (NPS)	A document setting out national policy against which proposals for Nationally Significant Infrastructure Projects (NSIPs) will be assessed and decided upon
NSIP Reform Action Plan	An Action Plan launched in February 2023 by Department for Levelling Up, Housing & Communities to reform the NSIP regime to ensure the effectiveness and resilience of the planning regime for the growing pipeline of critical infrastructure projects.
Offshore Export Cable Corridor (ECC)	The Offshore Export Cable Corridor (Offshore ECC) is the area within the Order Limits within which the export cables running from the array to landfall will be situated.
Offshore Restricted Build Area (ORBA)	The area within the array area, where no wind turbine generator, offshore transformer substation or offshore accommodation platform shall be erected.
Offshore Reactive Compensation Platform (ORCP)	A structure attached to the seabed by means of a foundation, with one or more decks (including bird deterrents) housing electrical reactors and switchgear for the purpose of the efficient transfer of power in the course of HVAC transmission by providing reactive compensation
Offshore Substation (OSS)	A structure attached to the seabed by means of a foundation, with one or more decks and a helicopter platform (including bird deterrents), containing— (a) electrical equipment required to switch, transform, convert electricity generated at the wind turbine generators to a higher voltage and provide reactive power compensation; and (b) housing accommodation, storage, workshop auxiliary equipment, radar and facilities for operating, maintaining and controlling the substation or wind turbine generators
Onshore Export Cable Corridor (ECC)	The Onshore Export Cable Corridor (Onshore ECC) is the area within which the export cables running from the landfall to the onshore substation will be situated.
Onshore Infrastructure	The combined name for all onshore infrastructure associated with the Project from landfall to grid connection.
Onshore substation (OnSS)	The Project's onshore HVAC substation, containing electrical equipment, control buildings, lightning protection masts, communications masts, access, fencing and other associated equipment, structures or buildings; to enable connection to the National Grid
Outer Dowsing Offshore Wind (ODOW)	The Project.
Order Limits:	The area subject to the application for development consent, The limits shown on the works plans within which the Project may be carried out.
The Planning Inspectorate	The agency responsible for operating the planning process for Nationally Significant Infrastructure Projects (NSIPs).
Pre-construction and post-construction	The phases of the Project before and after construction takes place.
Preliminary Environmental Information Report (PEIR)	The PEIR was written in the style of a draft Environmental Statement (ES) and provided information to support and inform the statutory consultation process during the pre-application phase.
The Project	Outer Dowsing Offshore Wind, an offshore wind generating station together with associated onshore and offshore infrastructure.

Term	Definition
Project Design Envelope	A description of the range of possible elements that make up the Project's design options under consideration, as set out in detail in the project description. This envelope is used to define the Project for Environmental Impact Assessment (EIA) purposes when the exact engineering parameters are not yet known. This is also often referred to as the "Rochdale Envelope" approach.
Receptor	A distinct part of the environment on which effects could occur and can be the subject of specific assessments. Examples of receptors include species (or groups) of animals or plants, people (often categorised further such as 'residential' or those using areas for amenity or recreation), watercourses etc.
Statutory consultee	Organisations that are required to be consulted by the Applicant, the Local Planning Authorities and/or The Planning Inspectorate during the pre-application and/or examination phases, and who also have a statutory responsibility in some form that may be relevant to the Project and the DCO application. This includes those bodies and interests prescribed under Section 42 of the Planning Act 2008.
Study Area	Area(s) within which environmental impact may occur – to be defined on a receptor-by-receptor basis by the relevant technical specialist.
Subsea	Subsea comprises everything existing or occurring below the surface of the sea.
Transboundary impacts	Transboundary effects arise when impacts from the development within one European Economic Area (EEA) state affects the environment of another EEA state(s)
Transition Joint Bay (TJBs)	The offshore and onshore cable circuits are jointed on the landward side of the sea defences/beach in a Transition Joint Bay (TJB). The TJB is an underground chamber constructed of reinforced concrete which provides a secure and stable environment for the cable.
Trenched technique	Trenching is a construction excavation technique that involves digging a narrow trench in the ground for the installation, maintenance, or inspection of pipelines, conduits, or cables.
Trenchless technique	Trenchless technology is an underground construction method of installing, repairing and renewing underground pipes, ducts and cables using techniques which minimize or eliminate the need for excavation. Trenchless technologies involve methods of new pipe installation with minimum surface and environmental disruptions. These techniques may include Horizontal Directional Drilling (HDD), thrust boring, auger boring, and pipe ramming, which allow ducts to be installed under an obstruction without breaking open the ground and digging a trench.
Wind turbine generator (WTG)	A structure comprising a tower, rotor with three blades connected at the hub, nacelle and ancillary electrical and other equipment which may include J-tube(s), transition piece, access and rest platforms, access ladders, boat access systems, corrosion protection systems, fenders and maintenance equipment, helicopter landing facilities and other associated equipment, fixed to a foundation

Reference Documentation

Document Number	Title
6.1.2	Need, Policy and Legislative Context
6.1.3	Project Description
6.1.7	Marine Physical Processes
6.1.8	Marine Water and Sediment Quality
6.1.10	Fish and Shellfish Ecology
6.3.11.2	Underwater Noise Assessment
6.3.11.1	Marine Mammal Technical Baseline
7.1	Report to Inform Appropriate Assessment
8.6.1	Outline Marine Mammal Mitigation Protocol for Piling Activities
8.6.2	Outline Marine Mammal Protocol for UXO Clearance
8.7	In Principle Southern North Sea Special Area of Conservation Site Integrity Plan
6.3.11.3	IPCoD cumulative assessment

11 Chapter 11 Marine Mammals

11.1 Introduction

1. This chapter of the Environmental Statement (ES) presents the results of the Environmental Impact Assessment (EIA) for the potential impacts of Outer Dowsing Offshore Wind ("the Project") on marine mammals. Specifically, this chapter considers the potential impact of the Project seaward of Mean High Water Springs (MHWS) during the construction, operation and maintenance, and decommissioning phases.
2. GT R4 Limited (trading as Outer Dowsing Offshore Wind) hereafter referred to as the 'Applicant', is proposing to develop the Project. The Project will be located approximately 54km from the Lincolnshire coastline in the southern North Sea. The Project will include both offshore and onshore infrastructure including an offshore generating station (windfarm), export cables to landfall, Offshore Reactive Compensation Platforms (ORCP), onshore cables, connection to the electricity transmission network, ancillary and associated development and areas for the delivery of up to two Artificial Nesting Structures (ANS) and the creation and recreation of biogenic reef (if these compensation measures are deemed to be required by the Secretary of State) (see Volume 1, Chapter 3: Project Description for full details (document reference 6.1.3)).

This chapter has been informed by the following chapters and technical reports:

- Part 6, Volume 1 (Chapters) :
  - Chapter 2 : Need, Policy and Legislative Context (document reference 6.1.2) ;
  - Chapter 3: Project Description (document reference 6.3.3);
  - Chapter 7: Marine Physical Processes (document reference 6.1.7);
  - Chapter 8: Marine Water and Sediment Quality (document reference 6.1.8); and
  - Chapter 10: Fish and Shellfish Ecology (document reference 6.1.10);
- Part 6, Volume 3 (Appendices) :
  - Appendix 3.2: Underwater Noise Assessment (document reference 6.3.11.2); and
  - Appendix 11.1: Marine Mammal Technical Baseline (document reference 6.3.11.1);
- Part 7: Habitat Regulations Assessment - Report to Inform Appropriate Assessment (document reference 7.1);
- Part 8 (Other Documents) :
  - Outline Marine Mammal Mitigation Protocol for Piling Activities (document reference 8.6.1);
  - Outline Marine Mammal Protocol for UXO Clearance (document reference 8.6.2); and
  - In Principal Southern North Sea Special Area of Conservation Site Integrity Plan (document reference: 8.7).

11.2 Statutory and Policy Context

3. This section identifies legislation and national and local policy of relevance to the assessment of potential impacts on marine mammals associated with the construction, operation and maintenance (O&M), and decommissioning of the Project. The Planning Act 2008 and Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (referred to as "the EIA Regulations") are considered along with the legislation relevant to marine mammal ecology.
4. The following section provides information regarding the legislative context surrounding the assessment of potential effects in relation to marine mammal ecology. Full details of all Need, Policy and Legislation relevant to the Project application are provided within in Volume 1, Chapter 2: Need, Policy and Legislative Context (document reference 6.1.2). A summary of the current policy and legislation is provided below, the Applicant has ensured that the assessment adheres to the relevant legislation. In undertaking the assessment, the following need, policy and legislation has been considered:
   - The EIA Regulations;
   - The Planning Act (2008);
   - Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) (1979);
   - EU Council Directive 92/43/EEC on the conservation of natural habitats and of wild flora and fauna (the 'Habitats Directive');
   - EU Directive 2008/56/EC Marine Strategy Framework Directive;
   - The Conservation of Offshore Marine Habitats and Species Regulations 2017 (as amended);
   - The Conservation of Habitats and Species Regulations 2017;
   - Marine and Coastal Access Act 2009;
   - The Wildlife and Countryside Act 1981 (as amended);
   - The Convention for the Protection of the Marine Environment of the North-East Atlantic (the OSPAR Convention) (1992);
   - The Convention on the Conservation of Migratory Species of Wild Animals 1979 (the Bonn Convention) (1979);
   - Biodiversity 2020: A strategy for England's wildlife and ecosystems services ;
   - The Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS) (1994);
   - Convention of International Trade in Endangered Species (CITES) (1975);
   - The Conservation of Seals Act 1970; and
   - The East Inshore and East Offshore Marine Plans (2014).

5. The relevant legislation and planning policy for offshore renewable energy Nationally Significant Infrastructure Projects (NSIPs), specifically in relation to marine mammals is outlines in Table 11-1 below.

Table 11-1 Legislation and policy context

Legislation/policy	Key provisions	Section where comment addressed
National Policy Statement for Energy (EN-1), (DESNZ, 2023)	Paragraph 4.3.1 states: "All proposals for projects that are subject to the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (the EIA Regulations) must be accompanied by an Environmental Statement (ES) describing the aspects of the environment likely to be significantly affected by the project."	The potential effects of the construction, operation and decommissioning phases of the Project on marine mammals have been assessed in regard to international, national and local sites designated for ecological or geological features of conservation importance (see section 11.6). Direct or indirect effects on features of relevant Special Area of Conservation (SAC) and Special Protection Area (SPA) sites were also considered in the Habitats Regulations Assessment (HRA) Screening Report (document reference 7.2) and where relevant have been included in the Report to Inform Appropriate Assessment (RIAA) (document reference 7.1). Important protected areas for marine mammals within their respective Management Units (MUs) are detailed in Appendix 11.1: Marine Mammals Technical Baseline (document reference 6.3.11.1).
National Policy Statement for Energy (EN-1), (DESNZ, 2023)	Paragraph 5.4.16 states: "Many individual wildlife species receive statutory protection under a range of legislative provisions. Other species and habitats have been identified as being of principal importance for the conservation of biodiversity in England and Wales, well as for their continued benefit for climate mitigation and adaptation and thereby requiring conservation action."	Relevant marine mammal policy and legislation has been listed in section 11.2. All species are protected under the Conservation of Habitats and Species Regulations 2017 (the Habitats Regulations) 2017, the Conservation of Offshore Marine Habitats and Species Regulations (the Offshore Habitats Regulations) 2017 and the Wildlife and Countryside Act 1981. All species of cetacean are listed as European Protected Species under schedule 1 of the Offshore Habitats Regulations and schedule 2 of the Habitats Regulations and seal species are also protected under the Conservation of Seals Act 1970.

Legislation/policy	Key provisions	Section where comment addressed
	Paragraph 5.4.35 states: "Applicants should include appropriate avoidance, mitigation, compensation and enhancement measures as an integral part of the proposed development. In particular, the applicant should demonstrate that: • during construction, they will seek to ensure that activities will be confined to the minimum areas required for the works • the timing of construction has been planned to avoid or limit disturbance • during construction and operation best practice will be followed to ensure that risk of disturbance or damage to species or habitats is minimised, including as a consequence of transport access arrangements • habitats will, where practicable, be restored after construction works have finished • opportunities will be taken to enhance existing habitats rather than replace them, and where practicable, create new habitats of value within the site landscaping proposals. Where habitat creation is required as mitigation, compensation, or enhancement the location and quality will be of key importance. In this regard habitat creation should be focused on areas where the most ecological and ecosystems benefits can be realised."	Embedded mitigation relevant for marine mammals to be adopted as part of the Project have been detailed in section 11.5 and Table 11-8
	Paragraph 5.4.54 states: "The Secretary of State should refuse consent where harm to the habitats or species and their habitats would result, unless the benefits (including need) of the development outweigh that harm. In this context the Secretary of State should give substantial weight to any such harm to the detriment of biodiversity features of	All species receptors, including those of principal importance for the conservation of biodiversity in England are summarised in section 11.4. Full details are provided in Appendix 11.1: Marine Mammals Technical Baseline (document reference 6.3.11.1).

Legislation/policy	Key provisions	Section where comment addressed
	national or regional importance or the climate resilience and the capacity of habitats to store carbon, which it considers may result from a proposed development.”	
National Policy Statement for Renewable Energy Infrastructure (EN-3), (DESNZ, 2023)	Paragraph 3.8.117 states: “Applicants should assess the potential of their proposed development to have net positive effects on marine ecology and biodiversity, as well as negative effects.”	The assessment methodology for marine mammals includes the provision for assessment of both positive and negative effects presented within section 11.5.
National Policy Statement for Renewable Energy Infrastructure (EN-3), (DESNZ, 2023)	Paragraph 3.8.118 states: “Applicants should consult at an early stage of pre-application with relevant statutory consultees, as appropriate, on the assessment methodologies, baseline data collection, and potential avoidance, mitigation and compensation options should be undertaken.”	Consultation with relevant statutory and non-statutory stakeholders has been conducted throughout the pre-application phase of the Project (see Table 11-2 for a summary of consultation with regards to marine mammals).
National Policy Statement for Renewable Energy Infrastructure (EN-3), (DESNZ, 2023)	Paragraph 3.8.120 states: “Any relevant data that has been collected as part of post-construction ecological monitoring from existing, operational offshore windfarms should be referred to where appropriate.”	Relevant data collected during post construction monitoring from other offshore windfarm (OWF) projects have informed the assessment of the Project in section 11.6.
National Policy Statement for Renewable Energy Infrastructure (EN-3), (DESNZ, 2023)	Paragraphs 3.8.139-141 states: “Construction activities, including installing wind turbine foundations by pile driving, geophysical surveys, and clearing the site and cable route of unexploded ordinance (UXOs) may reach noise levels which are high enough to cause disturbance, injury, or even death to marine mammals. All marine mammals are protected under Part 3 of the Habitats Regulations. If construction and associated noise levels are likely to lead to an offence under Part 3 of the Habitats Regulations (which would include deliberately disturbing, injuring or killing),	Injury and disturbance from construction activities, including piling, geophysical surveys and unexploded ordnance (UXO) clearance has been assessed in section 11.6 as part of the assessment of construction impacts on marine mammals. The Project are not seeking to licence UXO in the Development Consent Order (DCO). All appropriate licencing requirements will be met post-consent.

Legislation/policy	Key provisions	Section where comment addressed
	an application will have to be made for a wildlife licence[1] to allow the activity to take place."	
National Policy Statement for Renewable Energy Infrastructure (EN-3), (DESNZ, 2023)	Paragraphs 3.8.142 – 143 states: "The development of offshore windfarms can also impact fish species (see paragraphs 2.8.129 – 2.8.133), which can have indirect impacts on marine mammals if those fish are prey species. There is also the risk of collision with construction and maintenance vessels and potential entanglement risks from floating wind structures."	Impacts to marine mammals arising from changes to prey availability and vessel collision risk have been assessed in section 11.6. There is no risk of entanglement with floating wind structures as there are no floating elements to the Project (see Chapter 3: Project Description (document reference 6.1.3)).
National Policy Statement for Renewable Energy Infrastructure (EN-3), (DESNZ, 2023)	Paragraph 3.8.144 states: "Where necessary, assessment of the effects on marine mammals should include details of: ▪ likely feeding areas and impacts on prey species and prey habitat; ▪ known birthing areas / haul out sites for breeding and pupping; ▪ migration routes; ▪ protected areas; ▪ baseline noise levels; ▪ predicted construction and soft start noise levels in relation to mortality, permanent threshold shift (PTS), temporary threshold shift (TTS) and disturbance; ▪ operational noise; ▪ duration and spatial extent of the impacting activities including cumulative/in-combination effects with other plans or projects;	Throughout the Environmental Impact Assessment (EIA) and HRA all relevant impacts have been identified, discussed, analysed and mitigated for if necessary (see section 11.6).

[1] See https://www.gov.uk/guidance/understand-marine-wildlife-licences-and-report-an-incident

Legislation/policy	Key provisions	Section where comment addressed
	▪ collision risk; ▪ entanglement risk; and ▪ barrier risk.”	
National Policy Statement for Renewable Energy Infrastructure (EN-3), (DESNZ, 2023)	Paragraph 3.8.145 states: “The scope, effort and methods required for marine mammal surveys should be discussed with the relevant SNCB.”	Communication with Statutory Nature Conservation Body’s (SNCBs) has been consistent throughout the Project, targeted Expert Topic Groups (ETGs) have occurred as discussed in section 11.3.
National Policy Statement for Renewable Energy Infrastructure (EN-3), (DESNZ, 2023)	Paragraphs 3.8.146 – 148 states: “The applicant should discuss any proposed noisy activities with the relevant statutory body and must reference the JNCC and SNCB underwater noise guidance[2] in relation to noisy activities (alone and in-combination with other plans or projects) within HRA sites, in addition to the JNCC mitigation guidelines to piling[3], explosive use, and geophysical surveys. Where assessment shows that noise from construction and UXO clearance may reach noise levels likely to lead to noise thresholds being exceeded (as detailed in the JNCC guidance) or an offence as described in paragraph 2.8.138 above, the applicant should look at possible alternatives or appropriate mitigation. The applicant should develop a Site Integrity Plan (SIP) to allow the cumulative impacts of underwater noise to be reviewed closer to the construction date, when there is more certainty in other plans and projects.”	This has been assessed in the RIAA (document reference 7.1) and EIA impacts from underwater noise assessed in sections 0 of this document. An In Principal Southern North Sea Special Area of Conservation Site Integrity Plan has been submitted alongside the DCO application (document reference 8.7). A final Site Integrity Plan (SIP) will be submitted in the post-consent stage as required by the deemed Marine Licences (dMLs).

[2] See https://hub.jncc.gov.uk/assets/2e60a9a0-4366-4971-9327-2bc409e09784
[3] See https://jncc.gov.uk/our-work/marine-mammals-and-noise-mitigation/

Legislation/policy	Key provisions	Section where comment addressed
National Policy Statement for Renewable Energy Infrastructure (EN-3), (DESNZ, 2023)	Paragraph 3.8.236 states: “Applicants are advised to develop an ecological monitoring programme to monitor impacts during the pre-construction, construction and operational phases to identify the actual impacts caused by the project and compare them to what was predicted in the EIA/HRA.”	An In Principle Monitoring Plan (document reference 8.3) has been submitted alongside the application which outlines the proposed monitoring for the Project.
National Policy Statement for Renewable Energy Infrastructure (EN-3), (DESNZ, 2023)	Paragraph 3.8.254 states: “Monitoring of the surrounding area before and during the piling procedure can be undertaken by various methods including marine mammal observers and passive acoustic monitoring. Active displacement of marine mammals outside potential injury zones can be undertaken using equipment such as acoustic deterrent devices.”	Details have been provided in the Outline Marine Mammal Mitigation Protocol (MMMP) for Piling Activities (document reference 8.6.1), see Table 11-10 for more details.
National Policy Statement for Renewable Energy Infrastructure (EN-3), (DESNZ, 2023)	Paragraph 3.8.254 states: “Soft start procedures during pile driving may be implemented. This enables marine mammals in the area disturbed by the sound levels to move away from the piling before physical or auditory injury is caused.”	Mitigation measures are detailed in the Outline MMMP for Piling Activities (document reference 8.6.1), but see Table 11-10 for more details.
National Policy Statement for Renewable Energy Infrastructure (EN-3), (DESNZ, 2023)	Paragraphs 3.8.255-256 states: “Where noise impacts cannot be reduced be avoided, other mitigation should be considered, including alternative installation methods and noise abatement technology, spatial/temporal restrictions on noisy activities, alternative foundation types. Applicants should take a review of up-to-date research should be undertaken and all potential mitigation options	Mitigation is discussed in the Outline MMMP for Piling Activities (document reference 8.6.1), but see Table 11-10 for more details. Updates to mitigation options will be closely monitored and researched. The Applicant has now committed to deploying primary and/or secondary noise reduction methods (Noise Abatement Systems) for pile driving as secured in Outline MMMP for Piling Activities (Document reference: 8.6.1).

Legislation/policy	Key provisions	Section where comment addressed
	presented as part of the application, having consulted the relevant JNCC mitigation guidelines[4]"	
National Policy Statement for Renewable Energy Infrastructure (EN-3), (DESNZ, 2023)	Paragraph 3.8.330 states: "The Secretary of State should be satisfied that the preferred methods of construction, in particular the construction method needed for the proposed foundations and the preferred foundation type, where known at the time of application, are designed to reasonably minimise significant impacts on marine mammals."	The Project has considered different foundation options, hammer energies and ramp-ups. Mitigation methods are considered within the Outline MMMP for Piling Activities (document reference 8.6.1). The details of the final MMMP will be agreed once the final project design is known (Table 11-10). Compliance with the MMMP will be secured in the dML conditions within the DCO.
National Policy Statement for Renewable Energy Infrastructure (EN-3), (DESNZ, 2023)	Paragraph 3.8.332 states: "The conservation status of cetaceans and seals are of relevance and the Secretary of State should be satisfied that cumulative and in-combination impacts on marine mammals have been considered."	The conservation status of European Protected Species (EPS) and seals is presented in the Marine Mammals Technical Baseline (document reference 6.3.11.1) and is considered within the impact assessment and cumulative assessment for each species. The conservation status is considered within the in-combination assessment presented in the RIAA (document reference 7.1).
National Policy Statement for Renewable Energy Infrastructure (EN-3), (DESNZ, 2023)	Paragraph 3.11.28 states: "Applicants must undertake a detailed assessment of the offshore ecological, biodiversity and physical impacts of their proposed development, for all phases of the lifespan of that development, in accordance with the appropriate policy for offshore windfarm EIAs, HRAs and MCZ assessments (See Sections 4.2 and 5.4 of EN-1)."	Construction, operation and maintenance, and decommissioning phases of the Project have been assessed in section 11.6.
National Policy Statement for Renewable Energy	Paragraph 3.11.37 states:	Embedded mitigation relevant for marine mammals is detailed in Table 11-10.

[4] See https://jncc.gov.uk/our-work/marine-mammals-and-noise-mitigation/

Legislation/policy	Key provisions	Section where comment addressed
Infrastructure (EN-3), (DESNZ, 2023)	"Careful design and siting of the development is likely to be the primary form of impact mitigation, along with the choice of construction and installation techniques."	
National Policy Statement for Renewable Energy Infrastructure (EN-3), (DESNZ, 2023)	Paragraph 3.11.44 states: "The Secretary of State should consider the effects of a proposed development on marine ecology and biodiversity, taking into account all relevant information made available by the applicant, SNCBs and any other relevant party."	The potential effects on marine mammal ecology are presented within this chapter, with the assessment of effects presented within section 11.6.

6. The approach taken in this ES chapter mirrors the methodology outlined in Volume 1, Chapter 5: EIA Methodology (document reference 6.1.5). Additionally, besides the guidance provided in Chapter 5 (document 6.1.5), the assessment of marine mammals will also adhere to the following guidance documents where they are specific to the topic:
   - Offshore Wind Marine Environmental Assessments: Best Practice Advice for Evidence and Data Standards. Phase I: Expectations for pre-application baseline data for designated nature conservation and landscape receptors to support offshore wind applications (Natural England, 2021);
   - Offshore Wind Marine Environmental Assessments: Best Practice Advice for Evidence and Data Standards. Phase III: Expectations for data analysis and presentation at examination for offshore wind applications (Natural England, 2022);
   - Marine Environment: UXO clearance joint interim position statement compiled by the Department for Environment, Food and Rural Affairs (DEFRA), the Department for Business, Energy and Industrial Strategy (BEIS, now DESNZ), the Marine Management Organisation (MMO), the Joint Nature Conservation Committee (JNCC), Natural England, the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED), the Department of Agriculture, Environment and Rural Affairs (DAERA), NatureScot and Marine Scotland (DEFRA et al., 2021);
   - Marine Mammal Noise Exposure Criteria: Assessing the severity of marine mammal behavioural responses to human noise (Southall et al., 2021);
   - Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects (Southall et al., 2019);
   - The protection of marine European Protected Species from injury and disturbance. Guidance for the marine area in England and Wales and the United Kingdom (UK) offshore marine area (JNCC et al., 2010);
   - The Planning Inspectorate (hereafter referred to as The Planning Inspectorate) Advice Note 7: EIA: Process, Preliminary Environmental Information and Environmental Statements (The Planning Inspectorate, 2020);
   - Updated cumulative effects assessment tier system (Natural England, 2022);
   - Chartered Institute of Ecology and Environmental Management (CIEEM) Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater, Coastal and Marine (CIEEM, 2019);
   - Oslo Paris Convention (OSPAR) Guidance on Environmental Considerations for OWF Development (OSPAR, 2008);
   - Environmental Impact Assessment for offshore renewable energy projects – guide (British Standards Institute, 2015);
   - Approaches to Marine Mammal Monitoring at Marine Renewable Energy Developments (Macleod et al., 2010);
   - Guidelines for Data Acquisition to Support Marine Environmental Assessments of Offshore Renewable Energy Projects (Judd, 2012);

- Guidance for assessing the significance of noise disturbance against Conservation Objectives of harbour porpoise SACs (JNCC, 2020);
- JNCC guidelines for minimising the risk of injury to marine mammals from using explosives (JNCC, 2010a);
- Statutory Nature Conservation Agency Protocol for Minimising the Risk of Injury to Marine Mammals from Piling Noise (JNCC, 2010b);
- Marine mammal observations and compliance with JNCC guidelines during pile driving operations from 2010–2021 (Stone, 2023);
- Marine mammal observations and compliance with JNCC guidelines during explosives operations from 2010-2021 (Stone, 2023);
- An exploration of time-area thresholds for noise management in harbour porpoise SACs literature review and population modelling (Brown et al., 2023);
- An approach to impulsive noise mitigation in English waters (DEFRA et al., 2022); and
- An approach to impulsive noise mitigation in English waters - Appendix A (DEFRA et al., 2022).

11.3 Consultation

7. Consultation is a key part of the DCO application process. Consultation regarding marine mammals has been conducted through the Evidence Plan Process (EPP), ETG meetings, the EIA Scoping Process (Outer Dowsing Offshore Wind, 2022), and the section 42 consultations carried out on the Preliminary Environmental Information Report (PEIR) (Outer Dowsing Offshore Wind, 2023a) and the Autumn Environmental Update Report (Outer Dowsing Offshore Wind, 2023b) . An overview of the Project consultation process is presented within Volume 1, Chapter 6: Technical Consultation Report (document reference 6.1.6).
8. A summary of the key issues raised during consultation, specific to marine mammals, is outlined in Table 11-2 below, together with how these issues have been considered in the production of this ES.

Table 11-2: Summary of consultation relating to marine mammals

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
Scoping Opinion Comments		
19th January 2022 Pre-scoping Evidence Plan meeting	The uncertainty around bottlenose dolphin population expansion into English waters from the established Scottish population was highlighted.	The approach taken for bottlenose dolphin population densities is outlined in paragraph 16, with further details on the population provided in document reference 6.3.11.1.
19th January 2022 Pre-scoping Evidence Plan meeting	It was agreed a 5km EDR is acceptable for established low order techniques where sufficient data is available.	The justification for a 5km effective deterrent radius (EDR) for low-order UXO clearance is provided in paragraph 76. An assessment of permanent threshold shift (PTS) onset and disturbance from low-order clearance is provided in section
a19th January 2022 Pre-scoping Evidence Plan meeting	A number of animals which could be affected by TTS to be presented within the EIA assessment. However, it was agreed that it would be inappropriate to assess the significance of TTS.	An assessment of the number of individuals impacted by temporary threshold shift (TTS) is presented in section 11.6, however it does not include an assessment of significance.
9th September 2022 Scoping Opinion (The Planning Inspectorate, 2022)	The Planning Inspectorate notes the intention to seek consent for Unexploded ordnance (UXO) removal through a future Marine Licence application but that the effects of removal of UXO will be considered as part of the EIA process for the Development Consent Order (DCO) application. The ES should address any cumulative effects from the construction of the Proposed Development with the likely effects from the UXO clearance.	Consideration of underwater noise effects from UXO on marine mammals can be found within section 11.7.3.
9th September 2022 Scoping Opinion (The Planning	The Scoping Report proposes to scope out accidental pollution resulting from all phases of the Proposed Development. The Planning Inspectorate agrees that such effects are capable of being mitigated through standard management practices and can be scoped out of	Accidental pollution has been scoped out of the assessment due to the commitment of a Marine Pollution Contingency Plan (MPCP) and Outline Code of Construction Practice

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
Inspectorate, 2022)	the assessment. The ES should provide details of the proposed mitigation measures to be included in the PEMP and its constituent MPCP, and/or appropriate Code of Construction Practice (CoCP). The ES should also explain how such measures will be secured.	(CoCP). Details on pollution prevention are provided in Table 11-8
9th September 2022 Scoping Opinion (The Planning Inspectorate, 2022)	The Scoping Report lists a number of studies which evidence that the presence of operational OWFs does not, in the longer term, preclude the presence of marine mammals. The Scoping Report concludes that that "while disturbance leading to temporary displacement may occur, this is expected to be spatially and temporally small scale and thus it is not expected that any stage of the Project will result in a permanent barrier to the movement of marine mammals in the area." The Planning Inspectorate is content that barrier effects to marine mammals during operation will be small scale and short lived and unlikely to result in significant effects. The Planning Inspectorate therefore agrees this can be scoped out of the impact assessment.	Barrier effects have been scoped out of the assessment, see section 11.5.1.2
9th September 2022 Scoping Opinion (The Planning Inspectorate, 2022)	The Scoping Report references evidence that dates from 2018 that supports a position that there is no evidence of EMF from marine renewable devices having any impact (either positive or negative) on marine mammals. Furthermore, the only marine mammal stated to show any response to EMF is the Guiana dolphin (*Sotalia guianesi*), which are not reported as being present within the scoping area. EMF effects to marine mammals are therefore proposed to be scoped out. The Planning Inspectorate is content to scope this matter out on this basis.	Electromagnetic field (EMF) has been scoped out of the assessment, see paragraph 11.5.1.2
9th September 2022 Scoping Opinion (The Planning Inspectorate, 2022)	Construction activities resulting in disturbance to seals at haul-out sites are proposed to be scoped out on the basis of the distances to haul-outs (5-6km from the AoS) and the nature of the construction activities relative to activities which are generally reported to cause disturbance to seals at haul-outs (e.g. kayaks and fast-moving vessels within a few hundred metres). The Planning Inspectorate notes the	Disturbance at seal haul-outs has been assessed for construction, operation and decommissioning phases in section 11.6.

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
	absence of information in the Scoping Report with regards to likely ports to be used as a source of vessel movements and thus whether vessels would be transiting from a closer location to seal haul-outs. As such, The Planning Inspectorate does not agree that this matter can be scoped out of the assessment at this stage. The Planning Inspectorate expects the ES to provide an assessment of impacts and resulting effects on seal haul-out sites, or robust evidence to support the conclusion that significant effects are unlikely. The Vessel Management Plan (VMP) should consider measures to reduce disturbance to marine mammals including seals at haul-out sites, as applicable. The Applicant should make effort to agree the evidence required in the ES with relevant consultation bodies, including Natural England, as part of the EPP.	
9th September 2022 Scoping Opinion (The Planning Inspectorate, 2022)	It is recommended the Applicant use the latest version of the Inter Agency Marine Mammal Working Group (IAMMWG) reports (dated March 2022) to inform the impact assessment.	Following receipt of the Scoping Opinion, a further updated Inter Agency Marine Mammal Working Group (IAMMWG) report has been published in 2023, which has therefore been used to inform the population sizes for harbour porpoise, white beaked dolphin, bottlenose dolphin and minke whale MUs (see Table 11-4) (IAMMWG, 2023). These figures have been taken forward into the impact assessment in section 11.7.
9th September 2022 Scoping Opinion (The Planning Inspectorate, 2022)	The ES should clearly explain and justify the selection of the site-specific survey area for all marine mammals as 'the array area plus a 4km buffer', with reference to agreements sought through the EPP.	The site-specific area is defined as the AfL array area plus 4km buffer as is standard in baseline survey data collection (see section 11.4.2). This was agreed in the Marine Mammal ETG dated 19th January 2022.

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
9th September 2022 Scoping Opinion (The Planning Inspectorate, 2022)	The Planning Inspectorate considers that the ES should also assess effects on the minke whale feature of the Sea of the Hebrides MPA (Nature Conservation), where significant effects are likely to occur.	The minke whale feature of the Sea of Hebrides Marine Protected Area (MPA) has been included in the assessment and the site is identified as a relevant designated site in Table 11-17.
9th September 2022 Scoping Opinion (The Planning Inspectorate, 2022)	The ES should present the TTS impact ranges and the number of animals predicted to be at risk. The Applicant's attention is directed to the comments of the MMO and Natural England at Appendix 2 to this Opinion. The Applicant should seek to agree the approach to the assessment of PTS and TTS-onset on marine mammals with the relevant consultation bodies, including the MMO and Natural England, through the EPP.	TTS ranges have been presented in section 11.6, ranges, areas and number of individuals are presented with no assessment of significance as agreed in the Marine Mammal ETG dated 26th September 2022.
9th September 2022 Scoping Opinion (The Planning Inspectorate, 2022)	The Applicant's attention is directed to the comments of the MMO and Natural England at Appendix 2 to this Opinion with regards to use of TTS-onset as proxy for disturbance and also the use of the Effective Deterrence Range (EDR). The ES should clearly state the evidence base used to determine the approach to assessing disturbance from UXO clearance and other activities and justify the approach selected. The Applicant should seek to agree the approach to the assessment of UXOs and disturbance of marine mammals with the relevant consultation bodies through the EPP, including the MMO and Natural England.	The evidence for assessing disturbance from UXO is provided in section 11.5. The approach to the assessment of UXOs was discussed at the ETG on 23rd January 2023.
9th September 2022 Scoping Opinion (The Planning	Mitigation measures The ES should include consideration of measures to manage potential cumulative disturbance in the event that there is multiple piling or other noisy activities taking place simultaneously in the Southern	The RIAA (document reference 7.1) includes full consideration of any necessary mitigation measures required to avoid an adverse effect on the integrity of the Southern North Sea (SNS) Special Area of

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
Inspectorate, 2022)	North Sea Special Area of Conservation (SAC). It is also recommended an outline Site Integrity Plan (SIP) be provided with the Application.	Conservation (SAC), including the need for a Site Integrity Plan to manage in-combination effects. An In Principal SIP has been submitted alongside the DCO application which details the Project's approach to addressing underwater noise disturbance affecting harbour porpoise within the SNS SAC by identifying a series of potential mitigation measures which could be utilised if required (document reference 8.7).
26th August 2022 Scoping Opinion (The Planning Inspectorate, 2022) MMO	The MMO supports the use of soft-start procedures on commencement of piling. A 20-minute soft-start in accordance with Joint Nature Conservation Committee (JNCC) protocol for minimising the risk to injury to marine mammals and other fauna from piling noise (JNCC, 2010). Should piling cease for a period greater than 10 minutes, then the soft-start procedure must be repeated.	Embedded mitigation measures have been detailed in Further in section 11.5.3. Details on the soft-start and other measures are detailed in the Outline MMMP for Piling Activities (document reference 8.6.1).
26th August 2022 Scoping Opinion MMO	The primary potential impacts in relation to underwater noise have been adequately identified for marine mammals and the methods described are sufficient to inform a robust impact assessment.	The impact assessment for underwater noise is provided in section 11.6.
26th August 2022 Scoping Opinion (The Planning Inspectorate, 2022) MMO	The MMO considers it appropriate that the thresholds presented in Southall *et al.,* (2019) will be used in the impact assessment. However, it is worth noting that the noise exposure criteria will evolve over time, so the assessment should use the most current, peer-reviewed guidance available. It is also appropriate that both the instantaneous peak Sound Pressure Level (SPL_{peak}) and cumulative Sound Exposure Level (SEL_{cum}) over 24-hours will be assessed.	The hearing thresholds presented and used in the impact assessment are from Southall *et al.,* (2019), which remains the current best available criteria for a noise assessment, see section 11.6. Both Sound Pressure Level (SPL_{peak}) and cumulative Sound Exposure Level (SEL_{cum}) have been modelled and assessed in section 11.6.

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
26th August 2022 Scoping Opinion (The Planning Inspectorate, 2022) MMO	With reference to paragraph 7.5.40 of the Scoping Report, the MMO, in consultation with Cefas, does not agree that there should be no requirement to assess the potential significance of Temporary Threshold Shift (TTS). Although TTS is by definition both recoverable and temporary, it is nevertheless an injury to the sensory capability of the animal which has the potential for serious consequences. As agreed with other projects, as a minimum, the TTS impact ranges and the number of animals predicted to be at risk should be presented. Therefore, the MMO recommends including both the TTS effect ranges and number of animals predicted to be at risk.	TTS ranges have been presented in section 11.6. There is only the presentation of impact ranges, areas and number of individuals and no assessment of significance as agreed in the Marine Mammal ETG dated 26th September 2022.
26th August 2022 Scoping Opinion (The Planning Inspectorate, 2022) MMO	Furthermore, it is not appropriate to use the TTS-onset thresholds as a proxy for disturbance. TTS occurs at much higher sound exposure, and so will underestimate the risk of disturbance. The 26km Effective Deterrence Range (EDR) for other species should be used or evidence should be presented for review to support a different distance on the basis of behavioural response studies. The Unexploded Ordnance (UXO) blast signal (for high-order detonation) is a particularly loud signal, so applying caution is necessary in this case. It could be argued that the harbour porpoise EDRs are likely to be conservative because porpoise are sensitive to noise, so they are a good starting point and a reasonable option in the absence of other data.	The 26km EDR has been applied to all marine mammal species for disturbance from UXO clearance as requested in the Scoping Opinion response, see Table 11-18 However, an alternative disturbance threshold in which TTS-onset has been used as a proxy for disturbance has also been presented (see Table 11-20) alongside the 26km EDR assessment.
26th August 2022 Scoping Opinion (The Planning Inspectorate, 2022) MMO	Embedded mitigation measures are listed in paragraph 7.5.50 of the Scoping Report and include the development of, and adherence to, a Vessel Management Plan, implementation of a Marine Mammal Mitigation Protocol (MMMP) for piling, UXO geophysical survey work, as well as a decommissioning MMMP. These measures are in keeping with other windfarm developments and can provide a suitable means for managing and mitigating potential effects of the Project. The MMO expects details of the MMMPs, and specific mitigation	Details of embedded mitigation measures are presented in Table 11-8 and have been agreed with SNCBs. An Outline MMMP for Piling Activities (document reference: 8.6.1) and an Outline MMMP for UXO Clearance (document reference 8.6.2) have been submitted alongside the DCO application.

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
	measures will be discussed and agreed with the MMO and SNCBs, once project parameters have been defined, and the noise modelling has been undertaken.	
26th August 2022 Scoping Opinion (The Planning Inspectorate, 2022) MMO	The underwater noise assessment should include full details of the noise modelling methodology and model parameters and assumptions, including: ▪ Acoustic source level spectra and how they were derived (e.g., conversion from hammer strike energy, backpropagation from measurements). ▪ Specifications of the propagation model, including equations if appropriate, or references to the peer-reviewed scientific literature in which they are contained. ▪ The environmental conditions (local area bathymetry, seabed and water column properties) and how these have been parameterised in the model. ▪ Any assumptions or simplifications such as averaging in depth, space or time. ▪ The parameters of a fleeing model.	The full details of the Underwater Noise (UWN) Assessment are presented in document reference 6.3.11.2.
30th August 2022 Scoping Opinion (The Planning Inspectorate, 2022) Natural England	Natural England agrees with the proposed MUs for marine mammals but suggest that the latest version of the IAMMWG reports is used (March 2022) and that the reference for seal MUs is included in the future.	Following receipt of the Scoping Opinion, a further updated IAMMWG report has been published in 2023, which has therefore been used to inform the population sizes for harbour porpoise, white beaked dolphin, bottlenose dolphin and minke whale MUs (see Table 11-4) (IAMMWG, 2023). Seal MUs have been used to inform the population sizes of both harbour and grey seals (SCOS, 2023). These figures have

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
		been taken forward into the impact assessment in sections 11.5 and 0.
30th August 2022 Scoping Opinion (The Planning Inspectorate, 2022) Natural England	Natural England are broadly satisfied with the key datasets listed to inform the marine mammal baseline. Carter *et al.,* (2022) should be used, as the peer reviewed and slightly amended version of Carter *et al.,* (2020). Consideration should be given to inclusion of data from other nearby windfarms e.g., Hornsea zone.	Document reference 6.3.11.1 has included Carter *et al.,* (2022) for the density reference for grey and harbour seals, which has been taken forward into the impact assessment in section 11.6. The marine mammal baseline data that exist for the study are presented inTable 11-3
30th August 2022 Scoping Opinion (The Planning Inspectorate, 2022) Natural England	Natural England considers that most of the relevant marine mammal protected areas have been identified. The only site in a relevant MU that has been omitted is the Sea of Hebrides (NC)MPA for minke whales. Natural England recommends that the applicant reference the Sea of the Hebrides (NC)MPA, which lists minke whale.	Table 11-17 details the marine nature conservation designations of relevance to the marine mammal features which have been identified as present within the study area.
30th August 2022 Scoping Opinion Natural England	The list of guidance document is comprehensive and relevant for the marine mammal assessment.	The list of guidance documents has been provided in paragraph 6.
30th August 2022 Scoping Opinion (The Planning Inspectorate, 2022) Natural England	For reference, Natural England considers that there is insufficient evidence to demonstrate noise reduction from ‘low yield’ clearance of UXOs.	For the purposes of this assessment, “low-order” is considered to be referring to deflagration only.
30th August 2022 Scoping Opinion (The Planning	Natural England do not agree that the TTS-onset thresholds should be used as a proxy for disturbance given that TTS occurs at higher sound exposures, and so will underestimate the risk of disturbance.	The 26km EDR has been applied to all marine mammal species for disturbance from UXO clearance as requested in the

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
Inspectorate, 2022) Natural England		Scoping Opinion response, see Table 11-19. However, an alternative disturbance threshold in which TTS-onset has been used as a proxy for disturbance has also been presented alongside the 26km EDR assessment (see section 11.6). This was raised in the ETG dated 11th September 2023 and the Applicant confirmed TTS-onset is being used as a proxy for disturbance as per Southall *et al.,* 2007. This approach was agreed at the Marine Mammal ETG dated 23rd January 2023 and Natural England confirmed they welcomed the ranges used for UXO assessment in the ETG dated 11th September 2023.
30th August 2022 Scoping Opinion (The Planning Inspectorate, 2022) Natural England	The 5km EDR referenced here is only applicable for harbour porpoises. If it is to be applied to other species, further evidence is required.	A 5km EDR has been assumed for low-order UXO clearance for all species (as per the Sofia Offshore Windfarm Marine Licence application for UXO detonation) and based on the difference between the expected sound levels of low-order and high-order UXO clearance, rather than the sensitivity of different species. JNCC (2023) state 5km EDR for low-order clearances. An alternative disturbance threshold in which TTS-onset has been used as a proxy for disturbance has also been presented (see section 11.5.12) alongside the 26km EDR assessment. Natural England confirmed they welcomed the ranges used for UXO

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
		assessment in the ETG dated 11th September 2023.
30th August 2022 Scoping Opinion (The Planning Inspectorate, 2022) Natural England	Natural England agrees that the listed embedded mitigation protocols are relevant to the marine mammal assessment, however we advise that more measures may be required to manage disturbance in the SNS SAC in the event that construction takes place simultaneously with other OWF construction or noisy activities in the SAC. These plans and contingencies will need to be outlined in detail as part of the ES. Furthermore, a Site Integrity Plan (SIP) will need to be produced which will specify exactly how these plans will be implemented as part of marine licence. We reserve the right to comment on the suitability of these documents in mitigating impacts when they are submitted as part of the consultation process	The Report to Inform Appropriate Assessment (RIAA) includes full consideration of any necessary mitigation measures required to avoid an adverse effect on the integrity of the Southern North Sea Special Area of Conservation, including the need for a Site Integrity Plan to manage in-combination effects. An In Principle Southern North Sea Special Area of Conservation SIP has been submitted alongside the DCO application which details the Project's approach for addressing underwater noise disturbance affecting harbour porpoise within the SNS SAC by identifying a series of potential mitigation measures which could be utilised if required (document reference 8.7).
30th August 2022 Scoping Opinion (The Planning Inspectorate, 2022) Natural England	Natural England agrees with the proposed impacts scoped into the assessment.	The scope of the assessment has been presented in section 11.5.
30th August 2022 Scoping Opinion (The Planning Inspectorate, 2022)	Underwater noise from UXO clearance and other construction activities: Please refer to our comments above in regard to TTS-onset as a proxy for disturbance and 5km EDR range for low order detonation for other species	The 26km EDR has been applied to all marine mammal species for disturbance from UXO clearance as requested in the Scoping Opinion response, see Table 11-19. An alternative disturbance threshold in

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
Natural England		which TTS-onset has been used as a proxy for disturbance and has been presented (see Table 11-21) alongside the 26km EDR assessment. A 5km EDR has been assumed for low-order UXO clearance for all species based on the Sofia Offshore Windfarm Marine Licence application for UXO detonation. There is currently no advised EDR for low-order detonations so until empirical data are available 5km is the assumed EDR (see paragraph 76 for more detail).
30th August 2022 Scoping Opinion (The Planning Inspectorate, 2022) Natural England	Vessel collision and disturbance: Although not of concern, we found the proposed approach for assessment unclear thus we welcome further details on this at future EWG.	The assessment of vessel collision and disturbance for the construction, operation and decommissioning phases is provided in section The assessment of cumulative vessel disturbance is presented in section 11.7. The assessment of vessel collision and disturbance was discussed in the Marine Mammal ETG on the 23rd January 2023 including vessel routes to be assumed.
30th August 2022 Scoping Opinion (The Planning Inspectorate, 2022) Natural England	We agree with the Applicant's earlier statement (paragraph 7.5.48) that the final list of impacts scoped into the CEA cannot be determined at the Scoping stage. As such we do not advise that any impacts are scoped out at this stage e.g., indirect impacts.	Based on the Scoping Opinion and consultation the list of impacts to be scoped in has been updated, see section 11.5.
30th August 2022	Natural England agrees that accidental pollution, barrier effects (operation) and EMF should be scoped out of assessment. However,	Accidental pollution, barrier effects and EMF have been scoped out. Disturbance at

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
Scoping Opinion (The Planning Inspectorate, 2022) Natural England	we do not agree that the disturbance at haul-outs can be scoped out at this stage without knowledge of vessel movements and ports during the various phases. The Vessel Management Plan should consider measures to reduce disturbance to marine mammals including hauled out seals.	haul-out sites has been scoped in and assessed in section 11.6.
30th August 2022 Scoping Opinion (The Planning Inspectorate, 2022) Natural England	Natural England are broadly satisfied with the key datasets listed to inform the marine mammal baseline; however, we have provided several references above to be included in future documents.	The suggested references have been included in section 11.5 to strengthen the information provided in the marine mammal baseline of this ES.
30th August 2022 Scoping Opinion (The Planning Inspectorate, 2022) Natural England	Natural England considers that most of the relevant marine mammal protected areas have been identified, however, we recommend that the applicant also reference and include due consideration within the assessment to the Sea of the Hebrides (NC)MPA, which lists minke whale as a protected feature. Natural England advise that further review of the list of receptors will be required once the full results of the site-specific surveys have been analysed.	Table 11-5 details the marine nature conservation designations of relevance to the marine mammal features which have been identified as present within the study area.
30th August 2022 Scoping Opinion (The Planning Inspectorate, 2022) Natural England	Natural England believes that all of the likely impact pathways have been identified. However, we reserve the right to amend our advice once more information is provided	The scope of the assessment is presented in section 11.4.
30th August 2022 Scoping Opinion (The Planning	Natural England agrees that barrier effects (operation) and EMF should be scoped out of assessment. However, we do not agree that accidental pollution and disturbance at haul-outs can be scoped out at this stage without knowledge of vessel movements and ports during	Barrier effects and EMF have been scoped out, see section 11.5 . Disturbance at haul-out sites has been scoped in (see paragraph 11.5.1.2) and assessed in section 11.6.

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
Inspectorate, 2022) Natural England	the various phases and mitigations measures put in place for pollution incidents are secured. The Vessel Management Plan should consider measures to reduce disturbance to marine mammals including hauled out seals.	Accidental pollution has been scoped out due to the implementation of mitigation (i.e., the Outline Project Environmental Management Plan (PEMP (document references 8.4).
30th August 2022 Scoping Opinion (The Planning Inspectorate, 2022) Natural England	Please refer to our comments above in regard to TTS-onset as a proxy for disturbance and 5km EDR range for low order detonation for other species. Vessel collision and disturbance: Although not of concern, we found the proposed approach for assessment unclear thus we welcome further details on this at future EWG. We support the proposal by the applicant to review the list of impacts in the CEA after the Project alone assessment is complete	A 5km EDR has been assumed for low-order UXO clearance for all species based on the Sofia Offshore Windfarm Marine Licence application for UXO detonation. There is currently no advised EDR for low-order detonations so until empirical data are available 5km is the assumed EDR (see paragraph 1.6.34 for more detail). This approach was agreed at the Marine Mammal ETG dated 23rd January 2023 and Natural England confirmed they welcomed the ranges used for UXO assessment in the ETG dated 11th September 2023.
30th August 2022 Scoping Opinion (The Planning Inspectorate, 2022) Natural England	Natural England agrees that the listed embedded mitigation protocols are relevant to the marine mammal assessment, however more measures will be required to manage disturbance in the event that there are multiple pilling programmes underway in the Southern North Sea SAC and these need to be outlined in in the ES, we also advise including a Site Integrity Plan (SIP) to the list of documents to be included as part of the Application. We reserve the right to comment on the suitability of these documents in mitigating impacts when they are submitted as part of the consultation process.	Mitigation measures for the SNS SAC are detailed within the ES. An In Principle Southern North Sea Special Area of Conservation SIP (document reference 8.7) has been submitted alongside the DCO application.
30th August 2022 Scoping Opinion (The Planning	Natural England do not agree that the TTS-onset thresholds should be used as a proxy for disturbance given that TTS occurs at higher sound exposures, and so will underestimate the risk of disturbance. We	The 26km EDR has been applied to all marine mammal species for disturbance from UXO clearance as requested in the

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
Inspectorate, 2022) Natural England	advise that the applicant review the evidence base to determine an appropriate approach to assessing disturbance from UXO clearance and other activities. The 5km EDR referenced is only applicable for harbour porpoises, so if it is to be applied to other species, further evidence is required. Natural England refers the applicant to section 6.5.2 of the Best Practice: Phase III document in relation to the Soloway & Dahl (2014) methodology for assessment of impact ranges of UXO disposal.	Scoping Opinion response, see Table 11-19. However, an alternative disturbance threshold in which TTS-onset has been used as a proxy for disturbance has also been presented alongside the 26km EDR assessment (see section 11.6) A 5km EDR has been assumed for low-order UXO clearance for all species based on the Sofia Offshore Windfarm Marine Licence (ML) application for UXO detonation. There is currently no advised EDR for low-order detonations so until empirical data are available 5km is the assumed EDR. Please see section 11.6 and document reference 6.3.11.2 for details on how Soloway and Dahl (2014) has been incorporated into the UXO assessment.
25th August 2022 Scoping Opinion (The Planning Inspectorate, 2022) Lincolnshire Wildlife Trust	LWT strongly disagrees with the scoping out of project disturbances at haul-out sites, particularly at Donna Nook. This important haul-out site receives over 2,000 adult grey seals annually and serves as birthing grounds for roughly 2,000 pups each year (recent count data from 2021; lincstrust.co.uk). Given that grey seals are a qualifying feature for the Humber Estuary SAC, due diligence is demanded with regards to potential negative impacts from marine development. Furthermore, LWT believes that the Project is overestimating distances between project/construction activities and large concentrations of grey seals, given that adults will range in and use surrounding waters near haul-out sites. Further details of LWT's stance on the scoping out of disturbance to haul-out sites is detailed below in Appendix A.	Disturbance at haul out sites has been scoped in and assessed, see section 11.7. The impacts on the Humber Estuary SAC are detailed in the RIAA (document reference 7.1).

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
25th August 2022 Scoping Opinion (The Planning Inspectorate, 2022) Lincolnshire Wildlife Trust	LWT does not agree with the proposed buffer range of 4km that is sighted in the scoping report for marine mammals. Recent marine noise research suggests that impulsive noise signals, such as those arising from pile driving and marine construction, can propagate over substantial distances (~37km; Hastie *et al.,* 2019). Furthermore, the impulsive nature of a sound is likely to be a complex interaction of several parameters (e.g., duty cycle, recovery periods, and sound levels) that will strongly affect the risk of hearing damage in marine mammals. Ultimately, more research regarding auditory damage that explicitly considers ranges from noise sources is needed before safe distances can be determined. Until more is known about this complex issue, LWT would recommend reconsideration in favour of more conservative buffer zones to ensure that marine mammals are safeguarded from negative impacts.	The site-specific area is defined as the survey area plus a 4km buffer as is standard in baseline survey data collection (see paragraph 11.4.2). This was agreed in the Marine Mammal ETG dated 19th January 2023. The study areas have been clarified in section 11.4 and in document reference 6.3.11.1.
25th August 2022 Scoping Opinion (The Planning Inspectorate, 2022) Lincolnshire Wildlife Trust	LWT agrees with the inclusion of noise modelling and the methods outlined in Southall *et al.,* (2019). However, it would be prudent to include appropriate spatiotemporal scales, seasonality, and a range of individual responses in the modelling process. While a dose response risk assessment may help determine proportional risk to marine mammal populations, such an approach would be limited in quantifying impacts over space and time. There are alternative approaches (e.g., individual-based modelling; Nabe-Nielsen *et al.,* 2018) that may offer more detailed, quantifiable insight on noise-related impacts and help assess opportunities for effective mitigation. Furthermore, a ready-made model exists for the North Sea harbour porpoise that could be adapted to properly assess noise impacts to his and other marine mammal species as a result of the Project (Nabe-Nielsen *et al.,* 2018).	A species-specific dose-response approach has been used to assess disturbance from piling (see paragraph 11.5.12). For disturbance from UXO detonation three behavioural disturbance thresholds have been considered: 26km EDR for high-order clearance, 5km EDR for low-order clearance, and a fixed noise threshold for TTS-onset (see paragraph 77) Information on alternative population models has been provided in paragraphs 637 and 641 to support the approach to modelling undertaken in the impact assessment.

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
25th August 2022 Scoping Opinion (The Planning Inspectorate, 2022) Lincolnshire Wildlife Trust	Lastly, LWT recommends that vessel noise be scoped into the Project and included in noise modelling for the impacts of project-related noise (Erbe *et al.,* 2019).	Vessel noise has been assessed as part of vessel disturbance impact for construction, operation and decommissioning (see impact 10 in section 11.6). Additionally, impact ranges for vessel noise from Southall *et al.,* (2019) are presented in the UWN Assessment (document reference 6.3.11.2).
25th August 2022 Scoping Opinion (The Planning Inspectorate, 2022) Lincolnshire Wildlife Trust	Given the dense concentration of adult grey seals during reproductive/haul-out months at Donna Nook (2,000+ adults reported in 2021; lincstrust.org.uk) and subsequent pups birthed (2,000+ pups birthed at Donna Nook in 2021; lincstrust.org.uk), LWT firmly disagrees that potential impacts to haul-outs can be scoped out of the Project and that the developers are making a blind assumption when stating that 'it is not expected that activities during construction will directly impact seal haul-outs'. First, the distance to Donna Nook from the boundary of the ECC AoS (5 to 6km according to the Scoping Report) is too short to be scoped out considering that noise signals from marine construction still have a 0.5 mean probability of exceeding marine mammal risk criteria at ranges >3.5km (Hastie *et al.,* 2019). While LWT appreciates that noise impacts to seals are scoped in, the importance of haul-out sites to reproduction and population stability require deliberate and careful consideration with regards to potential anthropogenic disturbance. Second, the Project's assumed 'safe' distance of construction activity relative to Donna Nook does not account for important in water activity by seals near haul-outs. While the distance to Donna Nook from the ECC AoS boundary may be 5 to 6km, there is likely to be a high concentration of grey seals ranging in and using nearby waters for foraging forays during haul-out months. This means that the distance of construction activity relative to large concentrations of grey seals has potentially been	Disturbance at haul out sites has been scoped in and assessed, see section 11.6.

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
	overestimated and therefore requires reconsideration and proper evaluation in the PEIR and ES.	
Pre-PEIR Evidence Plan Meeting		
23rd January 2023 Pre-PEIR submission Evidence Plan meeting	It was queried whether cumulative effects of non-oil and gas pre-construction surveys and Carbon Capture Storage are captured in the CEA.	The offshore construction schedules for the projects included in the CEA have been investigated using publicly available information. An assumption regarding the likely number of surveys based on historical data has been used within the assessment, see section 11.7.
23rd January 2023 Pre-PEIR submission Evidence Plan meeting	The ICES marine noise registry should be reviewed to inform assumptions, including military UXO and sonar, in the CEA.	The marine noise registry has been consulted and used to inform the CEA, see section 11.7.
23rd January 2023 Pre-PEIR submission Evidence Plan meeting	It was queried whether the CEA was undertaken on an annual or seasonal basis.	The level of information is not fine scale enough so the assumption has been made that the levels of activity will be consistent throughout the year, see section 11.7.
Phase 2 Consultation (Section 42 consultation on the PEIR) Comments		
20th July 2023 Section 42 Natural England	Natural England considers that the assigned magnitude and sensitivity has been downplayed throughout the assessment. Thus, we recommend that the assigned scores are revised to take into account the sensitivity of all species to underwater noise, especially when it comes to impacts of Unexploded Ordnance (UXO) clearance and piling. Also, there does not seem to be a 'hierarchy' of assigned scores between high and low impact activities. For example, sensitivity score	The definition of impact magnitude and sensitivity has been further discussed with Natural England in the ETG on the 11th September 2023. Magnitude scores have been presented both pre- and post-mitigation for clarity in section 11.6. The definition text for the Project is the same as has been used by previous projects and

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
	'Low' is assigned for Permanent Threshold Shift (PTS) from UXO clearance and piling as well as for disturbance from other construction activities, despite these impacts being substantially different. This requires revisiting. Review assigned magnitude and sensitivity scores and update the assessments for the submitted Environmental Statement (ES) accordingly.	agreed with Natural England, only the terminology ranking for magnitude differed. The magnitude scores have been renamed to align with other projects after discussions with Natural England and the levels of sensitivity are therefore the same. Whilst the impacts are different, this does not preclude the sensitivity of the receptor being assessed as the same as it is dependent on how the receptor reacts to the impact and what consequences may arise from the impact. Full justifications for the magnitude and sensitivity scores are provided within the assessment.
20th July 2023 Section 42 Natural England	Only one year of baseline characterisation has been presented at PEIR stage. Therefore, we cannot agree with the density estimates derived from the digital aerial surveys presented. We anticipate that the density and abundance estimates will be updated in the ES. It will be necessary to present a baseline characterisation based on at least two years data in the submitted ES.	The full 2-year site-specific data of digital aerial surveys have been presented in section 11.4.
20th July 2023 Section 42 Natural England	The observation of 15 mother-juvenile Harbour porpoise pairs during the baseline survey, and conclusions that the area may be used as a nursery ground for Harbour porpoise, are important. Consequently, Natural England request that the presence of mother – juvenile pairs is presented clearly in the full survey results. Evidence from literature on impacts of disturbance during these sensitive life stages should be presented. Furthermore, Natural England recommends extra	The presence of mother and calves has been discussed in section 11.4 and with information on sensitive life stages included. The impact assessment in section 11.6 has taken into account the sensitive life stages and considered the potential for calves in the area.

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
	consideration is given to impact assessment and mitigation to account for higher sensitivity during this life stage. Clearly present information related to mother-juvenile pairs within the full 2-years survey results. Clearly state findings from literature related to impacts of disturbance during sensitive life stages. Take a precautionary approach to impact assessment and mitigation. Ensure the HRA incorporates consideration of impacts on potential nursery grounds within the Southern North Sea SAC and investigate whether this warrants further avoidance or mitigation measures to rule out adverse effects.	In section 5.3 of the RIAA (document reference 7.1) the potential nursery grounds within the Southern North Sea SAC (SNS SAC) are considered.
20th July 2023 Section 42 Natural England	There is no information on the number of unidentified species recorded, or how they are apportioned into the results presented in the technical baseline annex. The submitted ES should provide information on the number of unidentified species recorded and apportion species in discussion with Natural England in line with Phase 1 of the Natural England best practice advice.	The baseline technical report has been updated by supplementing the requested information regarding unidentified species recorded in discussion with Natural England in line with Phase 1 of the Natural England best practice advice.
20th July 2023 Section 42 Natural England	Many statements in the Marine Mammals PEIR chapter do not contain references to literature. As some of these statements are used to justify the projects' impact assessment, they should be directly referenced to scientific evidence. For example: "There appears to be little fitness cost to exposure to vessel noise and any local scale responses taken to avoid vessels."	The Applicant notes that references were supplied within the PEIR as deemed appropriate though notes that frequently these were only mentioned once within a paragraph or section of text, rather than repeated throughout. Additional references have been added to aid cross referencing to

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
	(11.7.137). This statement is disputed in Wisniewska *et al.,* (2018) (http://dx.doi.org/10.1098/rspb.2017.2314) Other statements are found in sections: 11.6.87 (removed 124), 11.7.83, 11.7.87, 11.7.26, 11.7.42, 11.7.45, 11.7.109, 11.7.111, 11.7.136, 11.7, 168.11.6.87, 11.7.83, 11.7.87, 11.7.26, 11.7.42, 11.7.45, 11.7.109, 11.7.111, 11.7.136, 11.7, 168. The submitted ES should provide a reference to the source of these statements. Where references are not available, the ES chapter should be amended to align with peer-reviewed science where needed.	the relevant sources. Where appropriate, further studies have been included, such as Benhemma La-Gall *et al.,* 2021 and 2023. The text has been amended for the ES. Further references have been supplemented to support the statements in paragraphs 263, 268, 338, 364 and 548 of this ES. The Applicant considers that sufficient references were previously provided within paragraphs 300, 368 - 370 and 523.
20th July 2023 Section 42 Natural England	Natural England recommends genuine consideration of the findings from Wisniewska (2016), as some statements in this chapter are conflicting to the results of this paper. (https://doi.org/10.1016/j.cub.2016.03.069) Review Wisniewska (2016) and amend any conflicting statements in text in the submitted ES.	The Applicant does not dispute the fact that disturbance can result in temporary reductions in foraging. However, the Applicant cautions against putting too much weight on the conclusions from the Wisniewska (2016) paper. The paper's title makes conclusions about vulnerability to disturbance but the paper itself only reports on the foraging behaviour and success rate whilst foraging. The paper does not cover energetic requirements of animals or explore what the observed foraging rates mean in the context of life history – only making an assertion in the Discussion (and Abstract and Title).

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
		Additionally, there are concerns with the methodologies used in the Wisniewska (2016) paper that bring its conclusions into question. These are summarized in a rebuttal to the original paper by Hoekendijk *et al.,* (2018) which calls for "a cautious, critical, and rational assessment of the results and interpretations". One of the key issues highlighted is that the porpoise were trapped in a pound net for 24+ hours before tagging and were not allowed to recover from stress and starvation once released. The high levels of foraging observed don't necessarily represent the typical foraging – i.e. they are not necessarily indicative of vulnerability to disturbance. Foraging behaviour after release may in part be a response to being captured and held. It is typical for the initial data recorded from tags to be excluded from analysis as it is not expected to be representative of typical behaviour (e.g. Wright *et al.,* 2017). Given that the tags on the porpoise in Wisniewska (2016) only recorded for 15-23 hours after tagging, it could be considered that all of the data are impacted by the response to being caught and tagged, and thus none of it is representative of typical behaviour. Wisniewska *et al.,* (2018) responded to the rebuttal by Hoekendijk *et al.,* (2018) by

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
		highlighting that it was unknown whether or not the captured porpoise fed while in the pound nets or whether this would have led to elevated stress. They state that the hunger levels of the released porpoise were unknown and that there was no evidence of prolonged response to the tagging circumstances. Further to this, a subsequent paper by Booth (2019) used the Wisniewska (2016) data combined with additional information on porpoise diet and the energy derived from different prey to highlight that the tagged animals likely were able to consume significant amounts of energy (well in excess of energetic requirements – based on the data available). This paper disputes the conclusion that porpoise exist on an "energetic knife-edge" as Wisniewska (2016) claims but does not justify in his paper.
20th July 2023 Section 42 Natural England	The text in section 4.1 of Appendix 3.2 states that table 4-2 to Table 4-13 presents the modelling results for the monopile foundation modelling scenarios 'assuming two sequential monopile installations.' However, Table 4-3, Table 4-7, 4-11 and 4--13, indicate Sound Exposure Level from cumulative exposure (SEL_{cum}) ranges that are just from modelling a single monopile.	Updated modelling results have been presented in the UWN Assessment (document reference: 6.3.11.2). Section 11.6 of this ES has been updated accordingly.

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
	Natural England requires clarification on which scenarios are being presented in these tables. The impact ranges should be presented for a single pile and for sequential piles. The submitted ES should provide clarification and present the impact ranges for all piling scenarios. Ensure the Worst-Case Scenario (WCS) is clearly presented.	
20th July 2023 Section 42 Natural England	Natural England defer to Cefas as the underwater noise specialists on the plausibility of the piling Permanent Threshold Shift (PTS)/Temporary Threshold Shift (TTS) impact ranges and the UXO clearance PTS/TTS impact ranges presented in this report. To note.	Noted. The impact ranges have been presented and discussed in section 11.6
20th July 2023 Section 42 Natural England	Provide justification as to why a maximum 800kg UXO size has been estimated within the Underwater Noise assessment Appendix. The submitted ES should provide justification for the UXO size selected.	The estimation of a maximum of 800kg UXO size has been detailed in Paragraph 152 .
20th July 2023 Section 42 Natural England	The maximum design scenario detailed in Table 11.7 of Chapter 11 of the PEIR states that there will be a maximum of two monopile events per day of which there could be a maximum of two simultaneous piling events/day. Similarly in section 11.3.27 of the RIAA it indicates that ‘Piling may be consecutive (single piling event per 24-hours) or concurrent (up to two piling rigs per 24-hours). In the Underwater Noise Assessment (Volume 2, Appendix 3.2) sequential modelling is also referred to but is not mentioned in these design scenarios. It is not clear how sequential piling fits into the described scenarios. The submitted ES should provide clarification on the different piling scenarios. And make sure that terminology is clearly defined and used consistently across reports.	Piling scenarios are detailed in the Chapter 3 (document reference 6.3.3) and the UWN Assessment (document reference 6.3.11.2).

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
20th July 2023 Section 42 Natural England	The text states 'Based on agreed density estimates for each species presented in document reference 6.3.11.2, 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'. Should this say 'Volume 2 Appendix 11.1 Marine Mammals technical Baseline' as no density estimates are presented in Appendix 3.2. The submitted ES should clarify/amend this point.	This cross reference has been amended.
20th July 2023 Section 42 Natural England	Natural England request to be consulted on any geophysical survey applications for the project. Please consult Natural England on any geophysical surveys for the project.	This is noted by the Project.
20/07/2023 Section 42 Natural England	Natural England notes that an indicative assessment has been provided for UXO clearance within this document and that a separate Marine Licence will be submitted when more information on the number and size of UXOs (Unexploded Ordnance) in the area become available. We agree with this approach. No further action needed	This is noted by the Project.
20th July 2023 Section 42 Natural England	Natural England does not agree with the assigned 'Negligible' magnitude for PTS from UXO clearance and piling. Considering that the PTS constitutes irreversible hearing damage, more appropriate magnitude would be 'Medium', as per the definition provided in Table 11.9. With the implementation of appropriate mitigation measures, we advise that the residual magnitude could be reduced to 'Low'. Amend the submitted ES accordingly.	The Project's Outline MMMP for Piling Activities (document reference 8.6.1) and Outline MMMP for UXO Clearance (document references 8.6.2) detail the potential mitigation measures which may be proposed in order to reduce the risk of PTS auditory injury to marine mammal from these operations to as low as reasonably practicable. The final MMMPs for the Project will be approved by the regulator and their advisors prior to the noisy

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
		activities occurring. Therefore, the Project are confident that this would equate to an impact of 'negligible' magnitude.
20th July 2023 Section 42 Natural England	Natural England considers that the assigned magnitude and sensitivity is downplayed throughout the assessment (for the project alone and the cumulative assessment) for all species and especially for Harbour porpoise. Thus, we recommend that the assigned scores are revised to consider the sensitivity of marine mammals to underwater noise, especially when it comes to impacts of UXO clearance and piling. Also, there does not seem to be a 'hierarchy' of assigned scores between high and low impact activities. For example, sensitivity score 'Low' is assigned for PTS from UXO clearance and piling as well as for disturbance from other construction activities, despite these impacts being substantially different. Review assigned magnitude and sensitivity scores for all species and update the submitted ES accordingly.	Magnitude scores have been presented both pre- and post-mitigation for clarity in section 11.6. The definition text for the Project is the same as has been used by previous projects and agreed with Natural England, only the terminology ranking for magnitude differed. The magnitude scores have been renamed to align with other projects after discussions with Natural England and the levels of sensitivity are therefore the same. Whilst the impacts are different, this does not preclude the sensitivity of the receptor being assessed as the same as it is dependent on how the receptor reacts to the impact and what consequences may arise from the impact. Full justifications for the magnitude and sensitivity scores are provided within the assessment.
20th July 2023 Section 42 Natural England	For impacts to bottlenose dolphin the texts states that the applicant is considering 'two different density estimates: 0.002 dolphins/km² (throughout entire impact range) and 0.110 dolphins/km² (2km from coast)' to account for the east coast Scottish population (associated with the Moray Firth SAC). However, throughout the impact assessment there only seems to be one density estimate used and only one figure for each assessed	Table 11-4 and Table 11-50 have been updated to more clearly present the quantitative impact assessment using two different density estimates for bottlenose dolphins, which are 0.0419 dolphin/km^2 for Project study area and offshore region, and 0.110 dolphin/km^2 as a highly precautionary estimate of dolphins within 2km of the

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
	impact presented for bottlenose dolphin. If two density estimates are being used, then both should be presented within the impact assessment. Furthermore, for bottlenose dolphin associated with the Moray Firth SAC, the Coastal East Scotland (CES) management unit (MU) should be used for the reference population.	coast of northeast England in consideration of coastal dolphin population density estimates for the Coastal East Scotland MU. The Coastal East Scotland (CES) MU has been used for reference population for bottlenose dolphin associated with the Moray Firth SAC in the RIAA.
20th July 2023 Section 42 Natural England	The Harbour porpoise dose response curve has been applied for all cetaceans. Whilst this is considered precautionary for dolphin species, there is no evidence that minke whale respond in the same way. Natural England advise that the applicant keeps the evidence base under review and utilise more appropriate methods should they become available. Keep the literature based on disturbance under review and utilise more appropriate methods for the submitted ES should they become available.	The level B harassment threshold, which appears to be a more applicable parameter, as was derived from grey whale responses to seismic surveys, has been considered for disturbance from piling for minke whales and explained in paragraphs 57, paragraphs 58 and Table 11-1.
20th July 2023 Section 42 Natural England	Natural England note that the applicant has presented multiple methods of assessing disturbance from UXO clearance including 26km EDR (Effective Deterrent Ranges) for high order (for all species), 5km EDR for low order (for all species) and TTS-onset as a proxy for disturbance. As highlighted in the text (and in previous discussions). Natural England do not consider TTS as a suitable proxy for disturbance and therefore will be considering the worst-case scenario (26km EDR approach). Consider using the 26km EDR for disturbance effects in the submitted ES. Keep the literature base on disturbance under review and utilise	This is noted by the Project, and the Project will continue to present all options for disturbance from UXO in the absence of established guidance. No new methods have been identified since PEIR; therefore no update has been made to the methods presented.

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
	more appropriate methods for the submitted ES should they become available.	
20th July 2023 Section 42 Natural England	Figures 11.21 and 11.23 of the Marine Mammals PEIR Chapter show the results of the behavioural disturbance noise contours for Harbour/Grey seal overlain on Carter *et al.,* 2022 at-sea density estimates. section 11.7.68 states that the worst-case scenario is predicted to occur at the SW location for Harbour seal and section 11.7.80 states that the NW (Northwest) location is worst for Grey seal. However, both figures show the disturbance contours being modelled at the NE location. Clarification should be provided as to which location disturbance has been modelled for each seal species. The worst-case disturbance scenario (considering the at sea density estimates) should be presented and used in the assessment. Review the disturbance modelling for seals and present the worst-case scenario with regards to at sea densities in the submitted ES.	Figure 11.4 and Figure 11.5 have been updated for clarity, however it should be noted that the assessments presented in the PEIR were based on the maximum number of individual disturbance, rather than the value for the Northeast (NE) location (which had the largest impact ranges).
20th July 2023 Section 42 Natural England	The offshore reactive compensation platform (ORCP) area has the potential to cause more disturbance to Harbour seal given its proximity to the Wash population (potentially up to 4.22% of the MU). Natural England therefore do not agree that this should be considered as low magnitude, especially giving the recent population decline of Harbour seal in this population. A figure showing the disturbance contours for Harbour seals at the ORCP area (similar to the one presented for the main array area) is needed.	The ES assessment has been updated based on the revised noise modelling for the Project. The justification for the magnitude of effect is described in paragraph 445.
20th July 2023 Section 42 Natural England	Table 11.7 states that during construction the peak number of vessels in a given 5km^2 area is 8, whilst Para.11.7.175 it says up to 10 vessels per 5km^2.	Table 11-7 has been updated accordingly to confirm the peak number of vessel in a given 5km^2 is 10.

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
	Review and clarify what the peak number of vessels per 5km2 area is during construction and operation and use this information in the submitted ES.	
20th July 2023 Section 42 Natural England	The vessel collision risk impact assessment is brief and could be presented in more depth. Additionally Natural England have not been provided the Vessel Management Plan (VMP) and therefore cannot agree at this stage that it will sufficiently minimise the potential for any potential collision risk. Please provide a more thorough assessment of vessel collision risk in the submitted ES. We also recommend that a draft VMP is provided within the submitted ES.	Please refer to the Outline VMP (document reference 8.20) submitted along with this ES for more information. The Project has used the Humber ports as an indicative construction base and therefore collision risk is based on that basis and the standard mitigations for VMP, such as following existing routes where possible, are included.
20th July 2023 Section 42 Natural England	The statement in this para. 11.7.126 on the presence of the novel vessels on site (“The introduction of additional vessels during construction of the Project is not a novel impact for marine mammals present in the area”) seems contrary to the statement made in paragraph 11.7.87. This states that “In addition to this mitigation, it is also likely that the presence of novel vessels and associated construction activity will ensure that the vicinity of the pile is free of Harbour porpoise by the time that piling begins.” The former statement suggests that Harbour porpoises are habituated to the presence of vessels, while the latter suggests that the vessels on site do disturb and deter the animals prior to the construction activities.	Paragraph 515 has been revised for further clarification.
20th July 2023 Section 42 Natural England	As mentioned in previous comments, Natural England have not been provided with the VMP and therefore cannot agree at this stage that it will sufficiently minimise the potential for impact from vessel disturbance. Please provide a draft VMP as part of the submitted ES.	Please refer to the Outline VMP (document reference 8.20) issued at this ES for more information.

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
20th July 2023 Section 42 Natural England	Assigned magnitude 'Negligible' is not sufficiently precautionary given the importance of prey to marine mammals, thus we would advise that this is revised to 'Low'. Please update presented magnitude in the submitted ES.	Section 482 been updated as per revision of Chapter 10 (document reference 6.1.10).
20th July 2023 Section 42 Natural England	Given the uncertainty around the noise emitted by the larger turbines, we are not confident in the statement "…it is unlikely that operational noise is expected to be of a level that would result in any disturbance effect." Thus, it would be more precautionary to assign 'Low' magnitude for disturbance instead of 'Negligible'. Review and provide further evidence to support the statement or amend the conclusion in the submitted ES.	The magnitude score has remained as Negligible and is detailed in paragraph 512.
20th July 2023 Section 42 Natural England	Natural England notes that the locations for the construction (and operation/maintenance) ports have not been confirmed. Therefore, Natural England do not agree that disturbance at seal haul out sites can be assessed as having a 'negligible impact' until more information is provided regarding these locations. Provide port locations or likely options in the submitted ES and review the likely level of disturbance to seal haul-out sites from each location.	Please refer to the Outline VMP (document reference 8.20) submitted alongside this ES for more information. The Project has used the Humber ports as an indicative construction base and therefore collision risk is based on that basis and the standard mitigations for VMP, such as following existing routes where possible, are included.
20th July 2023 Section 42 Natural England	As Natural England have advised that changes to prey should be assigned a 'Low' significance as opposed to 'Negligible' this impact should also be considered in the cumulative assessment. Include 'Changes to Prey' in the cumulative assessment	Table 11-93 has been updated as per revision of Chapter 10 (document reference 6.1.10).
20th July 2023 Section 42 Natural England	Natural England recommend that collision risk is scoped into the cumulative assessment and the draft VMP is provided for review. Include collision risk in the cumulative assessment and provide the draft VMP in the submitted ES.	Please refer to the Outline VMP (document reference 8.20) submitted alongside this ES for more information.

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
20th July 2023 Section 42 Natural England	Provide justification to why 'it has been assumed that four seismic surveys could be conducted within the North Sea at any one time'. Provide justification for the assumption in the submitted ES.	Justification has been supplemented in paragraph 576 accordingly.
20th July 2023 Section 42 Natural England	Natural England notes that no project level separation distance (for piling) has been set but that 'there remains potential for a separation distance to be applied to the Project as mitigation, if required.' Natural England request to be included in any further discussions regarding a potential piling separation distance.	This is noted by the Project.
20th July 2023 Section 42 Natural England	Natural England have not been provided with the VMP (Vessel Management Plan) and therefore are unable to assess its suitability at reducing collision risk. Therefore, Natural England advise that collision risk is screened into the in-combination assessment and that the VMP is provided for review. Include collision risk in the in-combination assessment and provide the VMP as part of the submitted ES.	Collision risk has been included in section 11.7 accordingly. Please refer to the Outline VMP (document reference 8.20) submitted alongside this ES for more information.
20th July 2023 Section 42 Natural England	Natural England note that auditory injury from underwater noise has not been included in the in-combination assessment as 'mitigation will be put in place to reduce injury risk.' Natural England's agreement of this approach is subject to agreement of the mitigation. Please refer to comments regarding the piling MMMP and absence of UXO MMMP. Refer to above comments regarding piling and UXO MMMP's.	This is noted by the Project. See Outline MMMP for piling activities (document references 8.6.1) and Outline MMMP for UXO clearance (document reference 8.6.2) submitted alongside the DCO application. Underwater noise has been assessed in section 11.6 and the significance conclusions are presented for both unmitigated and mitigated piling and UXO clearance.
20th July 2023 Section 42 Natural England	Soft start duration is recorded as 600s. JNCC recommends the soft-start duration for piling of monopiles and pin-piles is at least 20 minutes (1200s) (JNCC (2010) 'Statutory nature conservation agency	The Project notes that JNCC (2010) defines the soft-start as: "the gradual ramping up of piling power, incrementally over a set time

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
	protocol for minimising the risk of injury to marine mammals from piling noise'). Amend soft start duration in the submitted outline MMMP to align with JNCC guidance.	period, until full operational power is achieved." Under this definition, the full operational power at the Project is not reached until 6,000 sec (100 min) after the first blow (see Table 32 in the UWN Assessment (document reference 6.3.11.2)).
20th July 2023 Section 42 Natural England	Natural England acknowledges that a detailed communication protocol will be published in the final MMMP. We will review this when provided.	This is noted by the Project.
20th July 2023 Section 42 Natural England	No information is provided to confirm the Marine Mammal Observers (MMOs) will have standard required qualifications and experience, understand the mitigation procedures of the project, and have all the necessary equipment to effectively carryout the mitigation. Expertise requirements for MMOs should be confirmed in the final version of the MMMP.	The Project confirms that expertise and equipment requirements for MMObs will be confirmed in the final versions of the Piling and UXO Clearance MMMPs post-consent.
20th July 2023 Section 42 Natural England	Limited information has been presented on the procedure following a break in piling. In the final MMMP provide detail and include the actions taken if a break in piling occurs during reduced visibility (i.e., during fog, night-time, and increased sea state). In the final version of the MMMP provide a detailed protocol for when a break in piling occurs.	As stated in the Outline MMMP for Piling Activities (document reference: 8.6.1), the Project will confirm the final procedure for breaks in piling, with input from the piling contractor and SNCBs, and present this information in the Final Piling MMMP post-consent.
21st July 2023 Section 42 MMO	The MMO notes the relevant impacts that have been scoped in for assessment. The MMO, would expect the impact of UXO Clearance and TTS to be considered, alongside Permanent Threshold Shift (PTS) and disturbance. The MMO notes that a separate Marine licence application will be submitted for UXO, however disposal of UXO is	The impact of UXO clearance and associated TTS impact ranges have been presented in section 11.6. Full details of the underwater noise modelling and the resulting PTS-onset impact areas and ranges

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
	included in the impact assessment and other impacts should also be assessed. Noting that a detailed UXO survey will be completed prior to construction and that the type, size and number of possible detonations and duration of UXO clearance operations is not known at this stage, but disposal of UXO is included in the impact assessment.	are detailed in the UWN Assessment (document reference 6.3.11.2). In view of the uncertain size of possible detonations required, an estimation of the source level and predicted PTS- and TTS-onset impact ranges were calculated for a range of expected UXO sizes and detailed in paragraph 181.
21st July 2023 Section 42 MMO	For assessing disturbance from pile driving, a species-specific dose-response approach has been adopted, which is appropriate. Noise contours at 5dB 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 (paragraph 11.6.18). The report refers to appropriate literature, e.g., Graham *et al.,* (2017) for harbour porpoise, and Whyte *et al.,* (2020).	A dose-response curve has been adopted as detailed in section 11.5.11. The species-specific numbers of behaviourally disturbed individuals by pile driving have been listed in 11.6.
21st July 2023 Section 42 MMO	As per section 11.6.24, the MMO agrees that there is no disturbance threshold (effective disturbance range or dose-response function) for any other cetacean species included in this assessment. Therefore, in the complete absence of an alternative, the assessment for all cetacean species has used the porpoise dose-response function. This is considered highly precautionary and as such the number of animals predicted to experience behavioural disturbance is considered to be an overestimate and should be interpreted with a large degree of caution. The MMO welcomes this approach. Further, as per section 11.6.27, 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. The MMO agrees	A dose-response curve has been adopted as detailed in section 11.5.11. The adoption of porpoise dose-response function for other cetacean species and harbour seal dose-response function for grey seal has been described in section 11.5.4.

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
	with this approach and that this is considered to be an appropriate proxy for grey seals, since both species are categorised within the same functional hearing group.	
21st July 2023 Section 42 MMO	UXO - For UXO clearance, the MMO welcomes that the 26 km Effective Deterrence Range (EDR) for assessing disturbance has been applied to harbour porpoise and other marine mammal species. While the MMO recognises the lack of data for other marine mammal species, the harbour porpoise EDRs are likely to be conservative (as porpoise are so sensitive to underwater noise) and believes these are a reasonable option in the absence of other data. For low order UXO clearance, it is noted that a 5 km EDR has been assumed, although there is currently no advised EDR in the Statutory Nature Conservation Bodies (SNCB) guidance (Joint Nature Conservation Committee, 2020). The MMO notes it was requested that justification was provided to support the 5 km EDR, and section 11.6.34 states the following: "In the absence of empirical data with which to set a threshold, the Sofia Offshore Windfarm Marine Licence Application for UXO detonation assumed a 5km EDR for low-order detonations. This assumed EDR was based on the fact that data has shown that low-order deflagration detonations produce underwater noise that is over 20dB lower than high-order detonation (Robinson *et al.,* 2020). Note, the Sofia Offshore Windfarm Limited committed to undertaking noise monitoring of low-order detonations to confirm this proportionally lower noise level however, the data are not yet available. Until such time as empirical data are available to inform the EDR for low-order detonations, the 5km EDR suggested by Sofia Offshore Windfarm has been assumed". The MMO recommends that further evidence is provided to justify the 5 km EDR.	The adoption of a 5km EDR has been further discussed in paragraph 76. A 5km EDR has been assumed for low-order UXO clearance for all species (as per the Sofia Offshore Windfarm Marine Licence application for UXO detonation) and based on the difference between the expected sound levels of low-order and high-order UXO clearance, rather than the sensitivity of different species. The JNCC MNR disturbance tool (JNCC, 2023) provides default and worst-case EDRs for various noise sources, and lists default low-order UXO clearance EDR as 5 km. The 26km EDR has been adopted alongside the presentation of TTS-onset as a proxy for disturbance from UXO clearance. For additional details see paragraph 86.

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
	The MMO advises that it is not appropriate to use TTS-onset thresholds as a proxy for disturbance from UXOs. TTS occurs at much higher sound exposures, and so will underestimate the risk of disturbance. In this instance, TTS-onset as a proxy for disturbance has been presented alongside the 26 km EDR approach in acknowledgement that there is no empirically based threshold to assess disturbance from high-order UXO clearance currently available.	
21st July 2023 Section 42 MMO	Table 11.7 states the maximum design scenario assessed is 93 WTG foundations with a maximum 8 hours per pile. The piling profile in the underwater noise assessment in Appendix 3.2: Underwater Noise Assessment, assumes 4 hours per monopile. Furthermore, it is stated that there will be a maximum of 12 hours piling per day, but a maximum of two monopiles could be installed in 24-hours. The MMO requests clarification regarding these inconsistencies.	The total piling duration stated in Chapter 3 is the duration of piling works at each piling location, including set-up and retrieval works or any breaks in piling, rather than reflecting the period of continuous noise generation. The UWN Assessment (document reference 6.3.11.2) has been updated to reflect the ES Project parameters of 100 WTG foundations with a maximum of 8 hours per pile. The project description has been updated for the ES and is presented in Table 11-7.
21st July 2023 Section 42 MMO	It is noted that within section 11.7.101 it states "For all non-piling construction activities assessed (Table 11.32), the PTS-onset impact ranges are <100 m. Therefore, non-piling construction noise sources will have a local spatial extent and are transient and intermittent. This means that, with the most precautionary estimates, a marine mammal would have to remain within proximity (< 100 m) for a 24-hour period for PTS-onset to occur". The MMO believes that this statement / conclusion is incorrect. The modelling is based on a fleeing receptor, and, therefore, the receptor	The statement has been updated in Table 11-53 and Table 11-54 in the UWN Assessment (document reference 6.3.11.2) present the PTS and TTS impact ranges for both fleeing and static receptors.

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
	is simply at risk if they are within 100 m of the source when they start to move away (fleeing is about the receptor starting position). The MMO recommends that this is corrected here, and throughout the report.	
21st July 2023 Section 42 MMO	Given the availability of effective alternatives to unmitigated piling – i.e., measures to reduce noise at source, also known as noise abatement – it will be difficult for unmitigated pile driving to be justified on the basis that there are no realistic alternatives. It is therefore clear that noise abatement measures will likely be required for this development, in order to reduce the risk of potential impact on marine receptors.	The Project will follow best practice guidance during the construction phase regarding noise abatement systems (NAS) if these are established mitigation measures for piling in the UK at the time of construction. Potential NAS that could be considered are detailed in the Outline MMMP for Piling Activities (Document reference: 8.6.1) and the Outline MMMP for UXO Clearance (document reference:8.6.2). The details of the final MMMP will be agreed once the final project design is known (Table 11-8). Compliance with the MMMP is secured in the DCO. The Applicant has now committed to deploying primary and/or secondary noise reduction methods (Noise Abatement Systems) for pile driving as secured in Outline MMMP for Piling Activities (Document reference: 8.6.1) and In Principle SNS SAC SIP (document reference 8.7).
21st July 2023 Section 42 MMO	The MMO would highlight that given the wider context of the current ramp up of offshore wind development at unprecedented scale in the North Sea it is vital that these discussions begin as soon as possible.	The Project will follow best practice guidance and the advice of SNCBs during the construction phase regarding NAS if

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
	To ensure adequate preparations are made and potential delays avoided, it is therefore in the applicant's interest to plan for noise abatement measures at the earliest opportunity and to incorporate such measures into any future Marine Mammal Mitigation Plans (MMMP).	these are established mitigation measures for piling in the UK at the time of construction. Potential NAS that could be considered are detailed in the Outline MMMP for Piling Activities (Document reference: 8.6.1) and Outline MMMP for UXO Clearance (Document reference: 8.6.2). The details of the final MMMP will be agreed once the final project design is known (Table 11-8). Compliance with the MMMP is secured in the DCO. The Applicant has now committed to deploying primary and/or secondary noise reduction methods (Noise Abatement Systems) for pile driving as secured in Outline MMMP for Piling Activities (Document reference: 8.6.1) and In Principle SNS SAC SIP (document reference 8.7).
21st July 2023 Section 42 MMO	Overall, with the assumed source levels (SLs) (which are not particularly large, considering a hammer energy of 6,600 kJ, and a 14 m diameter monopile), the predictions look plausible / reasonable. It is important to note that measured data for large diameter (mono)piles and high hammer energies, such as those reported here, are lacking. Thus, there are associated uncertainties with the SLs and the subsequent modelling predictions.	This is noted by the Project. The modelling confidence is detailed in section 3.1 of the UWN Assessment (document reference 6.3.11.2).
21st July 2023 Section 42 MMO	The general approach / methodology to the underwater noise modelling is largely appropriate, and effort has been undertaken to produce an informative report, along with details of the input	This is noted by the Project.

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
	parameters used in the modelling. The assessment refers to appropriate noise exposure criteria for marine receptors. The MMO agrees with the report that at the time of writing, Southall *et al.,* (2019) and Popper *et al.,* (2014) represent the most up-to-date and authoritative criteria for marine mammals and fish respectively.	
21st July 2023 Section 42 MMO	Section 3 states: "The current version of INSPIRE (version 5.1) is the product of re-analysing all the impact piling noise measurements in Subacoustech's environmental measurement database and cross-referencing it with blow energy data from piling logs…. the current version of INSPIRE attempts to calculate closer to the average fit of the measured noise levels at all ranges". The MMO welcomes this clarification, and we acknowledge the drive for reducing unnecessary conservatism in modelling. Allegedly, the current version of INSPIRE should produce more realistic predictions.	This is noted by the Project.
21st July 2023 Section 42 MMO	Figure 3-1 in Appendix 3.2 presents a comparison between example measured impact piling data and modelled data using INSPIRE version 5.1. However, this comparison is lacking context. Firstly, the MMO notes that the pile sizes used in this comparison are much smaller (i.e., 1.8 m, 9.5 m, 6.1 m and 6.0 m) than the proposed 14 m diameter monopiles for Outer Dowsing. It is not clear how INSPIRE scales up the smaller piles. Additionally, the MMO requests clarification on whether other factors, such as the penetration depth and the water depth, have been considered in the modelling of the source levels. Secondly, the comparison should make clear the hammer energies used and whether they are relevant for this application. (It is very	This has been further elaborated in the UWN Assessment (document ref: 6.3.11.2).

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
	unlikely that these hammer energies are close to the proposed 6,600 kJ hammer energy for Outer Dowsing). Furthermore, the comparisons presented in Figure 3-1 are for the SPL_{peak} only, while for the vast majority of the predictions in this appendix, which are derived from SEL_{cum} calculations, the relevant metric is the single strike SEL_{ss}, and not SPL_{peak}. There is a lack of transparency in the modelling of these parameters which are crucial for determining the model predictions is not acceptable, and these details must be transparent within the ES. Three locations have been modelled inside the Order Limits and a further two positions located in the offshore reactor station study area of the ECC have been modelled (section 3.2.1, Table 3-1 and Figure 3-2). The report confirms that in a 24-hour period, there may be up to two monopile foundations or four jacket pile foundations driven; it is appropriate that this is considered in the modelling as a worst case. It should be noted that, for the ECC locations only a single monopile installed in a 24-hour period has been considered; both a single and four sequentially installed jacket piles have been assumed for these locations.	
21st July 2023 Section 42 MMO	Table 4-2 to Table 4-13 present the modelling results for the monopile foundation modelling scenarios, assuming two sequential pile installations. The MMO notes that the headings for these tables (i.e., Table 4-3, 4-5, 4-7 and 4-9 etc.) state that the results are based on a single monopile foundation. The MMO requests that this is clarified and amended in the report.	Tables 4-4, 4-7, 4-9, 4-12, 4-14, and 4-17 in the UWN Assessment (document ref: 6.3.11.2) have been amended to show the results for both single pile and two sequential pile installations.

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
21st July 2023 Section 42 MMO	This formula represents a statistical model that was used to assess the correlation between SPL and various parameters (distance, wind speed, turbine size) for the data in the Tougaard study. The MMO considers is that this is not suitable for estimation of the sound levels at 1m in a bespoke model, or as substitute for modelling the propagation loss to the far field. In particular, in terms of estimating propagation, the use of the formula would imply a loss of 23.7 log R, which is unrealistically large, and thus will lead to underestimation of the levels in the far field.	This has been further elaborated in the UWN Assessment (document ref: 6.3.11.2).
21st July 2023 Section 42 MMO	It is appropriate that the estimation of the noise source level for each charge weight has been carried out in accordance with the methodology of Soloway and Dahl (2014). It is noted that an attenuation correction has been added to the Soloway and Dahl (2014) equations for the absorption over long ranges (i.e., of the order of thousands of metres), based on measurements of high intensity noise propagation taken in the North Sea and Irish Sea.	This is noted by the Project.
21st July 2023 Section 42 MMO	The maximum PTS range calculated (based on the worst-case UXO) is 14 km for VHF cetaceans (SPL_{peak} criteria) (with a TTS range of 26 km). For fish, the maximum range is 930m. The MMO has conducted a spot check of the worst-case predictions which look reasonable (a PTS prediction of ~14 km for VHF cetaceans assuming the methodology from Soloway and Dahl and no attenuation correction).	This is noted by the Project.
21st July 2023 Section 42 MMO	The MMO welcomes this outline plan and will continue to engage on what is included within this document.	This is noted by the Project.
Evidence Plan ETG Meetings		
1st August 2023 ETG	This ETG discussed the key concerns raised by stakeholders in the Section 42 feedback described above.	All the comments discussed have been addressed as outlined in the Section 42 comments above.

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
11th September 2023 ETG,	Cefas stated that if water depths were taken into account the noise modelling locations were suitable. The MMO were to confirm whether the updated noise modelling locations were suitable for the assessments.	The water depth has been considered in this ES chapter, alongside the location to areas of high densities for harbour seals.
11th September 2023 ETG,	Natural England asked that other Projects be checked within the Southern North Sea, including OWFs and hydrogen interconnectors to make sure these are being considered in the cumulative impact assessments.	The CEA has been updated and CCUS, interlinks and cables have been screened into the longlist where there was publicly available information.
11th September 2023 ETG,	Cefas stated there is a clarification request for the Subacoustech report to add more information relating to simultaneous piling.	The difference in the calculated areas was a consequence of rounding, and rounding was generally up. All ranges and areas presented were to two significant figures, and thus (as an example), if the SW area was modelled at 415km^2 (rounded to 420) and the NE area was modelled at 1250km^2 (rounded to 1300) then the actual area would be 1,665km^2, which would be rounded to 1,700km^2. Further justification has been provided in the ES and the matric adjusted.
11th September 2023 ETG,	Natural England asked whether the Project had any more thoughts of observations of mother-juvenile pairs from the baseline, as there is not much known on porpoise nursery grounds. Natural England explained that they would like to see details on locations and times of years for the calves.	Any additional information about the mother-juvenile pairs within the Southern North Sea since PEIR has been included in the ES chapter.
11th September 2023 ETG	Natural England explained that Hornsea Four used a four scale approach to their sensitivity scores which the Project also does, However, the sensitivity scores do not align.	This has been addressed within Section 11.6, with the matrix now aligning with the Hornsea Four method.

9. As identified in Volume 1, Chapter 4: Site Selection and Consideration of Alternatives (document reference 6.1.4) and Chapter 3 (document reference 6.1.3), the Project design envelope has been refined throughout the stages of the Project prior to DCO submission. This process is reliant on stakeholder consultation feedback.

11.4 Scope

11.4.1 Study Area

10. The Project marine mammal study area varies depending on the species, considering individual species ecology and behaviour (Plate 11.1). The marine mammal study area has been defined at two spatial scales:

- The Management Unit (MU) study area: provides a wider geographic context in terms of species present and their estimated densities and abundance. This scale defines the appropriate reference populations for the assessment. The regional study area for each species is as follows:
  - Harbour porpoise: North Sea MU;
  - White-beaked dolphin: Celtic and Greater North Seas MU;
  - Bottlenose dolphin: Greater North Sea MU;
  - Minke whale: Celtic and Greater North Seas MU;
  - Grey seals: Southeast England MU and Northeast England MU; and
  - Harbour seals: Southeast England MU.
- The Project study area: includes the survey area for the Project site-specific aerial surveys (the AfL array area + 4km buffer) to provide an indication of the local densities of each species across the windfarm array area.

11.4.2 Data Sources

11. Table 11-3 outlines the baseline datasets that exist for the study area.

Table 11-3 Marine mammal baseline datasets

Source	Summary	Spatial Coverage
Site-specific surveys (HiDef, 2022; 2023)	Site-specific baseline characterisation digital video aerial surveys (March 2021 – February 2023).	The Project AfL array area plus 4km buffer.
The Project Site-specific geophysical surveys (Seiche 2022a; 2022b)	Marine Mammal Observer (MMOb) and PAM detections during surveys conducted between August 2021 – January 2022 MMOb and PAM detections during surveys conducted between April 2022 and July 2022.	The Project array area plus 500m buffer. Plus, coverage of the Silver Pit area to the west of the array.
Small Cetaceans in European Atlantic waters and the North Sea	Aerial and vessel visual surveys for cetaceans, June and July 2016.	North Sea and European Atlantic continental shelf

Source	Summary	Spatial Coverage
(SCANS) III (Hammond *et al.,* 2021)		waters. The Project is located in aerial survey block O.
Estimates of cetacean abundance in European Atlantic waters in summer 2022 from the SCANS-IV aerial and shipboard surveys (Gilles *et al.,* 2023)	Aerial and vessel visual surveys for cetaceans, June and July 2022.	North Sea and European Atlantic continental shelf waters. The Project is located in aerial survey block NS-C.
Joint Cetacean Protocol (JCP) Phase III (Paxton *et al.,* 2016)	38 data sources (aerial, vessel and land-based surveys) between 1994 - 2010. Species abundance estimates provided for each season for specific areas of commercial interest for all offshore development types (i.e., Oil & Gas, Offshore Renewables, Decommissioning Projects).	UK waters. Nearest areas of commercial interest for which data are available are Norfolk Bank and South Dogger Bank.
JCP Data Analysais Tool	The JCP Phase III Data Analysis Product has been used to extract abundance estimates averaged for summer 2007-2010 and scaled to the SCANS III estimates for user specified areas.	UK waters. User specified area for data extraction.
Marine Ecosystems Research Programme (MERP) (Waggitt *et al.,* 2020)	Species distribution maps available at monthly and 10 km^2 density scale. Collation of data from JCP (aerial and vessel), 1980-2018.	European Atlantic Waters.
Harbour porpoise densities (Heinänen and Skov, 2015)	Vessel and aerial surveys, 1994 – 2011.	UK waters.
Sea Watch Foundation Sightings	Seawatch Foundation Regional Group 10 (Lincolnshire: River Humber to Nene River Mouth). Sightings recorded between 26th July 2023 to 25th September 2023, data was accessed 9th October 2023.	Lincolnshire.
Special Committee on Seals (SCOS) reports (SCOS, 2023)	Scientific Advice on Matters Related to the Management of Seal Populations. This outlines the current status of both harbour and grey seals in the UK.	UK wide.
Seal haul-out data provided by Sea Mammal Research Unit (SMRU)	August haul-out surveys of harbour and grey seals. Latest haul-out counts are available from surveys in 2021.	UK wide.
Grey seal pup counts (provided by SMRU)	Surveys of the main UK grey seal breeding colonies annually between mid-September and late-November to estimate the numbers of pups born at the main breeding colonies.	UK wide.

Source	Summary	Spatial Coverage
Seal telemetry data provided by the Sea Mammal Research Unit (SMRU)	Data on movement of both harbour and grey seals from tagged individuals. A total of 86 harbour seals have been tagged in Southeast England MU since 2003. A total of 33 grey seals have been tagged in the Southeast England MU since 1998 and a further 31 have been tagged in the Northeast England MU.	UK wide.
Seal habitat preference maps (Carter *et al.,* 2020; 2022)	Density surface based on telemetry and count data.	UK waters.
EU seal telemetry data	Telemetry data from various studies on grey (Brasseur et al., 2015a, Brasseur *et al.,* 2015b, Vincent *et al.,* 2017; Aarts *et al.,* 2018) and harbour seals (Brasseur *et al.,* 2012, Brasseur and Kirkwood 2015, Vincent *et al.,* 2017) tagged in Netherlands, France and the Wadden Seas to assess connectivity to European sites.	EU waters.
Nearby OWFs	Site-specific data collated at nearby OWFs: ▪ Dudgeon & Sheringham Shoal Extensions ▪ Race Bank ▪ Triton Knoll ▪ Sheringham Shoal ▪ Dudgeon ▪ Docking Shoal ▪ Lincs ▪ Lynn ▪ Inner Dowsing ▪ Hornsea Project One ▪ Hornsea Project Two ▪ Hornsea Project Three ▪ Hornsea Project Four ▪ Humber Gateway ▪ Westermost Rough	OWF array area plus buffer (varies by site).

11.4.3 Existing Environment

12. The existing environment for marine mammals is thoroughly described in the Marine Mammals Technical Baseline (document reference 6.3.11.1), with a concise summary provided herein. It is advisable to review this ES chapter in conjunction with document reference 6.3.11.1, which evaluates the various species, as well as the abundance and density of marine mammals that may potentially be affected by the Project. This assessment is informed by data gathered from previous OWF projects and surveys covering the marine mammal MUs encompassing the Project array area.
13. The data available (see section 12 for details of data sources) have confirmed the likely presence of harbour porpoise, minke whale, white beaked dolphin, bottlenose dolphin, grey seal and harbour seal in the vicinity of the Project and, therefore, these species should be considered within the quantitative impact assessment. The most robust and relevant density estimates within each MU were determined for each species, with harbour porpoise estimated to have the highest density within its respective MU (Table 11-4).

Table 11-4 Marine mammal MU and density estimates (#/km^2) taken forward to impact assessment

Species	MU	MU size	MU ref	Density (individuals/km^2)	Density ref
Harbour porpoise	North Sea	346,601	IAMMWG (2023)	1.63 (monthly average across all surveys) 2.63 (average summer only estimate)	HiDef, (2023)
				Grid cell specific	SCANS III density surface (Lacey *et al.,* 2022)
				0.6027	SCANS IV (Gilles *et al.,* 2023)
White beaked dolphin	Celtic and Greater North Sea	43,951	IAMMWG (2023)	0.0006 (monthly average)	HiDef, (2023)
				Grid cell specific	SCANS III density surface (Lacey *et al.,* 2022)
				0.0149	SCANS IV (Gilles *et al.,* 2023)
Bottlenose dolphin	Greater North Sea	2,022	IAMMWG (2023)	0.0419	SCANS IV (Gilles *et al.,* 2023)

Species	MU	MU size	MU ref	Density (individuals/km^2)	Density ref
				0.110[5]	Uniform density within 2km from mainland Scotland within the Coastal East Scotland MU
Minke whale	Celtic and Greater North Sea	20,118	IAMMWG (2023)	Grid cell specific	SCANS III density surface (Lacey *et al.,* 2022)
Harbour seal	Southeast England	4,868	SCOS (2023) counts scaled to account for seals at sea using Longeran *et al.,* (2013)	Grid cell specific	Carter *et al.,* (2020, 2022)
Grey seal	Southeast England and Northeast	65,505	SCOS (2023) counts scaled using SCOS (2022) BP 21/03	Grid cell specific	Carter *et al.,* (2020, 2022)

14. Harbour porpoise within the North Sea MU have an estimated abundance of 346,601 (95% CI: 289,498 – 419,967, CV: 0.09) (IAMMWG, 2023). They have an overall conservation status of ‘unknown’ and an overall trend of ‘unknown’ (JNCC, 2019a). Harbour porpoise have a widespread distribution within the MU and were observed at the Project site during the two years of site-specific surveys that have been analysed to date (March 2021 – February 2022). The site-specific surveys obtained an average monthly harbour porpoise density estimate of 1.63 porpoise/km^2 (2.63 porpoise/km^2 summer average). The SCANS III data has been used to obtain predicted density surfaces (Lacey et al., 2022) and data extracted from these density surfaces showed there was a maximum density of 1.29 porpoise/km² the array area and 1.55 porpoise/km² in the ECC. In SCANS IV survey block NS-C there was an estimated block-wide abundance of 36,286 harbour porpoise (95% CI: 23,346 – 56,118) and an estimated density of 0.6027 harbour porpoise/ km2 (CV: 0.228).

[5] Only present within 2 km of the coastline

15. A single MU has been assigned for white-beaked dolphins, the Celtic and Greater North Sea with an estimated abundance of 43,951 (95% CI: 28,439 – 67,924, CV: 0.22) (IAMMWG, 2023). White-beaked dolphins are wide-spread across the continental shelf and three were observed in March 2021 of Project site-specific surveys. The average site-specific monthly estimate has been calculated as 0.0006 individuals/km2. The SCANS III data has been used to obtain predicted density surfaces (Lacey et al., 2022) and data extracted from these density surfaces showed there was a maximum density of 0.001 dolphins/km² the array area and 0.007 dolphins/km² in the ECC. In SCANS IV survey block NS-C there was an estimated block-wide abundance of 894 white-beaked dolphins (95% CI: 12 – 2,387) and an estimated density of 0.0149 dolphins/ km2 (CV: 0.758).
16. The Project is located in the Greater North Sea MU for bottlenose dolphins which has an estimated abundance of 2,022 (95% CI: 548 – 7,453, CV: 0.75) (IAMMWG, 2023). No bottlenose dolphins were identified in the two years of site-specific surveys (March 2021 – February 2023) and neither were any identified in block O of the SCANS III survey (Hammond et al., 2021). The SCANS III data has been used to obtain predicted density surfaces (Lacey et al., 2022) and data extracted from these density surfaces showed there was a maximum density of 0.002 bottlenose dolphin/km² in both the array area and ECC. Additionally, consideration has been provided for densities closer to the coast as the east coast Scottish population has been recorded ranging further south into the coast of northeast England. As there is no reliable estimate for bottlenose dolphin densities in the vicinity of the Project, a highly precautionary estimate of 0.110 dolphins/km² within 2km of the coast of northeast England has been assumed. Therefore, the quantitative impact assessment will present results assuming the two different density estimates: 0.002 dolphins/km² (throughout the entire impact range) and 0.110 dolphins/km² (2km from coast). In SCANS IV survey block NS-C there was an estimated block-wide abundance of 2,520 bottlenose dolphins (95% CI: 57-6,616) and an estimated density of 0.0419 dolphins/ km2 (CV: 0.683).
17. A single MU is implemented for minke whales in UK waters, the Celtic and Greater North Seas MU with an estimated 20,118 (95% CI: 14,061 – 28,786, CV: 0.18) (IAMMWG, 2023). A single minke whale was sighted in the two years of site-specific surveys (March 2021 – February 2023). SCANS III estimated a total of 603 minke whales (95% CI: 109-1,670, CV: 0.675) in block O, with an estimated density of 0.010 whales/km. The SCANS III data has been used to obtain predicted density surfaces (Lacey et al., 2022) and data extracted from these density surfaces showed there was a maximum density of 0.009 whales/km² the array area and 0.011 whales/km² in the ECC. In SCANS IV survey block NS-C there was an estimated block-wide abundance of 412 minke whales (95% CI: 4 – 1,392) and an estimated density of 0.0068 whales/ km2 (CV: 0.881).

18. The latest August haul-out data for harbour seals within the Southeast England MU from the 2021 dataset resulted in an estimated abundance of 4,868 (SCOS, 2023). It is important to note that the Southeast England SMU is currently in decline. For all sites between Donna Nook and Scroby Sands, there has been a ~30% decline in harbour seals counts compared to the mean of the previous five years (2019–2022 mean count = 3,132; 2014–2018 mean count = 4,296) (SCOS, 2023). The count for The Wash and North Norfolk SAC has decreased by ~19% (2019–2022 mean = 2,758; 2015-2018 mean = 3,399), Donna Nook counts have shown a 57% decrease and Scroby Sands showed a 70% decrease (SCOS, 2023). A total of 36 harbour seals were sighted in the two years of site-specific surveys (March 2021 – February 2023). The most reliable density estimate to take forward is from the Carter et al., (2020, 2022) habitat preference at-sea density surface. Within the 50 km buffer of The Project, there are predicted to be ~1,670 harbour seals at any one time, which equates to an average density of 0.13 harbour seals/km2.
19. Given the wide-ranging nature of grey seals (frequently travelling over 100 km between haul-out sites) (SCOS, 2021), and the large degree of movement between the northeast and southeast of England, it is not appropriate to consider the Southeast England MU as a discrete population unit in isolation, therefore the relevant population against which to assess impacts should be the combined Southeast and Northeast England MUs. The 2021 August haul-out count for the Southeast England MU (7,694) combined with the count for the Northeast England MU (6,517) can be scaled by the estimated proportion hauled-out to produce an estimate of 65,505 grey seals in the Southeast and Northeast England MUs combined. A total of 93 grey seals were recorded during the two years of site-specific surveys (March 2021 – February 2023). The most reliable density estimate to take forward is from the Carter et al., (2020, 2022) habitat preference at-sea density surface. Within the 50 km buffer of the Project, there are predicted to be ~11,018 grey seals at any one time, which equates to an average density of 0.85 grey seals/km2.

11.4.4 Designated Sites

20. A separate HRA draft Report to Inform Appropriate Assessment (RIAA) has been completed for the Project (RIAA document reference 7.1) which includes details on the designated sites screened into the HRA for each marine mammal species. This section outlines the Special Areas of Conservation (SACs) within the assessment MUs for each marine mammal species (Table 11-5).
21. The Project array area is partly located within the summer area of the Southern North Sea SAC and is in close proximity to the Wash and North Norfolk Coast SAC for harbour seals and the Humber Estuary SAC for grey seals. Further from the Project there is the Berwickshire and North Northumberland Coast SAC for grey seals, the Southern Trench MPA and Sea of Hebrides MPA for minke whale, and the Moray Firth SAC for bottlenose dolphins.

22. It is important to note that the mean 2019-2021 count for The Wash and North Norfolk SAC has decreased by ~19% compared to the mean count between 2015-2018 (2019–2021 mean = 2,758; 2015-2018 mean = 3,399) (SCOS, 2023). Therefore, the Natural England have revised the conservation objectives for The Wash and North Norfolk SAC from "maintain", to "restore" (Natural England, 2023).

Table 11-5 Marine nature conservation designations with relevance to marine mammals in the project

Protected Area	Designation	Species	Minimum distance from the Project array area (km)
Southern North Sea	SAC	Harbour porpoise (primary reason)	Partially overlaps
The Wash and North Norfolk Coast	SAC	Harbour seal (primary reason)	48km
Humber Estuary	SAC/Ramsar	Grey seal (qualifying feature)	54km
Berwickshire and North Northumberland Coast	SAC	Grey seal (primary reason)	260km
Southern Trench	MPA	Minke whale (primary reason)	450km
Moray Firth	SAC	Bottlenose dolphin (primary reason)	536km
Sea of the Hebrides	MPA	Minke whale (primary reason)	910km

11.4.5 Future Baseline

23. The EIA Regulations require that:

"A description of the relevant aspects of the current state of the environment (baseline scenario) and an outline of the likely evolution thereof without implementation of the development as far as natural changes from the baseline scenario can be assessed with reasonable effort on the basis of the availability of environmental information and scientific knowledge"

24. is included within the ES (EIA Regulations, Schedule 4, Paragraph 3). From the point of assessment, over the course of the development and operational lifetime of the Project (operational lifetime anticipated to be up to 30 years from first power), long-term trends mean that the condition of the baseline environment is expected to evolve. This section provides a qualitative description of the evolution of the baseline environment, on the assumption that the Project is not constructed, using available information and scientific knowledge of marine mammal ecology.

25. It is challenging to predict the future trajectories of marine mammal populations. Some UK marine mammal populations have undergone periods of significant change in parts of their range, with a limited understanding of the driving factors responsible. For example, there is uncertainty about whether a reduction in pup mortality or an increase in fecundity is the cause of the recent exponential growth of grey seals in the North Sea (Russell et al., 2017). Additionally, there is no appropriate monitoring at the right temporal or spatial scales to really understand the baseline dynamics of some marine mammal populations, including all cetacean species included in this assessment.

26. The results of the most recent UK assessment of favourable conservation status for each marine mammal species included in the assessment are outlined in Table 11-6. For grey seals the long-term trends in population size were categorised as increasing and the assessment resulted in a conclusion of the species having favourable future prospects. For harbour seals both the short- and long-term trends in population size were categorised as decreasing and the assessment resulted in a conclusion of the species having Unfavourable - Inadequate future prospects. Harbour porpoise are considered to have an Unknown conservation status, however the UK harbour porpoise population has been assessed as having Favourable future prospects. White-beaked dolphin, bottlenose dolphin and minke whale are Unknown future prospects and Unknown overall trend. The key impacts of climate change which are likely to effect marine mammal receptors will be:

- Increase in seawater temperatures; and
- Sea level rise, increased storm surges and wave energy.

27. The impact of climate change are unknown but could range from range shifts of marine mammal species or their prey, novel interactions between species, increased predation risk, disease prevalence and disturbance to seal haul out sites. Climate change related alterations to the baseline are only expected to be apparent in the long term, as such it is not expected that climate change will result in any changes to the baseline over the time periods considered herein.

Table 11-6 Summary of the conservation status of each marine mammal species (FV = Favourable, XX = Unknown, + = Improving, U1 = Unfavourable - Inadequate)

Species	Range	Population	Habitat	Future prospects	Conservation status	Overall trend	Reference
Harbour porpoise	FV	XX	XX	FV	XX	XX	JNCC (2019a)
White-beaked dolphin	FV	XX	XX	XX	XX	XX	JNCC (2019b)
Bottlenose dolphin	FV	XX	XX	XX	XX	XX	JNCC (2019c)

Species	Range	Population	Habitat	Future prospects	Conservation status	Overall trend	Reference
Minke whale	FV	XX	XX	XX	XX	XX	JNCC (2019d)
Grey seal	FV	FV	FV	FV	FV	+	JNCC (2019e)
Harbour seal	FV	U1	XX	U1	U1	XX	JNCC (2019f)

11.5 Basis of Assessment

11.5.1 Scope of Assessment

11.5.1.1 Impacts Scoped In For Assessment

28. The following impacts have been scoped into the assessment:

- Construction:
  - Impact 1: UXO Clearance - PTS;
  - Impact 2: UXO Clearance - Disturbance;
  - Impact 3: Pile driving - PTS;
  - Impact 4: Pile Driving – TTS;
  - Impact 5: Pile driving - Disturbance;
  - Impact 6: PTS from other construction activities;
  - Impact 7: TTS from other construction activities;
  - Impact 8: Disturbance from other construction activities;
  - Impact 9: Vessel collisions
  - Impact 10: Vessel disturbance;
  - Impact 11: Indirect impacts on prey;
  - Impact 12: Water quality impacts; and
  - Impact 13: Disturbance at seal haul-outs.
- Operation:
  - Impact 14: Operational noise;
  - Impact 15: Vessel collisions;
  - Impact 16: Vessel disturbance;
  - Impact 17: Indirect impacts on prey; and

    - Impact 18: Disturbance at seal haul-outs.
- Decommissioning:
    - Impact 19: Underwater noise from decommissioning;
    - Impact 20: Vessel collisions;
    - Impact 21: Vessel disturbance;
    - Impact 22: Indirect impacts on prey;
    - Impact 23: Water quality impacts; and
    - Impact 24: Disturbance at seal haul-outs.

11.5.1.2 Impacts Scoped Out For Assessment

29. In line with the Scoping Opinion (Natural England, The Planning Inspectorate, 2022), and based on the receiving environment, expected parameters of the Project (Chapter 3 (document reference 6.1.3), and expected scale of impact/potential for effect on the environment, the following impacts have been scoped out of the assessment:

- Construction and decommissioning:
    - Accidental pollution, this is due to the implementation of mitigation measures in the PEMP and MPCP.
- Operation:
    - Accidental pollution;
    - Barrier effects, as during operation these impacts will be small scale and short lived so unlikely to result in significant effects); and
    - EMF, as there is no likely significant effect (LSE) on the species identified in the baseline).

11.5.2 Realistic Worst Case Scenario

30. 33. The following section identifies the MDS in environmental terms, defined by the Project design envelope (Table 11-7).

Table 11-7: Maximum design scenario for marine mammals for the Project alone

Potential effect	Maximum design scenario assessed	Justification
Construction		
Impact 1 and 2: Underwater noise from UXO clearance	▪ Max number of clearance events within 24 hours: 2 ▪ Indicative duration: 25 days ▪ MDS clearance method: high-order detonation ▪ Max charge size: 800kg + donor ▪ Low-order (deflagration) charge: 0.5kg UXO clearance: late 2026 or early 2027	Estimated maximum design. A detailed UXO survey will be completed prior to construction. The type, size and number of possible detonations and duration of UXO clearance operations is not known at this stage. The Applicant is not seeking to license the disposal of UXO in this application, but it is included in the impact assessment.
Impact 3, 4 and 5: Underwater noise from piling	Monopile WTG: ▪ 100 WTG foundations = 100 monopiles total ▪ Max 14m pile diameter ▪ Max hammer energy: 6,600kJ ▪ Max 6 hours per pile ▪ Max 12 hours piling per day ▪ Max 2 simultaneous piling events ▪ 2 monopiles/day = 50 piling days ▪ 1 monopile/day = 100 piling days Monopile Offshore Platform (OP): ▪ Max 2 ORCPs, 4 OSS & 1 AC = 7 monopiles total ▪ Max pile diameter 14m ▪ Max hammer energy 6,600kJ ▪ Max 6 hours piling per monopile ▪ 1 monopile/day = 7 piling days Monopile ANS:	The maximum number of piled foundations, and the maximum number of piling days would represent the temporal maximum design scenario. The maximum predicted impact range for underwater noise for piled foundations would represent the spatial maximum design scenario. The ORCPs will be positioned within the Offshore ECC ORCP Area – there will be no simultaneous piling between the ORCP foundations and foundations in the array area.

Potential effect	Maximum design scenario assessed	Justification
	▪ Max 2 ANS = 2 monopiles total ▪ Max 8m pile diameter ▪ Max hammer energy: 3,500kJ ▪ Max 4 hours per pile ▪ Max 1 pile per day ▪ 1 monopile/day = 2 piling days Multi-leg pin-piled jacket WTG: ▪ Max 100 WTG foundations ▪ 4 legs per foundation (1 pin pile per leg) ▪ Max 400 pin piles total ▪ Max pin pile diameter 5m ▪ Max hammer energy 3,500kJ ▪ Max 4 hours piling per pile ▪ Max 24 hours piling per day (6 piles) ▪ Max 2 simultaneous piling events ▪ 4 pin piles/day = 100 piling days ▪ 6 pin piles/day = 67 piling days Multi-leg pin piled jacket OPs: ▪ Max 2 ORCPs, 4 OSS & 1 AC ▪ Max 24 piles/OP (8 legs, each with 3 piles) ▪ Max 168 pin piles total ▪ Max pin pile diameter 5m ▪ Max hammer energy 3,500kJ ▪ Max 2 legs (6 pin piles) per day ▪ 2 legs (6 pin piles)/day = 28 days piling Multi-leg pin piled jacket ANS: ▪ Max 2 ANS	

Potential effect	Maximum design scenario assessed	Justification
	▪ 4 pins per jacket = 8 pin piles total ▪ Max 5m pile diameter ▪ Max hammer energy: 3,500kJ ▪ Max 4 hours per pile ▪ Max 4 piles per day ▪ 4 pin piles/day = 2 piling days Piling: Q3 2027 – Q2 2029 Max piling days: • Monopile: 100 (WTG) + 7 (OPs) + 2 (ANS) = 107 piling days total • Pin pile: 100 (WTG) + 28 (OPs) + 2 (ANS) = 130 piling days total	
Impact 6, 7 and 8: Underwater noise from other construction activities	▪ Seabed preparation: levelling and/or dredging of soft mobile sediments. ▪ Cable route clearance methods: mass flow excavation, dredging. ▪ Cable burial methods: jet trenching, pre-cut and post-lay ploughing, mechanical trenching, dredging, max flow excavation, vertical injection and rock cutting. Offshore construction indicative dates: 2027 - 2029	Maximum potential for underwater noise impacts from pre-construction works.
Impact 9: Collision risk from vessels Impact 10: Disturbance from vessels	▪ Max total construction vessels: 131 ▪ Max total round trips: 4,471 ▪ Indicative peak vessels on-site in a given 5km^2 area simultaneously: 8 ▪ Offshore construction indicative dates: 2027-2029 ▪ Max round trips over 3 years: 13,413	The maximum numbers of vessels and associated vessel movements represents the maximum potential for collision risk and disturbance

Potential effect	Maximum design scenario assessed	Justification
Impact 11: Indirect impacts from prey	Assessment is based on the MDS presented in Volume 1, Chapter 10: Fish and Shellfish Ecology (Document Reference 6.1.10).	
Impact 12: Water quality impacts	Maximum amount of suspended sediment released during construction activities and associated duration - see Volume 1, Chapter 7: Marine Physical Processes (Document Reference 6.1.7) and Volume 1 Chapter 8: Marine Water Quality (Document Reference 6.1.8).	
Impact 13: Disturbance at haul out sites	Assessment is based on distances to vessel transit routes and landfall	
Operation and Maintenance		
Impact 14: Operational noise	Operational noise from offshore windfarms to date has been found to be not significant for marine mammals. However, the size of WTGs planned at the Proposed Development do not have empirical data for operational noise and therefore operational noise has been scoped in as a precaution. An updated assessment of predicted SPL from a range of turbine sizes proposed for the Project presented in Volume 1, Appendix 1.12: Underwater Noise Assessment (Document Reference 6.3.11.2).	
Impact 15: Collision risk from vessels	▪ Annual round trips: 2,480	The maximum numbers of vessels and associated vessel movements represents the maximum potential for collision risk and disturbance.
Impact 16: Disturbance from vessels		
Impact 17: Indirect impacts on prey	Assessment is based on the MDS presented in Volume 1, Chapter 10: Fish and Shellfish Ecology (Document Reference 6.1.10).	
Decommissioning		
Impact 18: Underwater noise	Maximum levels of underwater noise during decommissioning would be from underwater cutting required to remove structures. This is much less than pile driving and therefore impacts would be less than as assessed during the construction phase. Piled solutions assumed to be cut off at or below seabed	
Impact 19: Collision risk from vessels	Assumed to be similar vessel types, numbers and movements to construction phase (or less).	The maximum numbers of vessels and associated vessel movements represents the maximum potential for collision risk and disturbance.
Impact 20: Disturbance from vessels		
Impact 21: Indirect impacts from prey	Assessment is based on the MDS presented in Volume 1, Chapter 10: Fish and Shellfish Ecology (Document Reference 6.1.10).	

Potential effect	Maximum design scenario assessed	Justification
Impact 22: Water quality impacts	Maximum amount of suspended sediment released during decommissioning activities and associated duration - see Volume 1, Chapter 7: Marine Physical Processes and Volume 1 Chapter 8: Marine Water Quality.	
Cumulative impacts		
See section 11.7		

11.5.3 Embedded Mitigation

31. Mitigation measures that were identified and adopted as part of the evolution of the Project design (embedded into the Project design) and that are relevant to marine mammals are listed in Table 11-8 General mitigation measures, which would apply to all parts of the Project, are set out first. Thereafter mitigation measures that would apply specifically to marine mammal issues associated with the construction, operation and decommissioning, are described separately.

Table 11-8 Embedded mitigation relating to marine mammals

Project phase	Mitigation measures embedded into the Project design
General	
Project Environment Management Plan (PEMP)	A Project Environmental Management Plan (PEMP) (for the construction and operational phases) will be produced and followed. This will include a Marine Pollution Contingency Plan (MPCP) which will safeguard the marine environment in the event of accidental pollution occurring as a result of ODOW operations. Plans will also highlight key organisations and contact details in the event of a spill (e.g. Environment Agency, Marine Management Organisation, Natural England and the Maritime and Coastguard Agency (MCA)).
Decommissioning Plan	A decommissioning plan will be prepared in line with any updated guidance and environmental assessments.
Construction	
Project design	Identification of a maximum hammer energy to be used during pile driving (6,600kJ for monopiles, 3,500kJ for pin-piles). Inclusion of soft-start and ramp up procedures for pile driving. Maximum of two simultaneous piling events.
Marine Mammal Mitigation Protocol (MMMP) for piling	Implementation of a piling Marine Mammal Mitigation Protocol (MMMP) (to minimise the risk of auditory injury, i.e. to negligible levels).
MMMP for UXO	Implementation of a UXO MMMP (to minimise the risk of auditory injury, i.e. to negligible levels).
Vessel Management Plan (VMP)	Development of, and adherence to, a Vessel Management Plan (VMP) (including defined vessel navigational routes, a vessel code of conduct to reduce collision risk and minimise disturbance and identification and avoidance of sensitive areas where practicable).
Noise reduction	The Applicant has committed to deploying primary and/or secondary noise reduction methods (Noise Abatement Systems) for pile driving~~, unless otherwise agreed with the MMO~~. The assessment for pile driving provided in this ES chapter is for unmitigated piling.
Decommissioning	
Decommissioning MMMP	Implementation of a decommissioning MMMP (if required) (to minimise the risk of auditory injury, i.e. to negligible levels);

11.5.4 Assessment Methodology

32. Determining the significance of effect is a two-stage process that involves defining the sensitivity of the receptors and the magnitude of the impacts. This section describes the criteria applied in this chapter to assign values to the sensitivity of receptors and the magnitude of potential impacts (see Chapter 5 (document reference 6.1.5)).
33. Information about the Project and the Project activities for all stages of the Project life cycle (construction, O&M and decommissioning) have been combined with information about the environmental baseline to identify the potential interactions between the Project and the environment. These potential interactions are known as potential impacts. The potential impacts are then assessed to give a level of significance of effect upon the receiving environment/receptors.
34. The outcome of the assessment is to determine the significance of these effects against predetermined criteria.

11.5.5 Magnitude of Impact

35. The magnitude of potential impacts is defined by a series of factors including the spatial extent of any interaction, and the likelihood, duration, frequency and severity of a potential impact. The magnitude of the impact is defined in Table 11-9

Table 11-9 Impact magnitude definitions

Magnitude	Description/reason
High	The impact would affect the behaviour and distribution of sufficient numbers of individuals, with sufficient severity, to affect the favourable conservation status and/or the long-term viability of the population at a generational scale (Adverse).
	Long term, large scale increase in the population trajectory at a generational scale (Beneficial).
Medium	Temporary changes in behaviour and/or distribution of individuals at a scale that would result in potential reductions to lifetime reproductive success to some individuals although not enough to affect the population trajectory over a generational scale. Permanent effects on individuals that may influence individual survival but not at a level that would alter population trajectory over a generational scale (Adverse).
	Benefit to the habitat influencing foraging efficiency resulting in increased reproductive potential and increased population health and size (Beneficial).
Low	Short-term and/or intermittent and temporary behavioural effects in a small proportion of the population. Reproductive rates of individuals may be impacted in the short term (over a limited number of breeding cycles). Survival and reproductive rates very unlikely to be impacted to the extent that the population trajectory would be altered (Adverse).
	Short term (over a limited number of breeding cycles) benefit to the habitat influencing foraging efficiency resulting in increased reproductive potential (Beneficial).
Negligible	Very short term, recoverable effect on the behaviour and/or distribution in a very small proportion of the population. No potential for any changes in the individual

Magnitude	Description/reason
	reproductive success or survival therefore no changes to the population size or trajectory (Adverse).
	Very minor benefit to the habitat influencing foraging efficiency of a limited number of individuals (Beneficial).

11.5.6 Sensitivity Of Receptors

36. The sensitivities of marine mammal receptors are defined by their potential vulnerability to an impact from the proposed development, their recoverability, and their importance in terms of relative ecological, social or economic value or status. The sensitivity/importance of the receptor is defined in Table 11-10.

37. The categories of receptor sensitivity have been renamed for marine mammals after consultation with Natural England on the PEIR to align with marine mammal assessments on other projects. The definitions remain the same and unchanged.

Table 11-10 Sensitivity of the marine mammal receptor

Receptor sensitivity	Definition
Very high	▪ No ability to adapt behaviour so that survival and reproduction rates are affected; ▪ No tolerance - Effect will cause a change in both reproduction and survival rates; and ▪ No ability for the animal to recover from any impact on vital rates (reproduction and survival rates).
High	▪ Limited ability to adapt behaviour so that survival and reproduction rates may be affected; ▪ Limited tolerance – Effect may cause a change in both reproduction and survival of individuals; and ▪ Limited ability for the animal to recover from any impact on vital rates (reproduction and survival rates).
Medium	▪ Ability to adapt behaviour so that reproduction rates may be affected but survival rates not likely to be affected; ▪ Some tolerance – Effect unlikely to cause a change in both reproduction and survival rates; and ▪ Ability for the animal to recover from any impact on vital rates (reproduction and survival rates).
Low	▪ Receptor is able to adapt behaviour so that survival and reproduction rates are not affected.

38. Assessment of the significance of potential effects is described in Table 11-11. The magnitude of the impact is correlated against the sensitivity of the receptor to provide a level of significance. On this basis, potential impacts are assessed as Negligible, Minor, Moderate or Major (definitions are provided in Chapter 5 (document reference 6.1.5)).

39. For the purposes of this assessment, any effects with a significance level of major and/or moderate have been deemed significant in EIA terms, while those of a minor or negligible significance level are deemed non-significant.

Table 11-11 Matrix to determine effect significance specific to marine mammals

		Magnitude of impact			
		Negligible	Low	Medium	High
Sensitivity of receptor	Low	Negligible (Not significant)	Negligible (Not significant)	Minor (Not significant)	Minor (Not significant)
	Medium	Negligible (Not significant)	Minor (Not significant)	Minor (Not significant)	Moderate (Significant)
	High	Minor (Not significant)	Minor (Not significant)	Moderate (Significant)	Major (Significant)
	Very high	Minor (Not significant)	Moderate (Significant)	Major (Significant)	Major (Significant)

11.5.7 Injury (Permanent Threshold Shift)

40. Exposure to loud sounds can lead to a reduction in hearing sensitivity (a shift in hearing threshold), which is generally restricted to particular frequencies. This threshold shift results from physical injury to the auditory system and may be permanent (PTS). The PTS-onset thresholds used in this assessment are those presented in Southall et al., 2019) (Table 11-12). The methods used to calculate PTS-onset impact ranges for both 'instantaneous' PTS (SPLpeak), and 'cumulative' PTS (SELcum, over 24-hours) are detailed in document reference 6.3.11.2.

Table 11-12 PTS-onset thresholds for impulsive noise (from Southall et al., 2019).

Hearing group	Species	Cumulative PTS (SEL_{cum} dB re 1µPa^{2}s weighted)	Instantaneous PTS (SPL_{peak} dB re 1µPa unweighted)
Very High Frequency (VHF) Cetacean	Harbour porpoise	155	202
High Frequency (HF) Cetacean	Bottlenose dolphin White-beaked dolphin	185	230

Hearing group	Species	Cumulative PTS (SEL_{cum} dB re 1µPa^{2}s weighted)	Instantaneous PTS (SPL_{peak} dB re 1µPa unweighted)
Low Frequency (LF) Cetacean	Minke whale	183	219
Phocid (PCW)	Grey seal Harbour seal	185	218

41. In calculating the noise level that animals are likely to receive during the whole piling sequence, all HF and VHF cetaceans were assumed to start moving away at a swim speed of 1.5 m/s once the piling has started (based on reported sustained swimming speeds for harbour porpoises; Otani 2000). Minke whales are assumed to swim at a speed of 3.25 m/s (Blix and Folkow, 1995). The calculated PTS onset impact ranges therefore represent the minimum starting distances from the piling location for animals to escape and prevent them from receiving a dose higher than the threshold (Table 11-13).

Table 11-13 Marine mammal swimming speed used in the cumulative PTS-onset assessment.

Hearing group	Species	Speed (m/s)
Very High Frequency (VHF) Cetacean	Harbour porpoise	1.5
High Frequency (HF) Cetacean	Bottlenose dolphin White-beaked dolphin	1.5
Low Frequency (LF) Cetacean	Minke whale	3.25
Phocid (PCW)	Grey seal Harbour seal	1.5

42. Southall et al. (2019) proposes the SPLpeak metric as (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).

43. 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 the species hearing group specific weighting curves given in Southall et al. (2019) (Plate 11.1).

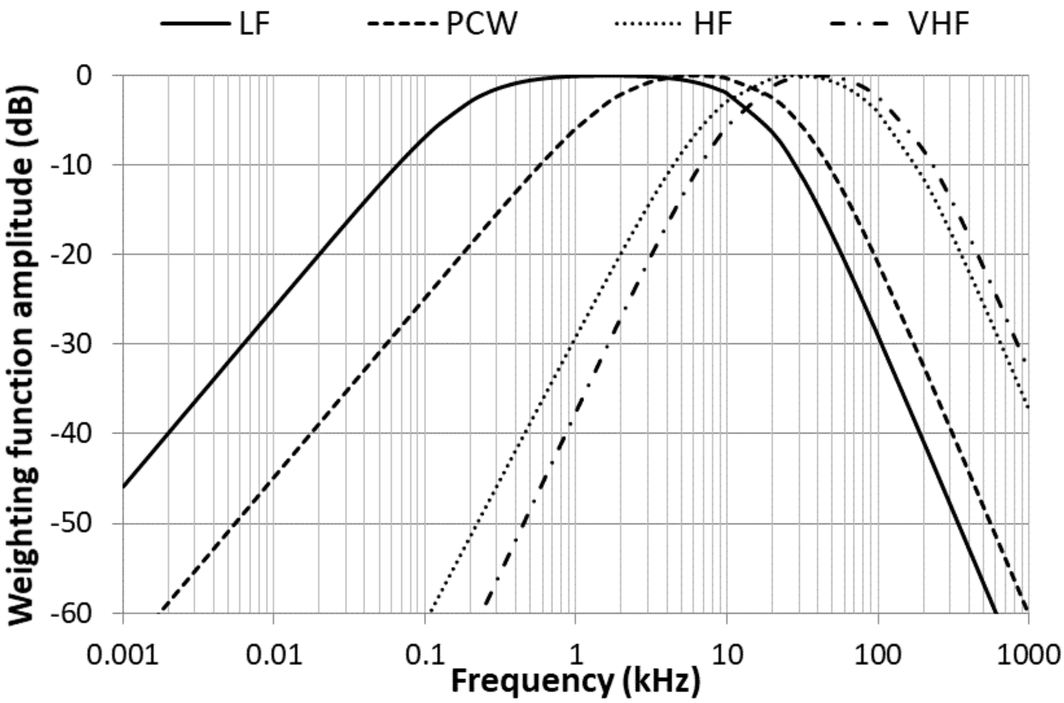

Plate 11.1 Auditory weighting functions for low frequency (LF), high frequency (HF) and very high frequency (VHF) cetaceans as well as phocid (PCW) pinnipeds in water taken from to Southall (2019).

11.5.8 PTS – Pile Driving

44. 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) (see Table 11-12). Based on agreed density estimates for each species presented in document reference 6.3.11.2, 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.
45. The SELcum 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 SELcum 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 SELcum over a piling event. Concurrent piling scenarios where two piling events occur within 24-hours, have also be modelled.

11.5.9 PTS – UXO Clearance

46. The Southall et al. (2019)thresholds (see Table 11-12) have been used to assess the PTS onset impact from UXO detonation from a range of charge sizes. The number of animals expected in the PTS onset impact range has been calculated and presented as a proportion of the relevant population size.

11.5.10 PTS – Other Construction Activities

47. In the absence of specific guidance on the PTS onset thresholds that should be used to assess the noise impacts from non piling noise, noise modelling has been undertaken using the Southall et al. (2019) thresholds. Non-piling noise includes vessel activity, dredging, trenching and rock dumping. Full results are presented in document reference 6.3.11.2 and have been used to estimate the number and range of animals predicted to experience PTS from other construction activities.

11.5.11 Disturbance – Pile Driving

48. The assessment of disturbance from pile driven foundations has been 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.
49. For example, 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 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".

50. Noise contours at 5dB 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.
51. Compared with the EDR and fixed noise threshold approaches, the application of a dose response curve allows for more realistic assumptions about animal response varying with dose, which is supported by a growing number of studies. A dose-response function is 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., 2021).

11.5.11.1 Harbour porpoise dose-response function

52. 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. (2017a) (Plate 11.2). The Graham et al. (2017a) 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 Windfarm monitoring program. Changes in porpoise occurrence (detection positive hours per day) were estimated using 47 CPODs placed around the windfarm site during piling and compared with baseline data from 12 sites outside of the windfarm 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., 2017a).

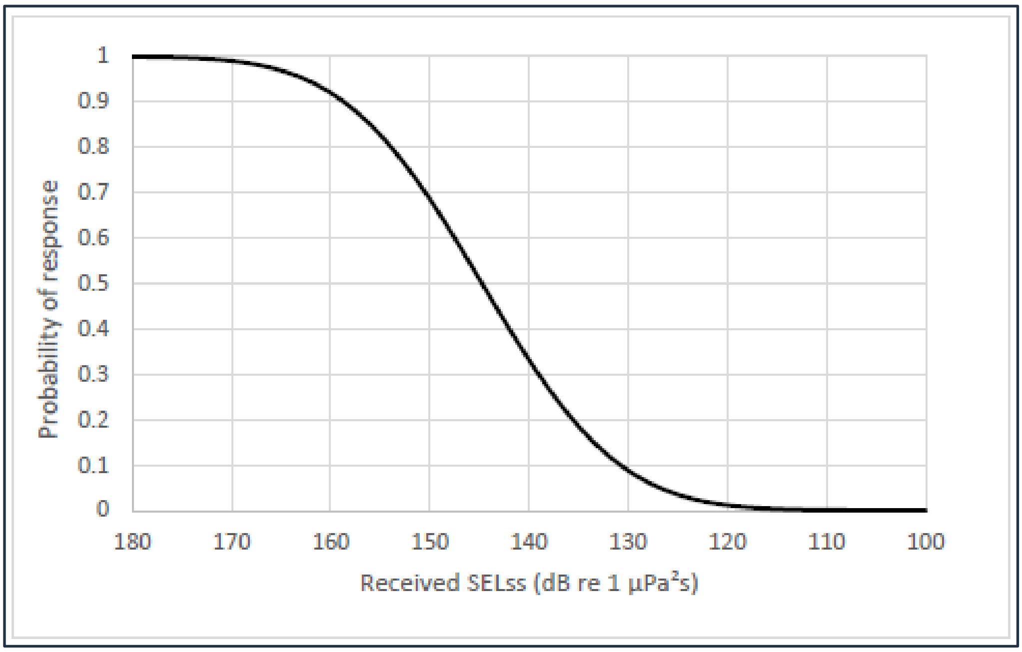

Plate 11.2: Relationship between the proportion of porpoise responding and the received single strike SEL (SELss) (Graham et al., 2017a).

53. Since the initial development of the dose-response function in 2017, additional data from the remaining pile driving events at Beatrice Offshore Windfarm have been processed, and are presented in Graham (2019). The passive acoustic monitoring showed a 50% probability of porpoise response (a significant reduction in detection relative to baseline) within 7.4km at the first location piled, with decreasing response levels over the construction period to a 50% probability of response within 1.3km by the final piling location (Plate 11.3) (Graham et al., 2019). Therefore, 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.

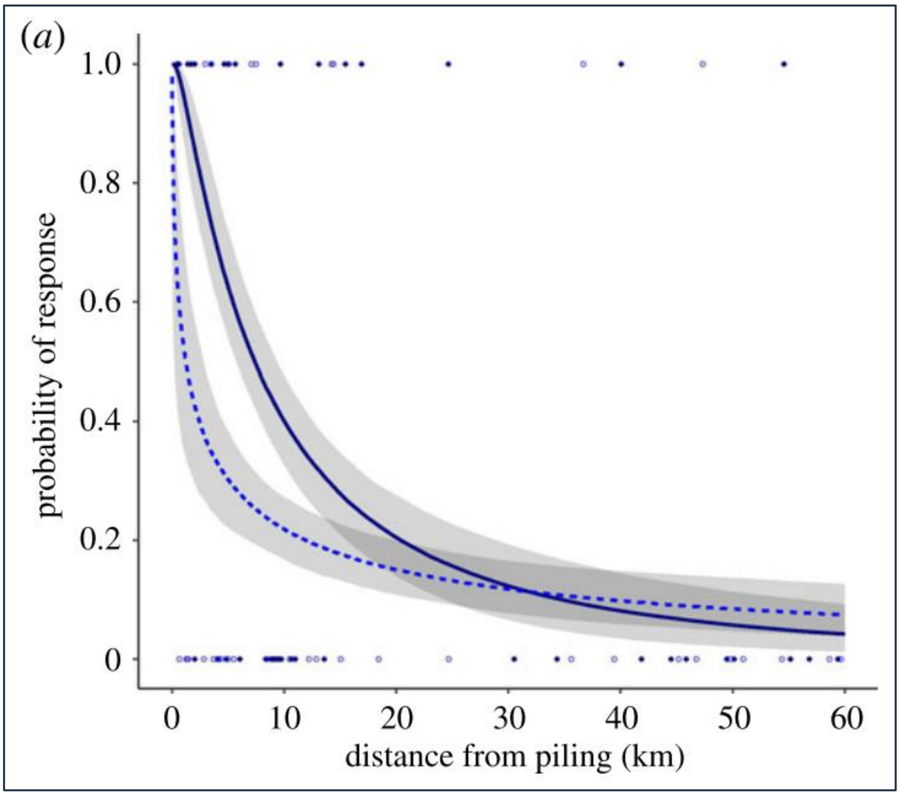

Plate 11.3: The probability of a harbour porpoise response (24 h) in relation to the partial contribution of distance from piling (solid navy line) and the final location piled (dashed blue line). Obtained from Graham et al. (2019)

54. In the absence of species-specific data on bottlenose dolphins, common dolphins, Risso's dolphins 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 function to other cetacean species is highly over precautionary. 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; Sarnocinska et al., 2019; Thompson et al., 2020; Benhemma-Le Gall et al., 2021).

55. 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 (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). In the Moray Firth, bottlenose dolphins have been shown to remain in the impacted area during both seismic activities and pile installation activities (Fernandez-Betelu et al., 2021) which highlights a lack of complete displacement response. Likewise, other 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).

56. The assessment for all cetacean species has used the porpoise dose-response function. This is considered highly precautionary and as such the number of animals predicted to experience behavioural disturbance is considered to be an over-estimate and should be interpreted with a large degree of caution.

Level B Harassment

57. Acknowledging that there are limitations to the application of the porpoise dose-response function to dolphins and minke whales, an alternative threshold for disturbance has also been presented in this assessment. The National Marine Fisheries Service (NMFS) uses the Level B harassment threshold to predict marine mammal behavioural harassment. This threshold predicts that Level B harassment[6] will occur when an animal is exposed to received levels above 160 dB re 1µPa (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).

58. The Level B Harassment threshold has been used in this assessment as an alternative method to assess the potential for disturbance from pile driving to minke whales and dolphin species.

[6] 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.

Seal dose-response function

59. For harbour seals, the dose-response function adopted was based on the data presented in Whyte (2020)(Plate 11.4). 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 windfarm. 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 estimate levels of seal usage in the area in order to assess how seal usage changed in relation to the pile driving activities at the Lincs Offshore Windfarm in 2011-2012.
60. In the Whyte (2020) dose-response function it has been assumed that all seals are displaced at sound exposure levels above 180dB re 1µPa2s. 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≤180dB re 1µPa2s 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.
61. 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 is 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.

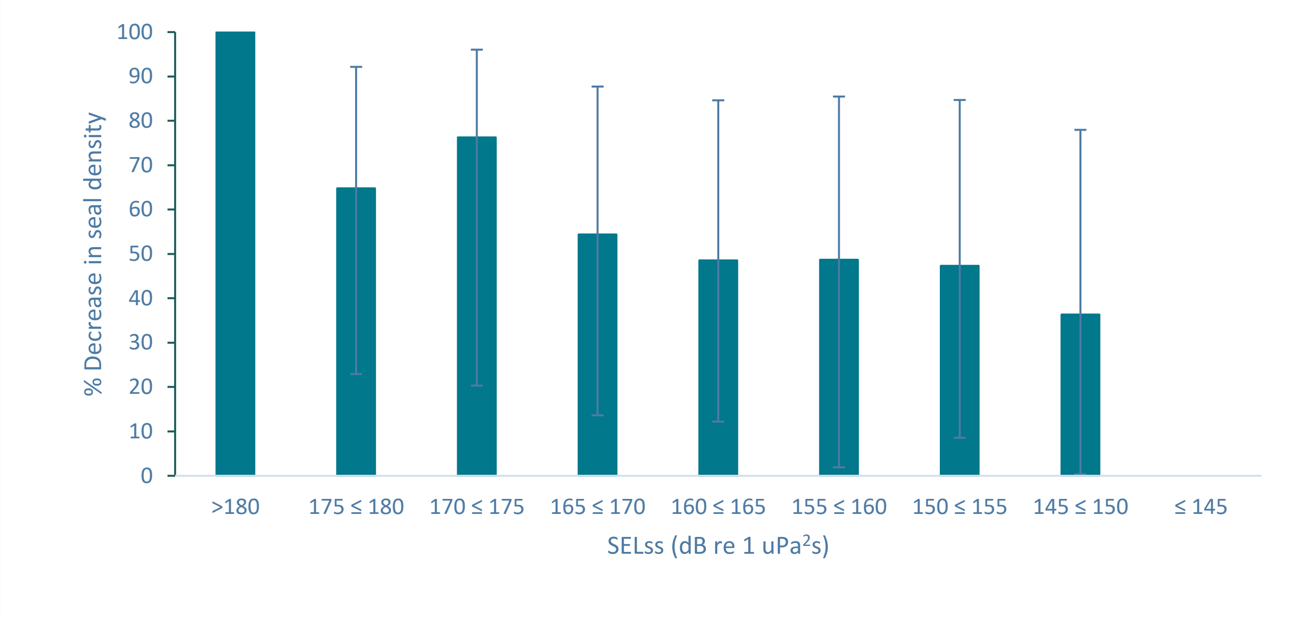

Plate 11.4: Predicted decrease in seal density as a function of estimated sound exposure level, error bars show 95% CI (Whyte et al., 2020).

11.5.11.2 Population modeling

62. The iPCoD framework (Harwood *et al.*, 2014, King *et al.*, 2015) was used to predict the potential population consequences of the predicted amount of PTS and disturbance resulting from the piling. The 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.
63. 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.

64. 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.

65. The Applicant provided two piling schedules, one for monopiles and one for jacket pin-piles, for piling of the artificial nesting structures (ANS) and wind turbine generators/offshore platforms (Table 11-14). The number of piling days were randomly distributed across each month listed.

Table 11-14 Outer Dowsing piling schedule (number of piling days per month) for monopiles and jackets (ANS and WTG)

Month	Foundation	Monopile	Jacket
Feb	ANS	2	4
Jul	WTGs/offshore platforms	4	8
Aug		6	12
Sep		4	8
Oct		0	0
Nov		8	15
Dec		8	16
Jan		4	9
Feb		8	16
Mar		8	16
Apr		9	17
May		11	23
Jun		12	24
Jul		15	29
Aug		10	21
Sep		0	0
Total		**109**	**218**

66. The MU specific demographic parameters used in the iPCoD modelling were obtained from Sinclair *et al.* (2020) and are summarised in Table 11-15. In Sinclair *et al.* (2020) the southeast England harbour seal MU was modelled to be stable, however, recent counts show that this population is now in decline (SCOS, 2023). Therefore, both a stable and a declining population has been modelled.

Table 11-15 Demographic parameters used in the iPCoD modelling from Sinclair *et al.* (2020)

	Harbour porpoise	Bottlenose dolphin	Minke whale	Harbour seal		Grey seal
Trend	Stable	Stable	Stable	Stable	Declining[7]	Increasing
Calf/pup survival	0.8455	0.86	0.7	0.4	0.24	0.222
Juvenile survival	0.85	0.94	0.77	0.78	0.86	0.94
Adult survival	0.925	0.94	0.96	0.92	0.8	0.94
Fertility	0.34	0.25	0.91	0.85	0.9	0.84
Age at independence	1	2	1	1	1	1
Age at first birth	5	9	9	4	4	6

67. The iPCoD framework (Harwood et al., 2014, King et al., 2015) has also been used to predict the the potential population consequences of the predicted amount of disturbance resulting from the piling cumulatively with other projects. This assessment is presented in IPCoD cumulative assessment (document reference 6.3.11.3) submitted at deadline 6.

11.5.12Disturbance – UXO Clearance

68. 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" sound sources, 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.

69. 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.

---

[7] Using demographic parameters for the declining North Coast and Orkney harbour seal MU in the absence of declining parameters specific to the southeast England MU

11.5.12.1 EDR – 26km for high-order UXO clearance

70. 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 26km 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 content) with respect to disturbance of harbour porpoise in SACs.
71. The recommendation for the 26km 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 2.4m to 2.6m diameter up to 30m 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:
72. *"The 26km 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).
73. 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:
74. *"… a one-off explosion would probably only elicit a startle response and would not cause widespread and prolonged displacement…"* (JNCC, 2020).
75. In the Scoping Opinion responses (The Planning Inspectorate, 2022) both the MMO and Natural England advised that the 26km EDR is applied not only to harbour porpoise, but to all marine mammal species. While this has been presented here as requested, 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 500kJ 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.

EDR - 5km for low-order UXO clearance

76. There are no empirical data upon which to set a threshold for disturbance from low-order UXO clearance. Data has 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 worst-case EDRs for various noise sources, and lists the default low-order UXO clearance EDR as 5km. In the absence of any further data, this 5km EDR for low-order UXO clearance will be assumed here.

Fixed noise threshold – TTS-onset

77. 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):

"Even strong behavioral 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 behavioral 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 recognize that this is not a behavioral effect per se, but we use this auditory effect as a de facto behavioral 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 behavior." (Southall et al., 2007)."

"Due to the transient nature of a single pulse, the most severe behavioral reactions will usually be temporary responses, such as startle, rather than prolonged effects, such as modified habitat utilization. A transient behavioral 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 behavioral 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 behavioral 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).

78. 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).

79. In the Scoping Opinion Responses (The Planning Inspectorate, 2022), both the MMO and Natural England advised that it is not appropriate to use TTS-onset thresholds as a proxy for disturbance from UXOs. However, TTS-onset as a proxy for disturbance has been presented alongside the 26km EDR approach in acknowledgement that there is no empirically based threshold to assess disturbance from high-order UXO clearance currently available.

Summary

80. In the absence of agreed thresholds to assess the potential for behaviour disturbance in marine mammals from UXO detonations, the Project impact assessment presents results for each of the following behavioural disturbance thresholds:

- 26km EDR for high-order detonations;
- 5km EDR for low-order detonations; and
- TTS-onset thresholds for both high and low-order detonations.

81. While the Applicant acknowledges that there is no empirical data to validate these thresholds as appropriate for behavioural disturbance from UXO detonations, these thresholds do cover our understanding of the range of potential behavioural responses from impulsive sound sources, and, as such, provide the best indication as to the potential level of impact.
82. 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.

Disturbance – other construction activities

83. 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 the Project, with dredging potentially being required for seabed preparation work for foundations as well as for export cable, array cable and interlink cable installations.

Assumptions and Limitations

84. 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 set out below.

PTS-onset Assumptions

85. There are no empirical data on the threshold for auditory injury in the form of PTS-onset for marine mammals, as to test this would be inhumane. 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 (6dB), and assumes that PTS occurs from exposures resulting in 40dB or more of TTS measured approximately four minutes after exposure (NMFS, 2018).

Proportion Impacted

86. 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 (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. Therefore, the number of animals predicted to be within PTS-onset ranges are precautionary, since they assume that all animals are impacted.

Exposure to Noise

87. 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.
88. 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 windfarm construction are not specifically addressed. The dose-response functions for porpoise include behavioural responses at noise levels down to 120dB SELss which may be indistinguishable from ambient noise at the ranges these levels are predicted.

Cumulative PTS

89. The cumulative sound exposure level (SELcum) 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 SELcum exceeds the energy based threshold. The calculation of SELcum 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.
90. 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.
91. Another reason is that the prediction of the onset of PTS (which is assumed to be at the SELcum 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.
92. 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 SELcum 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.
93. Both assumptions, therefore, lead to a conservative determination of the impact ranges and are discussed in further detail in the sections below.

94. Modelling the SELcum 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

95. The equal-energy hypothesis assumes that exposures of equal energy 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 gunfires of the same SELcum exposed to human, where 30 impulses with an SPLpeak of 150dB re 1m Pa result in a TTS of 20dB, while 300 impulses of a respectively lower SPLpeak did not result in any TTS.
96. 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 (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 SELcum threshold is not valid, and as such, models will overestimate the level of threshold shift experienced from intermittent noise exposures.
97. Another detailed example to give is the study of (Kastelein et al., 2014), where a harbour porpoise was exposed to a series of 12kHz 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 to 8dB lower TTS when exposed to sound with a duty cycle of 25% compared to a continuous sound (Plate 11.5). A one second silent period in between pulses resulted in a 3 to 5dB lower TTS compared to a continuous sound (Plate 11.5).

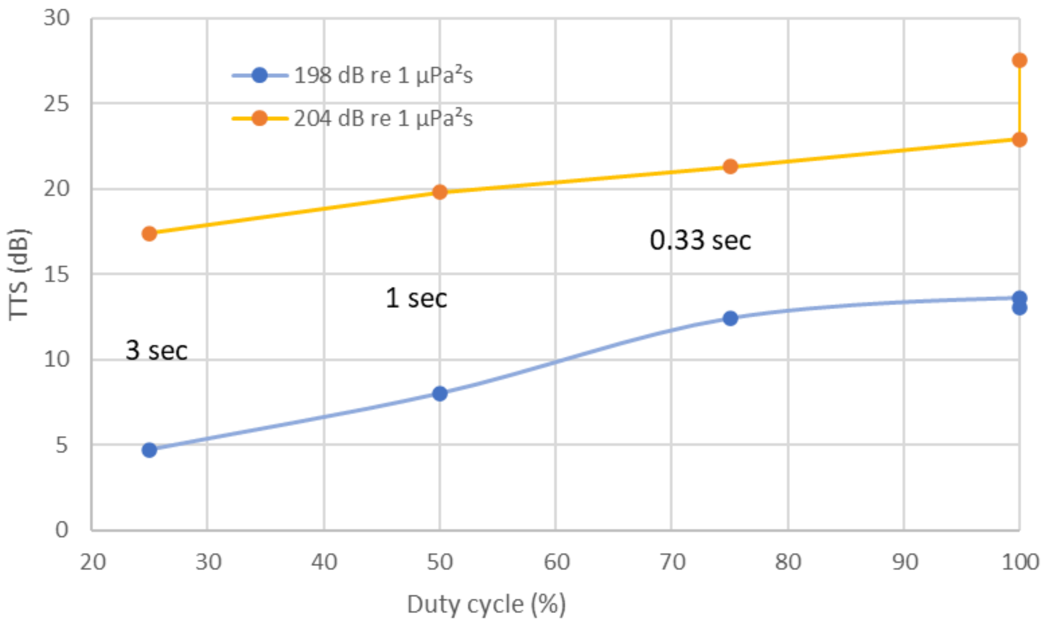

Plate 11.5 Temporary threshold shift (TTS) elicited in a harbour porpoise by a series of 1-2kHz sonar down-sweeps of 1 second duration with varying duty cycle and a constant SELcum of 198 and 204dB re1 µPa²s, respectively. Also labelled is the corresponding 'silent period' in-between pulses. Data from Kastelein et al., (2014).

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

99. Pile strikes are relatively short signals; the signal duration of monopile 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 3.3km to 3.6km. Duration will however increase with increasing distance from the pile site.

100. For the pile driving at the Project, the soft start is 10 blows/min and the ramp-up is 30 blows per minute. Assuming a signal duration of around 0.5 seconds for a pile strike, the soft start has been an 8.3% duty cycle (0.5 seconds pulse followed by 5.5 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 three seconds corresponds to a duty cycle of 25%. The reduction in TTS at a duty cycle of 25% is 5.58.3dB. Assuming similar effects to the hearing system of marine mammals in the Project array area, the PTS-onset threshold would be expected to be around 2.4dB higher than that proposed by Southall et al. (2019) and used in the current assessment, as reasoned in the following section.

101. Southall (2009) calculates the PTS-onset thresholds based on the assumption that a TTS of 40dB will lead to PTS, and that an animal's hearing threshold will shift by 2.3dB per dB SEL received from an impulsive sound. This means, if the same SEL elicits a ≥5.5dB lower TTS at 25% duty cycle compared to 100% duty cycle, to elicit the same TTS as a sound of 100% duty cycle, a ≥2.4dB (≥5.5dB/2.3) 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 2.4dB higher than the PTS-onset threshold proposed by Southall et al. (2019).

102. If a 2 or 3dB increase in the PTS-threshold is assumed, then this can make a significant difference to the maximum predicted impact range for cumulative PTS.

103. Table 11-16 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 NE location decreases from 3.3km for harbour porpoise to 2.2km (+2dB) or 1.7km (+3dB). For minke whale the PTS impact ranges for the NE location decreases from 5.4km to 4.0km (+2dB) or 3.2km (+3dB).

104. Therefore, accounting for recovery in hearing between pulses by increasing the PTS-onset threshold by 2 or 3dB significantly decreases the predicted PTS-onset impact ranges. This approach to modelling cumulative PTS is in development and has not yet been fully assessed or peer reviewed. Therefore, the 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 11.14: Difference in predicted cumulative PTS impact ranges if recovery between pulses is accounted for and the PTS-onset threshold is increased by 2 or 3 dB.

Threshold		Max impact range (km)	Reduction in impact range (km)
Minke whale			
PTS	183 SEL_{cum}	5.4	-
PTS + 2dB	185 SEL_{cum}	4.0	1.4
PTS + 3dB	186 SEL_{cum}	3.2	2.2
Harbour porpoise			
PTS	155 SEL_{cum}	3.3	-
PTS + 2dB	157 SEL_{cum}	2.2	1.1
PTS + 3dB	158 SEL_{cum}	1.7	1.6

Impulsive Characteristics

105. Southall et al. (2019) calculated the PTS onset thresholds based on the assumption that an animal's hearing threshold will shift by 2.3dB per dB SEL received from an impulsive sound, but only 1.6dB 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 SELcum that lies somewhere between the PTS-onset thresholds of impulsive and non-impulsive sound.

106. 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).

107. Using the criteria of signal duration[8] , rise time[9] , crest factor[10] and peak pressure[11] divided by signal duration[12] , Hastie (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 (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 (2019), the rise-time and peak pressure may be the most appropriate indicators to determine the impulsive/non-impulsive transition.

108. 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 5km 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.

---

[8] Time interval between the arrival of 5% and 95% of total energy in the signal.

[9] Measured time between the onset (defined as the 5th percentile of the cumulative pulse energy) and the peak pressure in the signal.

[10] 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.

[11] The greatest absolute instantaneous sound pressure within a specified time interval.

[12] Time interval between the arrival of 5% and 95% of total energy in the signal.

109. It is acknowledged that the Hastie (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.

110. Since the Hastie (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 20m water depth (at the Block Island Windfarm in the USA). For the impact piling sound, they recorded sound at four distances between ~500m and 9km, 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 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 three 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:

- 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.

111. For the evaluation of their data, Martin (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 Plate 11.6 For the unweighted and LFC weighted sound, the kurtosis value was >40 within 2km from the piling site. Beyond 2km, the kurtosis value decreased with increasing distance. For the VHFC weighted sound, kurtosis factor is more inconclusive with the median value >40 for the 500m and 9km measuring stations, and at 40 for the stations in between. However, the variability of the kurtosis value for the VHFC weighted sound increased with distance.

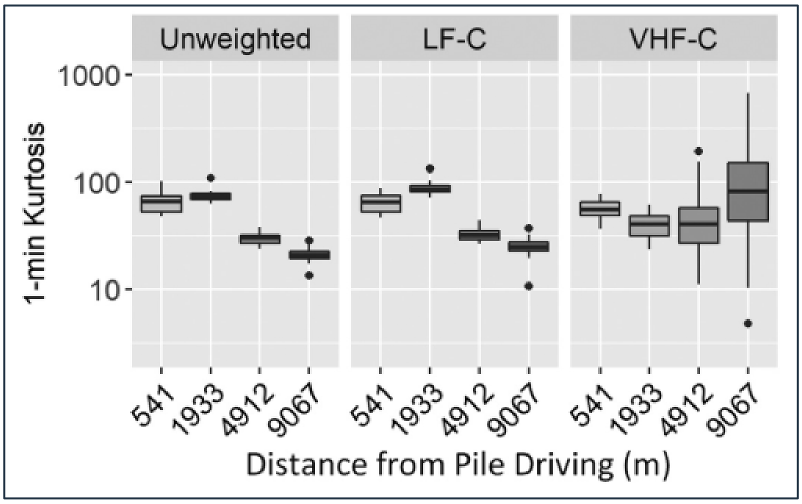

Plate 11.6 The range of kurtosis weighted by LF-C and VHF-C Southall (2019) auditory frequency weighting functions for 30 min of impact pile driving data measured in 25m of water at the Block Island Windfarm. Boxplots show the median value (horizontal lines), interquartile range (boxes) and outlier values (dots). Boxplots reproduced from Martin (2020).

112. From these data, Martin (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]"*

113. (i.e., the sounds they recorded retain their impulsive character while being at sound levels that can contribute to auditory injury). However, we interpret their results differently. Plate 11.6 clearly 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 (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.

114. 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 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.

115. 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".*

116. 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 discernable energy (relative to ambient noise at the same location) at frequencies ≥ 10kHz could be used to distinguish when the relevant hearing effect criteria transitions from impulsive to non impulsive".*

117. Southall (2021), however, notes that:

> *"it should be recognized that the use of impulsive exposure criteria for receivers at greater ranges (tens of kilometers) is almost certainly an overly precautionary interpretation of existing criteria".*

118. 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 5km in all above mentioned examples, the cumulative PTS-onset threshold for animals starting to flee at 5km should be higher than the Southall et al., (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.

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

Animal Depth

120. Empirical data on SELss levels recorded during piling construction at the Lincs offshore windfarm have been compared to estimates obtained using the Aquarius pile driving model (Whyte et al., 2020). This has demonstrated that measured recordings of SELss levels made at 1m depth were all lower than the model predicted single-strike sound exposure levels for the shallowest depth bin (2.5m). In contrast, measurements made at 9m depth were much closer to the model predicted single-strike sound exposure levels. This highlights the limitations of modelling exposure using depth averaged sound levels, as the acoustic model can overpredict exposure at the surface. This is important to note since animals may conduct shorter and shallower dives when fleeing (e.g. van Beest et al., 2018).

Cumulative PTS Conclusion

121. Given the above, SMRU Consulting considers that the calculated SELcum 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.

Density

122. 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 particular 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.

Predicting response

123. 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 Windfarm and therefore uses the most recent and site-specific information on disturbance to harbour porpoise as a result of pile driving noise.

124. 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 section 63 above 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.

Duration of Impact

125. 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 Windfarm 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 windfarm 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 windfarms in Germany has shown that harbour porpoise detections were reduced between one and two days after piling (Brandt et al., 2018).

126. Analysis of data from monitoring of marine mammal activity during piling of jacket pile foundations at Beatrice Offshore Windfarm (Graham et al.,2017a, 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. 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.

TTS Limitations

127. 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"*

128. 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 overestimate of the potential impact of TTS. Furthermore, the prediction of TTS impact ranges, based on the sound exposure level (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.

129. 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 6dB 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"

130. 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 15dB above hearing threshold, TTS reduced by 4 to 6dB per decade for dolphins, and 4 to 13dB 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.

131. For small threshold shifts of 4 to 5dB 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.

132. 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 40dB may lead to the onset of PTS.

133. For pile driving for offshore windfarm 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 cumulative sound exposure level (SELcum), for which the sound energy over successive strokes is summated. The SELcum 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 2.3dB per dB noise received; for non-impulsive sound this rate is smaller (1.6dB per dB noise) (Southall et al., 2007). Please see the section above for further details on the limitations of SELcum thresholds (the same limitations apply to TTS as PTS).

134. Modelling the SELcum 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 SELcum 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 when sound energy over successive strokes is summated. Therefore, these uncertainties and conservativisms will have a relatively larger effect on predictions of TTS ranges.

135. 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.

136. 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.

137. 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 2-10kHz 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 8kHz (Kastelein et al., 2016) and centred at 4kHz (Kastelein et al.,2012a; Kastelein et al., 2012b; Kastelein et al., 2013b; Kastelein et al., 2017).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.

138. TTS impact ranges, impacted areas and number of animals within the TTS-onset area are presented in this assessment. However, the significance of impact has not been assessed, as agreed in the Marine Mammal ETG dated 26th September 2022.

iPCoD Assumptions & Limitations

139. 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.

140. 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 will not forage for 24 hours after being disturbed
- The lack of density dependence in the model (meaning the population will not respond to any reduction in population size)

- The level of environmental and demographic stochasticity in the model, and
- The estimates of the number of animals disturbed come from noise impact assessments with many levels of precaution.

Duration of disturbance: minke whales and bottlenose dolphins

141. The iPCoD model for minke whale and bottlenose dolphin disturbance was last updated following the expert elicitation in 2013 (Harwood *et al.*, 2014). 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 Project.

Lack of density dependence

142. 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., 2014). The iPCoD assumes no density dependence for any of the species available in the model, since there is insufficient data to parameterise this relationship. Essentially, this means that there is no ability for the modelled, impacted population to increase in size and return to carrying capacity following disturbance. It is possible that populations with a positive growth rate (i.e. an increasing population) will continue to increase in the absence of disturbance.

143. 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. That means, for a population which is assumed to be stable (i.e., neither increasing or decreasing), it would be expected that if the impacted population declines, it would later recover to carrying capacity, rather than continuing at a stable trajectory that is smaller than that of the un-impacted population. Note that in the iPCoD model, for stable populations, carrying capacity is assumed to be equal to the size of un-impacted population – i.e., it is assumed the un-impacted population is at carrying capacity.

Environmental and demographic stochasticity

144. 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.*, 2014). Demographic stochasticity is defined as *"variation among individuals in their realised vital rates as a result of random processes"* (Harwood *et al.*, 2014).

145. 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., 2014).

146. 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 7, after 25 years of simulation, the un-impacted population size varies between 6,692 (lower 2.5%) and 16,516 (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.

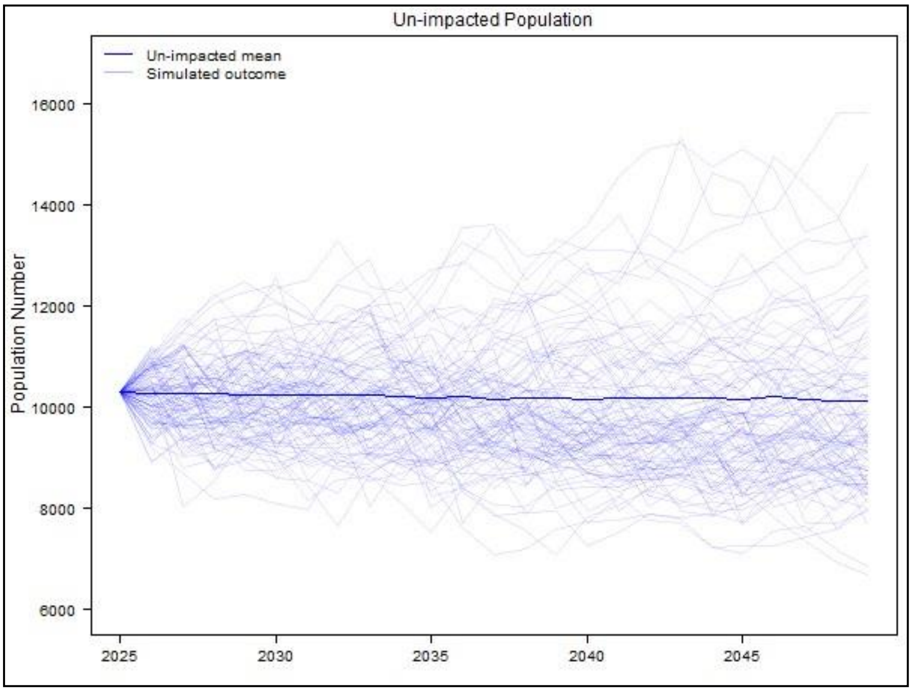

Figure 7 Simulated un-impacted (baseline) population size over the 25 years modelled

Summary

147. All of these precautions built into the iPCoD model mean that the results are considered to be highly conservative. Despite the identified limitations and uncertainties, this iPCoD population level 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.

11.6 Impact Assessment

Construction

148. This section presents the assessment of impacts arising from the construction phase of the Project.

11.6.1.1 Impact 1: UXO Clearance - PTS

149. If UXO are found, a risk assessment will be undertaken and items of UXO will either be avoided, removed or detonated in situ. Recent advancements in the available methods for UXO clearance mean that high-order detonation may be avoided. The methods of UXO clearance considered for the Project would follow the mitigation hierarchy:

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

150. 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. The Project is located in the vicinity of historical industrial and commercial coastal towns which may have been subject to bombing during World War Two and therefore UXOs may be present in these areas. Furthermore, Lincolnshire was home to a large number of military airfields during World War Two which increases the likelihood of encountering UXOs in the region. Despite this, much of the Project area is classified as Low Risk for UXOs.

151. Current advice from the SNCBs (Natural England and the MMO) is that the Southall et al., (2019) criteria for impulsive sounds should be used for assessing the impact of PTS from UXO detonation on marine mammals. Whilst this is currently considered the recommended method to use for assessment, 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 impulsiveness of the sound, and whether current propagation models can accurately predict the range at which these thresholds are reached.

152. An estimation of the source level and predicted PTS-onset impact ranges were calculated for a range of expected UXO sizes. The maximum charge weight for the potential UXO devices that could be present within the Project site boundary has been estimated as 800kg. This has been modelled alongside a range of smaller high-order charges at 25, 55, 120, 240, 525 and 700kg. In addition, a low-order deflagration has been assessed, which assumes that the donor or shaped-charge (charge weight 0.5kg[13]) detonates fully but without the follow-up detonation of the UXO. No mitigation measures have been considered for the modelling of the range and number of animals predicted to be disturbed by the detonation of high-order and low-order charges. The charge sizes presented herein are based on those presented in recent Marine Licence applications for UXO clearance for Hornsea Project Two, Triton Knoll and Sofia Offshore WindFarms and are therefore considered reasonable for the purposes of informing the likely charge sizes which may be encountered at the Project.

153. Full details of the underwater noise modelling and the resulting PTS-onset impact areas and ranges are detailed in document reference 6.3.11.2. The source level of each UXO charge weight was calculated in accordance with Soloway and Dahl (2014), which follows Arons (1954) and Barett (1996), and using conservative calculation parameters that result in the upper estimate of the source level for each charge size. This is therefore considered to be an indication of the potential maximum noise output from each charge size and, as such, likely results in an overestimate of PTS-onset impact ranges, especially for larger charge sizes and low-order clearance. More recent models developed by Robinson (2022) were found to agree reasonably well with the experimental characterisation of explosive noise sources in shallow water environments used by Soloway and Dahl (2014).

---

[13] *It should be noted that a charge weight of 0.5kg is considered highly conservative for a low-order charge based on the results of Robinson et al., (2022)*

154. In line with the recommendations outlined within the recent position statement on UXO clearance (DEFRA et al., 2021) this impact assessment includes an assessment for high-order detonations, though this is considered unlikely to occur in practice. The results for PTS from UXO clearance are presented in Table 11-16.

Table 11-16 PTS-onset impact ranges and number of animals predicted to experience PTS-onset for UXO detonation. All charge sizes listed are in kg. For all charge sizes above 25kg a donor of 0.5kg is assumed

Species (density)	Threshold	Metric	Charge size 0.5	25	55	120	240	525	700	800
Unweighted SPL_{peak} (dB re 1µPa)										
Harbour porpoise (1.63/km²)	202dB (VHF)	Range (km)	1.2	4.6	6.0	7.8	9.8	12.0	14.0	14.0
		# animals	7	108	184	312	492	737	1,004	1,004
		% MU	<0.01	0.03	0.05	0.09	0.14	0.21	0.29	0.29
Harbour porpoise (0.6027/km²)		# animals	3	40	68	115	182	273	371	371
		% MU	<0.01	0.01	0.02	0.03	0.05	0.08	0.11	0.11
Bottlenose dolphin (0.0419/km²)	230dB (HF)	Range (km)	0.07	0.26	0.34	0.45	0.56	0.73	0.81	0.84
		# animals	0	0	0	0	0	0	0	0
		% MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
White-beaked dolphin (0.0149/km²)	230dB (HF)	Range (km)	0.07	0.26	0.34	0.45	0.56	0.73	0.81	0.84
		# animals	0	0	0	0	0	0	0	0
		% MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
White-beaked dolphin (0.0006/km²)		# animals	0	0	0	0	0	0	0	0
		% MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Minke whale (0.0068/km²)	219dB (LF)	Range (km)	0.22	0.82	1.0	1.3	1.7	2.2	2.4	2.6
		# animals	0	0	0	0	0	0	0	0
		% MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Harbour seal (0.13/km²)	218dB (PCW)	Range (km)	0.24	0.91	1.1	1.5	1.9	2.5	2.7	2.8
		# animals	0	0	0	1	1	3	3	3
		% MU	<0.01	<0.01	0.01	0.02	0.03	0.05	0.06	0.07
Grey seal (0.85/km²)	218dB (PCW)	Range (km)	0.24	0.91	1.1	1.5	1.9	2.5	2.7	2.8
		# animals	0	2	3	6	10	17	19	21
		% MU	<0.01	<0.01	<0.01	0.01	0.01	0.03	0.03	0.03
Weighted SEL_{ss} (dB re 1µPa²s)										
		Range (km)	0.11	0.57	0.74	0.95	1.1	1.4	1.5	1.6

Species (density)	Threshold	Metric	Charge size							
			0.5	25	55	120	240	525	700	800
Harbour porpoise (1.63/km^2)	155dB (VHF)	# animals	0	2	3	5	6	10	12	13
		% MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Harbour porpoise (0.6027/km^2)		# animals	0	1	1	2	2	4	4	5
		% MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Bottlenose dolphin (0.0419/km^2)	185dB (HF)	Range (km)	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.06	0.06
		# animals	0	0	0	0	0	0	0	0
		% MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
White-beaked dolphin (0.0149/km^2)	185dB (HF)	Range (km)	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.06	0.06
		# animals	0	0	0	0	0	0	0	0
		% MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
White-beaked dolphin (0.0006/km^2)		# animals	0	0	0	0	0	0	0	0
		% MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Minke whale (0.0068/km^2)	183dB (LF)	Range (km)	0.32	2.2	3.2	4.7	6.5	9.5	10.0	11.0
		# animals	0	0	0	0	1	2	2	3
		% MU	<0.01	<0.01	<0.01	<0.01	0.01	0.01	0.01	0.01
Harbour seal (0.13/km^2)	185dB (PCW)	Range (km)	0.06	0.39	0.57	0.83	1.1	1.6	1.9	2.0
		# animals	0	0	0	0	0	1	1	2
		% MU	<0.01	<0.01	<0.01	0.01	0.01	0.02	0.03	0.03
Grey seal (0.85/km^2)	185dB (PCW)	Range (km)	0.06	0.39	0.57	0.83	1.1	1.6	1.9	2.0
		# animals	0	0	1	2	3	7	10	11
		% MU	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.01	0.02

Sensitivity

155. Most of the acoustic energy produced by a high-order detonation is below a few hundred Hz, decreasing on average by about SEL 10dB per decade above 100 Hz, and there is a pronounced drop-off in energy levels above ~5-10kHz (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. Therefore, most marine mammals (porpoise, dolphins and seals) have been assessed as having a Medium sensitivity to PTS from UXO clearance.

156. 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 as having a potentially High sensitivity to PTS from UXO clearance.

Harbour porpoise

Magnitude

157. At the largest modelled charge size of 800kg + a 25kg donor charge, the impact range for harbour porpoise using unweighted SPLpeak is expected to be 14km, resulting in PTS-onset in 1,004 harbour porpoise, equating to 0.29% of the MU (Table 11-16). Using weighted SELss, the maximum impact range calculated for harbour porpoise was 1.5km, impacting 12 harbour porpoise, equating to <0.01% of the MU.

158. For harbour porpoise, the unmitigated impact is assessed as Medium. This is due to the fact that while only a very small proportion of the management unit, and thus a small number of individuals, are predicted to be impacted, PTS is a permanent impact. Therefore, auditory injury from UXO clearance is expected to have a permanent effect on individuals and their survival, but the level of impact on harbour porpoise would not alter the population trajectory over a generational scale.

159. As part of any future consent for UXO removal, the Project will be required to implement a UXO-specific MMMP to ensure that the effect significance of PTS is negligible. The exact mitigation measures contained with the UXO MMMP are yet to be determined and will be agreed with Natural England. Multiple measures are available and have been implemented elsewhere for UXO clearance, such as the use of Acoustic Deterrent Devices (ADDs) to displace animals to beyond the PTS impact range, or noise abatement techniques where appropriate. The magnitude of this mitigated impact is, therefore, considered to be reduced to Negligible for harbour porpoise.

Significance

160. The sensitivity of harbour porpoise to PTS onset from UXO clearance has been assessed as **Medium**.

161. The unmitigated magnitude of PTS onset to harbour porpoise from UXO clearance has been assessed as **Medium**. The effect significance of unmitigated PTS onset to harbour porpoise from UXO clearance is **Minor**, which is not significant in EIA terms.

162. The mitigated magnitude of PTS onset to harbour porpoise from UXO clearance has been assessed as **Negligible**. The effect significance of mitigated PTS onset to harbour porpoise from UXO clearance is **Negligible**, which is not significant in EIA terms.

Bottlenose dolphin

Magnitude

163. At the largest modelled charge size, the impact range for bottlenose dolphin using unweighted SPLpeak is expected to be 0.84km, resulting in no predicted PTS-onset in bottlenose dolphin (Table 11-16). Using weighted SELss, the maximum impact range calculated for bottlenose dolphin was 0.06km, also resulting in no predicted PTS-onset (Table 11-16). Given the low density of bottlenose dolphins on the area, it is expected that no bottlenose dolphins will be within the PTS impact ranges. The unmitigated magnitude of this impact is, therefore, considered to be Negligible for bottlenose dolphin. This is due to the fact there is no potential for changes in the reproductive or survival success of individual bottlenose dolphins at this level of impacts and therefore no changes to the population size or trajectory.

164. The implementation of a UXO-specific MMMP will further ensure that the mitigated effect significance of PTS on bottlenose dolphins is Negligible.

Significance

165. The sensitivity of bottlenose dolphin to PTS-onset from UXO clearance has been assessed as Medium.

166. Both the unmitigated and mitigated magnitude of PTS-onset to bottlenose dolphin from UXO clearance has been assessed as Negligible. Therefore, both the unmitigated and mitigated effect significance of PTS-onset to bottlenose dolphin from UXO clearance is Negligible, which is not significant in EIA terms.

White-beaked dolphin

Magnitude

167. At the largest modelled charge size, the impact range for white-beaked dolphin using unweighted SPLpeak is expected to be 0.84km, resulting in no predicted PTS-onset in white-beaked dolphin (Table 11-16). Using weighted SELss, the maximum impact range calculated for white-beaked dolphin was 0.06km, also resulting in no predicted PTS-onset (Table 11-17). Given the low density of white-beaked dolphins in the area, it is expected that no white-beaked dolphins will be within the PTS impact ranges. The unmitigated magnitude of this impact is, therefore, considered to be Negligible for white-beaked dolphin. This is due to the fact that there is no potential for changes in the reproductive or survival success of individual white-beaked dolphins at this level of impact, and therefore, no changes to the population size or trajectory.

168. The implementation of a UXO-specific MMMP will further ensure that the effect significance of PTS on white-beaked dolphins is Negligible.

Significance

169. The sensitivity of white beaked dolphin to PTS onset from UXO clearance has been assessed as Medium.

170. Both the unmitigated and mitigated magnitude of PTS-onset to white-beaked dolphin from UXO clearance has been assessed as Negligible.

171. Therefore, the unmitigated and mitigated effect significance of PTS-onset to white-beaked dolphin from UXO clearance is Negligible (not significant) in EIA terms.

Minke whale

Magnitude

172. At the largest modelled charge size, the impact range for minke whale using unweighted SPLpeak is expected to be 2.6km, resulting in no predicted PTS-onset in minke whale (Table 11-16). Using weighted SELss, the maximum impact range calculated for minke whale was 11km, impacting 3 minke whales, equating to 0.01% of the MU (Table 11-17). The unmitigated magnitude of this impact is, therefore, considered to be Low for minke whales. This is due to the fact that survival and reproductive rates are very unlikely to be impacted to the extent that the population trajectory would be altered.

173. As part of any future consent for UXO removal the Project will be required to implement a UXO-specific MMMP to ensure that the effect significance of PTS is negligible. The mitigated magnitude of this impact is, therefore, considered to be Negligible for minke whale.

Significance

174. The sensitivity of minke whale to PTS-onset from UXO clearance has been conservatively assessed as High.

175. The unmitigated magnitude of PTS-onset to minke whale from UXO clearance has been assessed as Low.

176. The mitigated magnitude of PTS-onset to minke whale from UXO clearance has been assessed as Negligible.

177. Therefore, both the unmitigated and mitigated effect significance of PTS-onset to minke whales from UXO clearance is Minor, which is not significant in EIA terms.

Harbour seal

Magnitude

178. At the largest modelled charge size, the impact range for harbour seal using unweighted SPLpeak is expected to be 2.8km, resulting in PTS-onset in three harbour seals, equating to 0.07% of the MU (Table 11-16). Using weighted SELss, the maximum impact range calculated for harbour seals was 2km, impacting two harbour seals, equating to 0.03% of the MU (Table 11-17). The unmitigated magnitude of this impact is, therefore, considered to be Low for harbour seal. This is due to the fact that survival and reproductive rates are very unlikely to be impacted to the extent that the population trajectory would be altered.

Significance

179. The sensitivity of harbour seal to PTS-onset from UXO clearance has been assessed as Medium.

180. The unmitigated magnitude of PTS-onset to harbour seal from UXO clearance has been assessed as Low.

181. The mitigated magnitude of PTS-onset to harbour seal from UXO clearance has been assessed as Negligible.

182. The effect significance of unmitigated PTS-onset to harbour seals from UXO clearance is Minor, which is not significant in EIA terms.

183. The effect significance of mitigated PTS-onset to harbour seals from UXO clearance is Negligible, which is not significant in EIA terms.

Grey seal

Magnitude

184. At the largest modelled charge size, the impact range for grey seal using unweighted SPLpeak is expected to be 2.8km, resulting in PTS-onset in 21 grey seals, equating to 0.03% of the MU (Table 11-16). Using weighted SELss, the maximum impact range calculated for grey seals was 2km, impacting 11 grey seals, equating to 0.02% of the MU (Table 11-16). The unmitigated magnitude of this impact is, therefore, considered to be Low for grey seal. This is due to the fact that survival and reproductive rates very unlikely to be impacted to the extent that the population trajectory would be altered.

185. As part of any future consent for UXO removal the Project will be required to implement a UXO-specific MMMP to further ensure that the effect significance of PTS is negligible. The mitigated magnitude of this impact will therefore be Negligible for grey seal.

Significance

186. The sensitivity of grey seal to PTS-onset from UXO clearance has been assessed as Medium.

187. The unmitigated magnitude of PTS-onset to grey seal from UXO clearance has been assessed as Low.

188. The mitigated magnitude of PTS-onset to grey seal from UXO clearance has been assessed as Negligible.

189. The effect significance of unmitigated PTS-onset to grey seals from UXO clearance is Minor, which is not significant in EIA terms.

190. The effect significance of mitigated PTS-onset to grey seals from UXO clearance is Negligible, which is not significant in EIA terms.

UXO clearance – PTS summary

191. Table 11-17 presents a summary of the sensitivity, magnitude and significance of PTS-onset from UXO clearance for marine mammals, both before and after the mitigation in the form of a UXO MMMP. The mitigated significance has been assessed as Negligible for most marine mammal species (porpoise, dolphins and seals) and Minor for minke whales, which is not significant in EIA terms.

Table 11-17 Summary of marine mammal sensitivity, magnitude and significance of PTS from UXO clearance.

Species	Sensitivity	Unmitigated Magnitude	Unmitigated Significance	Mitigated Magnitude	Significance
Harbour porpoise	Medium	Medium	Minor	Negligible	**Negligible (Not significant)**
Bottlenose dolphin	Medium	Negligible	Negligible	Negligible	**Negligible (Not significant)**
White-beaked dolphin	Medium	Negligible	Negligible	Negligible	**Negligible (Not significant)**
Minke whale	High	Low	Minor	Negligible	**Minor (Not significant)**
Harbour seal	Medium	Negligible	Minor	Negligible	**Negligible (Not significant)**
Grey seal	Medium	Negligible	Minor	Negligible	**Negligible (Not significant)**

11.6.1.2 Impact 2: UXO Clearance - Disturbance

192. As previously stated, there are currently no empirically-derived behavioural thresholds or dose response functions for UXO detonation. Therefore, in the absence of agreed thresholds to assess the potential for behaviour disturbance in marine mammals from UXO detonations, the Project impact assessment presents the results for the 26km EDR (high-order ; Table 11-18), 5km EDR (low-order; Table 11-19) and TTS-onset thresholds (Table 11-20:).

193. It is acknowledged 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.

Table 11-18: Disturbance from high-order UXO clearance using an EDR of 26km.

Species	Density (#/km^2)	Area (km^2)	# impacted	MU size	% MU
Harbour porpoise	1.63	2,123.72	3,462	346,601	1.0
	0.6027		1,280		0.4

Species	Density (#/km^2)	Area (km^2)	# impacted	MU size	% MU
Bottlenose dolphin	0.0419	2,123.72	89	2,022	4.4
White-beaked dolphin	0.0149	2,123.72	32	43,951	0.1
	0.0006		1		0.0
Minke whale	0.0068	2,123.72	14	20,118	0.1
Harbour seal	0.13	2,123.72	276	4,868	5.7
Grey seal	0.85	2,123.72	1,805	65,505	2.8

Table 11-19:Disturbance from low-order UXO clearance using an EDR of 5km

Species	Density (#/km^2)	Area (km^2)	# impacted	MU size	% MU
Harbour porpoise	1.63	78.54	128	346,601	<0.1
	0.6027		47		<0.1
Bottlenose dolphin	0.002	78.54	3	2,022	0.1
White-beaked dolphin	0.0006	78.54	1	43,951	<0.1
	0.0149		1		<0.1
Minke whale	0.0068	78.54	1	20,118	<0.1
Harbour seal	0.13	78.54	10	4,868	0.2
Grey seal	0.85	78.54	67	65,505	0.1

Table 11-20: Disturbance from UXO clearance using TTS-onset as a proxy for disturbance.

Species (density)	Threshold	Metric	Charge size							
			0.5	25	55	120	240	525	700	800
Unweighted SPL_{peak} (dB re 1µPa)										
Harbour porpoise (1.63/km^2)	196dB (VHF)	Range (km)	2.3	8.5	11	14	18	23	25	26
		# animals	27	370	620	1,004	1,659	2,709	3,200	3,462
		% MU	0.01	0.11	0.18	0.29	0.48	0.78	0.92	1.00
Harbour porpoise (0.6027/km^2)		# animals	6	137	229	371	613	1,002	1,183	1,280
		% MU	<0.01	0.04	0.07	0.11	0.18	0.29	0.34	0.37
Bottlenose dolphin (0.0419/km^2)	224dB (HF)	Range (km)	0.13	0.49	0.64	0.83	1.0	1.3	1.4	1.5
		# animals	0	0	0	0	0	0	0	0
		% MU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
White-beaked dolphin (0.0149/km^2)	224dB (HF)	Range (km)	0.13	0.49	0.64	0.83	1.0	1.3	1.4	1.5
		# animals	0	0	0	0	0	0	0	0
		% MU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
White-beaked dolphin (0.0006/km^2)		# animals	0	0	0	0	0	0	0	0
		% MU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Minke whale (0.0068/km^2)	213dB (LF)	Range (km)	0.41	1.5	1.9	2.5	3.2	4.1	4.5	4.7
		# animals	0	0	0	0	0	0	0	0
		% MU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Harbour seal (0.13/km^2)	212dB (PCW)	Range (km)	0.45	1.6	2.1	2.8	3.5	4.6	5.0	5.3
		# animals	0	1	2	3	5	9	10	11
		% MU	0.00	0.02	0.04	0.07	0.10	0.18	0.21	0.24
Grey seal (0.85/km^2)	212dB (PCW)	Range (km)	0.45	1.6	2.1	2.8	3.5	4.6	5.0	5.3
		# animals	1	7	12	21	33	57	67	75
		% MU	<0.01	0.01	0.02	0.04	0.06	0.11	0.13	0.14
Weighted SEL_{ss} (dB re 1µPa^{2}s)										

Species (density)	Threshold	Metric	Charge size							
			0.5	25	55	120	240	525	700	800
Harbour porpoise (1.63/km^2)	140dB (VHF)	Range (km)	0.93	2.4	2.8	3.2	3.5	4.0	4.1	4.2
		# animals	4	29	40	52	63	82	86	90
		% MU	<0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03
Harbour porpoise (0.6027/km^2)		# animals	1	11	15	19	23	30	32	33
		% MU	<0.01	<0.01	<0.01	0.01	0.01	0.01	0.01	0.01
Bottlenose dolphin (0.0419/km^2)	170dB (HF)	Range (km)	<0.05	0.15	0.21	0.30	0.39	0.53	0.62	0.69
		# animals	0	0	0	0	0	0	0	0
		% MU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
White-beaked dolphin (0.0149/km^2)	170dB (HF)	Range (km)	<0.05	0.15	0.21	0.30	0.39	0.53	0.62	0.69
		# animals	0	0	0	0	0	0	0	0
		% MU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
White-beaked dolphin (0.0006/km^2)		# animals	0	0	0	0	0	0	0	0
		% MU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Minke whale (0.0068/km^2)	168dB (LF)	Range (km)	4.5	29	41	57	76	100	110	120
		# animals	0	18	36	69	123	214	258	308
		% MU	0.00	0.09	0.18	0.35	0.61	1.06	1.28	1.53
Harbour seal (0.13/km^2)	170dB (PCW)	Range (km)	0.80	5.2	7.5	10	14	19	22	23
		# animals	0	11	23	41	80	147	198	216
		% MU	0.01	0.23	0.47	0.84	1.65	3.04	4.07	4.45
Grey seal (0.85/km^2)	170dB (PCW)	Range (km)	0.80	5.2	7.5	10	14	19	22	23
		# animals	2	72	150	267	523	964	1,292	1,413
		% MU	<0.01	0.14	0.28	0.50	0.99	1.82	2.44	2.67

Sensitivity

196. 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 Medium at most.

Harbour porpoise

Magnitude

197. When using the 26km EDR for disturbance from high-order detonations. it is anticipated that 3,462 harbour porpoise would be disturbed by high-order UXO clearance, equating to 1.0% of the MU (Table 11-18). Given the small proportion of the MU expected to be disturbed by high-order UXO clearance, and the fact that disturbance will be short-term/intermittent and temporary effect, the impact is assessed as a Low magnitude to harbour porpoise.

198. When using the 5km EDR for disturbance from low-order detonations, it is anticipated that 186 harbour porpoise would be disturbed by low-order UXO clearance, equating to 0.1% of the MU (Table 11-19). Given the number and proportion of the MU expected to be disturbed by low-order UXO clearance, the impact is assessed as a Negligible magnitude.

199. When using TTS-onset as a proxy for behavioural disturbance, the impact range for harbour porpoise for the maximum UXO clearance of 800kg UXO + a 25kg donor charge using unweighted SPLpeak was calculated at a maximum of 26km, impacting 3,642 harbour porpoise, equating to 1.0% of the MU (Table 11-20). Using weighted SELss, the maximum impact range calculated for harbour porpoise was 4.2km, impacting 90 harbour porpoise, equating to 0.03% of the MU (Table 11-21). Given the small proportion of the MU expected to be disturbed by UXO clearance, and the fact that the disturbance will be a short-term/intermittent and temporary effect, the impact is assessed as Low magnitude.

Significance

200. The sensitivity of harbour porpoise to disturbance from UXO clearance has been assessed as Medium.

201. The magnitude of disturbance to harbour porpoise from UXO clearance has been assessed as Negligible to Low.

202. Therefore, the effect significance of disturbance to harbour porpoise from UXO clearance is Negligible to Minor, neither of which is significant in EIA terms.

Bottlenose dolphin

Magnitude

203. When using the 26km EDR for disturbance from high-order detonations, it is anticipated that 89 bottlenose dolphins would be disturbed by high-order UXO clearance, equating to 4.4% of the MU (Table 11-18). Given the small proportion of the MU expected to be disturbed by high-order UXO clearance, and the fact that the disturbance will be a short-term/intermittent and temporary effect, the impact is assessed as a Low magnitude to bottlenose dolphin.

204. When using the 5km EDR for disturbance from low-order detonations, it is anticipated that no bottlenose dolphins within the MU would be disturbed by low-order UXO clearance (Table 11-19). Therefore, the impact is assessed as a Negligible magnitude to bottlenose dolphin.

205. When using TTS-onset as a proxy for behavioural disturbance, the impact range for bottlenose dolphin for the maximum UXO clearance of 800kg UXO + a 25kg donor charge was calculated at a maximum of 1.5km, resulting in no predicted impact to bottlenose dolphin (Table 11-20)Using weighted SELss, the maximum impact range calculated for bottlenose dolphin was 0.69km, also resulting in no predicted impact to bottlenose dolphin (Table 11-20). Therefore the impact is assessed as Negligible magnitude to bottlenose dolphin.

Significance

206. The sensitivity of bottlenose dolphins to disturbance from UXO clearance has been assessed as Medium.

207. The magnitude of disturbance to bottlenose dolphin from UXO clearance has been assessed as Negligible to Low.

208. Therefore, the effect significance of disturbance to bottlenose dolphins from UXO clearance is Negligible to Minor, neither of which is significant in EIA terms.

White-beaked dolphin

Magnitude

209. When using the 26km EDR for disturbance from high-order detonations, it is anticipated that 32 white-beaked dolphins within the MU would be disturbed by high-order UXO clearance, equating to 0.1% of the MU (Table 11-18). Given the very small proportion of the MU expected to be disturbed by high-order UXO clearance, and the fact that the disturbance will be a short-term/intermittent and temporary effect, the impact is assessed as a Negligible magnitude to white-beaked dolphins.

210. When, using the 5km EDR for disturbance from low-order detonations, it is anticipated that 1 white-beaked dolphin within the MU would be disturbed by low-order UXO clearance, equating to <0.1% of the MU (Table 11-19). Given the very small proportion of the MU expected to be disturbed by low-order UXO clearance, and the fact that the disturbance will be a short-term/intermittent and temporary effect, the impact is assessed as a Negligible magnitude to white-beaked dolphins.

211. When using TTS-onset as a proxy for behavioural disturbance, the impact range for white-beaked dolphin for the maximum UXO clearance of 800kg UXO + a 25kg donor charge was calculated at a maximum of 1.5km, resulting in no predicted impact to white-beaked dolphin (Table 11-20). Using weighted SELss, the maximum impact range calculated for white-beaked was 0.69km, also resulting in no predicted impact to bottlenose dolphin (Table 11-20). Therefore, the impact is assessed as Negligible magnitude.

Significance

212. The sensitivity of white beaked dolphins to disturbance from UXO clearance has been assessed as Medium.

213. The magnitude of disturbance to white beaked dolphins from UXO clearance has been assessed as Negligible.

214. Therefore, the effect significance of disturbance to white beaked dolphins from UXO clearance is Negligible, which is not significant in EIA terms.

Minke whale

Magnitude

215. When using the 26km EDR for disturbance from high-order detonations, it is anticipated that 14 minke whales would be disturbed by high-order UXO clearance, equating to 0.1% of the MU (Table 11-18). Given the very small proportion of the MU expected to be disturbed by high-order UXO clearance, and the fact that the disturbance will be a short-term/intermittent and temporary effect, the impact is assessed as a Negligible magnitude to minke whales.

216. When using the 5km EDR for disturbance from low-order detonations, it is anticipated that one minke whale would be disturbed by low-order UXO clearance, equating to <0.1% of the MU (Table 11-19). Given the very small proportion of the MU expected to be disturbed by low-order UXO clearance, and the fact that the disturbance will be a short-term/intermittent and temporary effect, the impact is assessed as a Negligible magnitude to minke whales.

217. Using TTS onset as a proxy for behavioural disturbance: The impact range for minke whale for the maximum UXO clearance of 800kg UXO + a 25kg donor charge was calculated at a maximum of 4.7km, impacting 0 minke whales (Table 11-20). Using weighted SEL_{ss}, the maximum impact range calculated for minke whale was 120km, impacting 308 minke whales, equating to 1.53% of the MU (Table 11-20). Despite the large TTS-onset impact range presented, it should be noted that the Soloway and Dahl (2014) equation used for modelling the impact ranges in Volume 2, Appendix 3.2: Underwater Noise Assessment is not considered valid at such a distance from the noise source. Given the small proportion of the MU expected to be disturbed by UXO clearance, and the fact that the disturbance will be a short-term/intermittent and temporary effect, the impact is assessed as **Low** magnitude.

Significance

218. The sensitivity of minke whales to disturbance from UXO clearance has been assessed as Medium.

219. The magnitude of disturbance to minke whales from UXO clearance has been assessed as Negligible.

220. Therefore, the effect significance of disturbance to minke whales from UXO clearance is Negligible, which is not significant in EIA terms.

Harbour seal

Magnitude

221. Using the 26km EDR for disturbance from high-order detonations: It is anticipated that 276 harbour seals would be disturbed by high-order UXO clearance, equating to 5.7% of the MU (Table 11-19). Given the small proportion of the MU expected to be disturbed by high-order UXO clearance, and the fact that the disturbance will be a short-term/intermittent and temporary effect, the impact is assessed as a Low magnitude to harbour seals.

222. Using the 5km EDR for disturbance from low-order detonations: It is anticipated that 10 harbour seals would be disturbed by low-order UXO clearance, equating to 0.2% of the MU (Table 11-20). Given the very small proportion of the MU expected to be disturbed by low-order UXO clearance, and the fact that the disturbance will be a short-term/intermittent and temporary effect, the impact is assessed as a Negligible magnitude to harbour seals.

223. Using TTS onset as a proxy for behavioural disturbance: The impact range for harbour seals for the maximum UXO clearance of 800kg UXO + a 25kg donor charge was calculated at a maximum of 5.3km, impacting 11 harbour seals, equating to 0.24% of the MU (Table 11-21). Using weighted SELss, the maximum impact range calculated for harbour seal was 23km, impacting 216 harbour seal, equating to 4.45% of the MU (Table 11-21). Given the small proportion of the MU expected to be disturbed by UXO clearance, and the fact that the disturbance will be a short-term/intermittent and temporary effect, the impact is assessed as Low magnitude.

Significance

224. The sensitivity of harbour seals to disturbance from UXO clearance has been assessed as Medium.

225. The magnitude of disturbance to harbour seal from UXO clearance has been assessed as Negligible to Low.

226. Therefore, the effect significance of disturbance to harbour seal from UXO clearance is Negligible to Minor, neither of which is significant in EIA terms.

Grey seal

Magnitude

227. When using the 26km EDR for disturbance from high-order detonations, it is anticipated that 1,805 grey seals would be disturbed by high-order UXO clearance, equating to 3.4% of the MU (Table 11-19). Given the small proportion of the MU expected to be disturbed by high-order UXO clearance, and the fact that the disturbance will be a short-term/intermittent and temporary effect, the impact is assessed as a Low magnitude to grey seals.

228. When using the 5km EDR for disturbance from low-order detonations, it is anticipated that 67 grey seals would be disturbed by low-order UXO clearance, equating to 0.1% of the MU (Table 11-20). Given the very small proportion of the MU expected to be disturbed by low-order UXO clearance, and the fact that the disturbance will be a short-term/intermittent and temporary effect, the impact is assessed as a Negligible magnitude to grey seals.

229. When using TTS-onset as a proxy for behavioural disturbance, the impact range for grey seals for the maximum UXO clearance of 800kg UXO + a 25kg donor charge was calculated at a maximum of 5.3km, impacting 75 grey seals, equating to 0.14% of the MU (Table 11-21). Using weighted SELss, the maximum impact range calculated for grey seal was 23km, impacting 1,413 grey seals, equating to 2.67% of the MU (Table 11-20). Given the small proportion of the MU expected to be disturbed by UXO clearance, and the fact that the disturbance will be a short-term/intermittent and temporary effect, the impact is assessed as Low magnitude.

Significance

230. The sensitivity of grey seals to disturbance from UXO clearance has been assessed as Medium.

231. The magnitude of disturbance to grey seals from UXO clearance has been assessed as Negligible to Low .

232. Therefore, the effect significance of disturbance to grey seals from UXO clearance is Negligible to Minor, neither of which is significant in EIA terms.

233. UXO clearance – disturbance summary

234. Table 11-21 presents a summary of the sensitivity, magnitude and significance of disturbance from UXO clearance for marine mammals. The significance has been assessed as Negligible for bottlenose dolphins, white-beaked dolphins, and as Minor to Negligible for harbour porpoise, minke whale, harbour seal and grey seals, which are not significant in EIA terms.

UXO clearance – disturbance summary

235. Table 11-21 presents a summary of the sensitivity, magnitude and significance of disturbance from UXO clearance for marine mammals. The significance has been assessed as Negligible for minke whale and white-beaked dolphins, and as Minor to Negligible for harbour porpoise, bottlenose dolphin, harbour seal and grey seals, which are **not significant** in EIA terms.

Table 11-21 Summary of marine mammal sensitivity, magnitude and significance of disturbance from UXO clearance.

Species	Sensitivity	Magnitude	Significance
Harbour porpoise	Medium	Negligible to Low	**Negligible to Minor (Not significant)**
Bottlenose dolphin	Medium	Negligible to Low	**Negligible to Minor (Not significant)**
White-beaked dolphin	Medium	Negligible	**Negligible (Not significant)**
Minke whale	Medium	Negligible to Low	**Negligible (Not significant)**
Harbour seal	Medium	Negligible to Low	**Negligible to Minor (Not significant)**

Species	Sensitivity	Magnitude	Significance
Grey seal	Medium	Negligible to Low	**Negligible to Minor (Not significant)**

11.6.1.3 Impact 3: Pile driving – PTS

Piling parameters

236. A total of seven piling locations has been considered for the onset of PTS. These include three locations for the piling within the array area (Array-SW, Array-NW, Array-NE), one location for the ORCP, and two locations for piling of the ANS (ANS-NW, ANS-SE) (Table 11-22). Both monopiles and pin-piles have been considered at each modelling location.

Table 11-22 Piling locations included in the underwater noise monitoring

Location	Latitude	Longitude	Depth (m)
Array - SW	53.48762°N	001.06477°E	8.6
Array - NW	53.54229°N	001.01642°E	14.5
Array - NE	53.6355°N	001.4890°E	24.5
ORCP	53.26277°N	000.51374°E	14.1
ANS - NW	53.75820°N	000.96025°E	29.7
ANS - SE	53.45718°N	001.75641°E	20.5

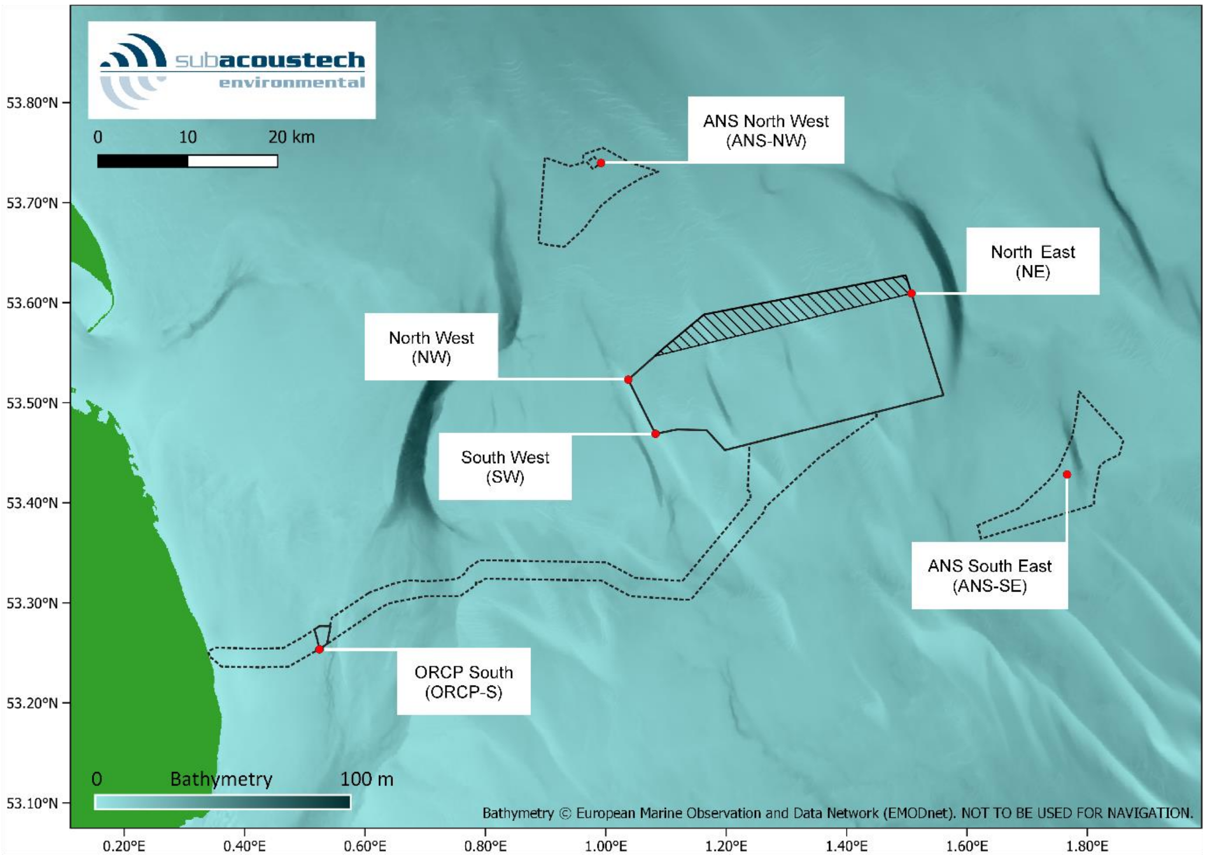

Plate 11.8 Underwater noise modelling locations

237. For the calculation of PTS-onset from piling at the array area and ORCP, the assumption has been made that two monopiles can be installed sequentially (one after the other) in a 24-hour period. Only a single monopile in the ANS areas would be installed in a 24-hour period. For piling of pin-piles at the array area and ORCP, the assumption has been made that six pin-piles can be installed sequentially in a 24-hour period. For piling of pin-piles at the ANS areas, the assumption has been made that four pin-piles can be installed sequentially in a 24-hour period. Table 11-23 outlines the piling parameters input into the underwater noise modelling for each piling scenario.

Table 11-23: Piling parameters included in the underwater noise modelling

	Soft-start and ramp-up				Max	TOTAL
Monopile Array and ORCP: 14 m diameter pile, max 2 piles/day						
Blow energy (kJ)	660	1650	3300	4950	6600	-
No. of strikes	100	450	900	1350	7800	10,600 (x1) 21,200 (x2)
Phase duration (s)	600	900	1800	2700	15600	6 hr (x1) 12 hr (x2)
Strike rate (blows/min)	10	30	30	30	30	-
Jacket Array and ORCP: 5 m diameter pile, max 6 piles/day						
Blow energy (kJ)	350	875	1750	2625	3500	-
No. of strikes	100	450	900	900	4650	7,000 (x1) 42,000 (x6)
Phase duration (s)	600	900	1800	1800	9300	4 hr (x1) 24 hr (x6)
Strike rate (blows/min)	10	30	30	30	30	-
Monopile ANS: 8 m diameter pile, max 1 pile/day						
Blow energy (kJ)	350	875	1750	2625	3500	-
No. of strikes	100	450	900	900	4650	7,000 (x1)
Phase duration (s)	600	900	1800	1800	9300	4 hr (x1)
Strike rate (blows/min)	10	30	30	30	30	-
Jacket ANS: 5 m diameter pile, max 4 pile/day						
Blow energy (kJ)	350	875	1750	2625	3500	-
No. of strikes	100	450	900	900	4650	7,000 (x1) 28,000 (x4)
Phase duration (s)	600	900	1800	1800	9300	4 hr (x1) 16 hr (x4)
Strike rate (blows/min)	10	30	30	30	30	-

Harbour porpoise

Sensitivity

238. 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 hearing14 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. A number of 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.

239. Southall (2007) defined the onset of TTS as *"being a temporary elevation of a hearing threshold by 6dB"* (in which the reference pressure for the dB is 1µPa). Although 6dB of TTS is a somewhat arbitrary definition of onset, it has been adopted largely because 6dB 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 6dB, 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 40dB. 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 40dB of TTS, i.e., 40dB of TTS is assumed to equate to 6dB of PTS.

240. For piling noise, most energy is between ~30 – 500Hz, with a peak usually between 100 – 300Hz and energy extending above 2kHz (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 occurring at 4 and 8kHz (Kastelein et al., 2016) and centred at 4kHz (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 – 10kHz range (Kastelein et al., 2017) and that a PTS 'notch' of 6 – 18dB in a narrow frequency band in the 2 - 10kHz region is unlikely to significantly affect the fitness of individuals (ability to survive and reproduce). The expert elicitation concluded that:

[14] Workshop experts included representatives from Woods Hole Oceanographic Institute, Aarhus University, National Marine Mammal Foundation, SEAMRCO, JASCO Applied Sciences, SMRU (University of St Andrews) and University of Aberdeen.

"… the effects of a 6dB PTS in the 2-10kHz 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 6dB 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."

241. For harbour porpoise, the predicted decline in vital rates from the impact of a 6dB PTS in the 2-10kHz band for different percentiles of the elicited probability distribution are provided in Table 11-24. The data provided in Table 11-24 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 6dB PTS (a notch a few kHz wide and 6dB high) occurring somewhere in the hearing between 2-10kHz) (Plate 11.9).
- Experts estimated that the median decline in an individual mature female harbour porpoise's fertility was 0.09% (due to a 6dB PTS (a notch a few kHz wide and 6dB high) occurring somewhere in the hearing between 2-10kHz) (Plate 11.10).
- Experts estimated that the median decline in an individual harbour porpoise juvenile or dependent calf survival was 0.18% (due to a 6dB PTS (a notch a few kHz wide and 6dB high) occurring somewhere in the hearing between 2-10kHz) (Plate 11.12).

Table 11-24: 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

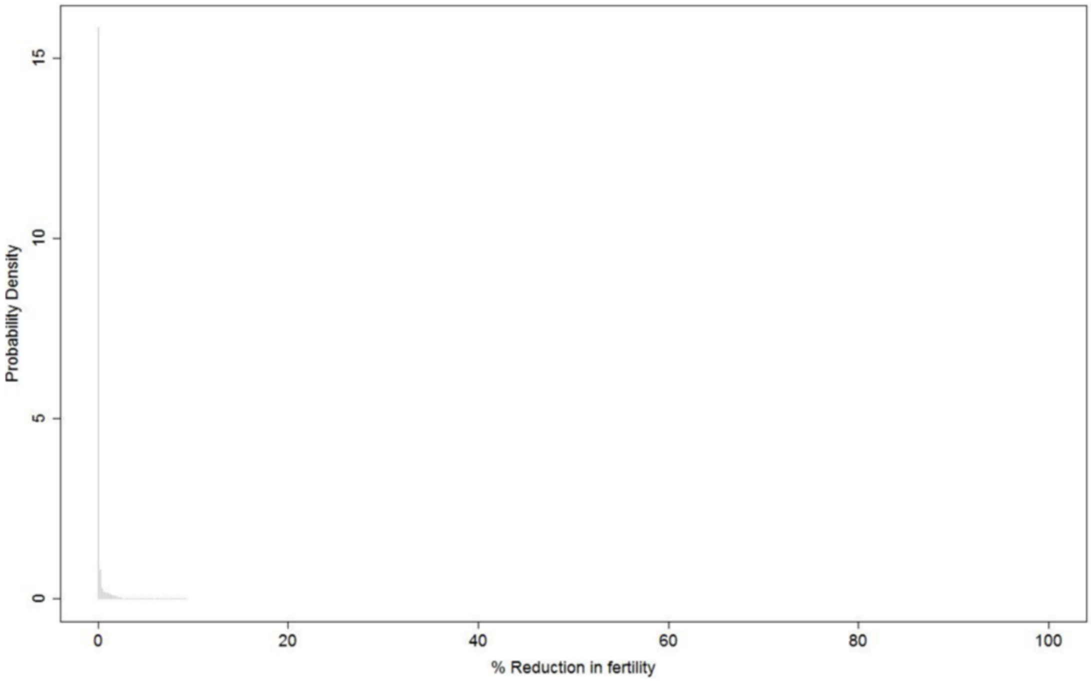

Plate 11.9: Probability distribution showing the consensus distribution for the effects on fertility of a mature female harbour porpoise as a consequence of a maximum 6dB of PTS within a 2-10kHz band (Booth and Heinis, 2018).

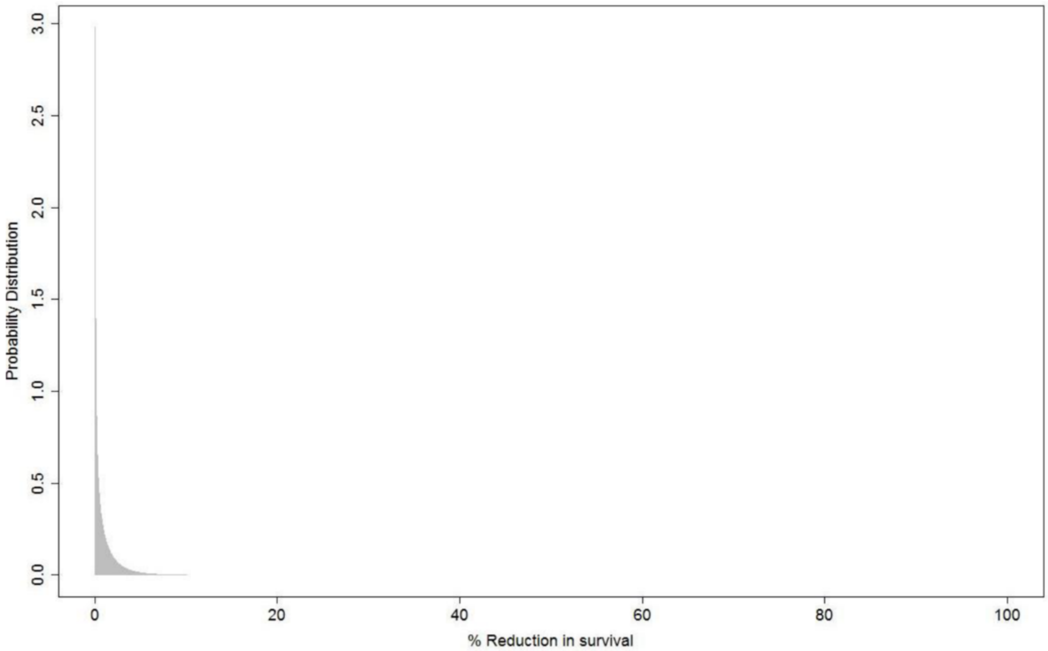

Plate 11.10: Probability distribution showing the consensus distribution for the effects on survival of a mature female harbour porpoise as a consequence of a maximum 6dB of PTS within a 2-10kHz band (Booth and Heinis, 2018).

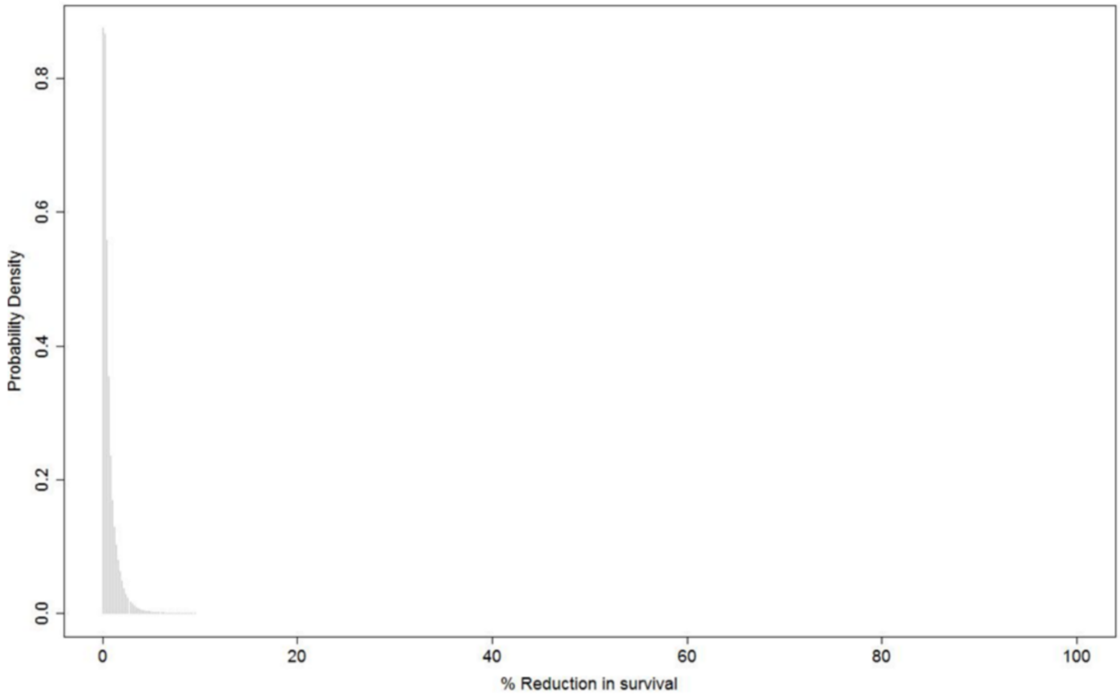

Plate 11.11: Probability distribution showing the consensus distribution for the effects on survival of juvenile or dependent calf harbour porpoise as a consequence of a maximum 6dB of PTS within a 2-10kHz band (Booth and Heinis, 2018).

242. Furthermore, data collected during windfarm construction have demonstrated that porpoise detections around the pile driving site decline several hours 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). 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.

243. Whilst PTS is a permanent effect which cannot be recovered from, the evidence suggests that PTS from piling is unlikely to cause a change in both reproduction and survival rates; therefore, harbour porpoise have been assessed as having a **Medium** sensitivity to PTS.

Magnitude

244. The predicted areas and maximum impact ranges for auditory injury (PTS-onset) from pile driving of a monopile and pin-piles for harbour porpoise are outlined in Table 11-25 and Table 11-26 This includes the prediction of impact for each of the eight modelling locations.

Table 11-25: PTS-onset impact ranges, number of harbour porpoise and percentage of MU predicted to experience instantaneous PTS-onset during piling (unweighted SPLpeak dB re 1µPa) using the uniform DAS estimate (1.63/km2), the SCANS III density surface (Lacey et al cell specific) and the SCANS IV density estimate (0.6027/km^2) (Gilles et al. 2023).

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
as Monopile							
Area (km^2)	0.22	0.48	1	No cumulative effect[15]	0.47	0.94	0.63
Max range (m)	270	420	580		390	550	460
# (DAS)	<1	1	2		1	1	1
% MU (DAS)	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001
# (Lacey et al. 2022)	<1	1	1		1	1	1
% MU (Lacey et al. 2022)	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001
# (SCANS IV)	<1	<1	1		<1	<1	<1
% MU (SCANS IV)	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001
Jacket							
Area (km^2)	0.16	0.35	0.75	No cumulative effect	0.34	0.91	0.61
Max range (m)	230	360	490		340	540	450
# (DAS)	<1	1	1		1	1	1
% MU (DAS)	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001
# (Lacey et al. 2022)	<1	<1	1		<1	1	1
% MU (Lacey et al. 2022)	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001
# (SCANS IV)	<1	<1	<1		<1	1	<1
% MU (SCANS IV)	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001

[15] There is no in-combination effect when piling occurs at the two locations simultaneously, generally where the individual ranges are small enough that the distant site does not produce an influencing additional exposure.

Table 11-26: PTS-onset impact ranges, number of harbour porpoise and percentage of MU predicted to experience cumulative PTS during piling (weighted SELss dB re 1µPa2s) using the uniform DAS estimate (1.63/km2), the SCANS III density surface (Lacey *et al.,* 2022) (grid cell specific) and the SCANS IV density estimate (0.6027/km2) (Gilles *et al.,* 2023).

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Monopile x1							
Area (km^2)	0.9	5.2	22	No cumulative effect[16]	2.6	17	7.5
Max range (m)	650	1,600	3,000		1,300	2,600	1,900
# (DAS)	1	9	36		4	27	12
% MU (DAS)	<0.001	0.003	0.010		0.001	0.008	0.004
# (Lacey et al. 2022)	1	7	30		4	23	8
% MU (Lacey et al. 2022)	<0.001	0.002	0.009		0.001	0.007	0.002
# (SCANS IV)	1	3	14		2	10	5
% MU (SCANS IV)	<0.001	<0.001	0.004		<0.001	0.003	0.001
Monopile x2							
Area (km^2)	0.9	5.3	22	280[17]	2.6	NA	
Max range (m)	650	1,600	3,000	-	1,300		
# (DAS)	1	9	36	456	4		
% MU (DAS)	<0.001	0.003	0.010	0.132	0.001		
# (Lacey et al. 2022)	1	7	30	368	4		
% MU (Lacey et al. 2022)	<0.001	0.002	0.009	0.106	0.001		
# (SCANS IV)	1	3	14	179	2		
% MU (SCANS IV)	<0.001	<0.001	0.004	0.052	<0.001		
Jacket x1							
Area (km^2)	<0.1	1.5	9.7	No cumulative effect	0.6	17	7.5
Max range (m)	230	930	2,000		650	2,600	1,900
# (DAS)	<1	2	16		1	27	12

[16] There is no in-combination effect when piling occurs at the two locations simultaneously, generally where the individual ranges are small enough that the distant site does not produce an influencing additional exposure.
[17] Note: this impact area is much higher than for a single location. This is explained in the underwater noise report: "*When considering SELcum modelling, piling from multiple sources has the ability to increase impact ranges and areas significantly as, in this case, it introduces noise from double the number of pile strikes to the water. Unlike sequential piling […], fleeing receptors can be closer to a source for more pile strikes resulting in higher cumulative exposures*."

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
% MU (DAS)	<0.001	<0.001	0.005		<0.001	0.008	0.004
# (Lacey et al. 2022)	<1	2	13		1	23	8
% MU (Lacey et al. 2022)	<0.001	<0.001	0.004		<0.001	0.007	0.002
# (SCANS IV)	<1	1	7		<1	10	5
% MU (SCANS IV)	<0.001	<0.001	0.002		<0.001	0.003	0.001
Jacket x6						Jacket x4	
Area (km²)	<0.1	1.5	9.7	220	0.6	17	7.5
Max range (m)	230	930	2,000	-	650	2,600	1,900
# (DAS)	<1	2	16	365	1	28	12
% MU (DAS)	<0.001	<0.001	0.005	0.105	<0.001	0.008	0.004
# (Lacey et al. 2022)	<1	2	13	292	1	24	8
% MU (Lacey et al. 2022)	<0.001	<0.001	0.004	0.084	<0.001	0.007	0.002
# (SCANS IV)	<1	1	7	142	<1	10	5
% MU (SCANS IV)	<0.001	<0.001	0.002	0.041	<0.001	0.003	0.001

Array

245. For the installation of monopiles within the array area (Array SW, NW, NE locations), the maximum instantaneous PTS-onset impact range was 580m at the NE monopile location when using the maximum hammer energy. When using the DAS density estimate, this equates to a maximum of 2 harbour porpoise (<0.001% MU) predicted to experience auditory injury. When using the Lacey et al. (2022) and SCANS IV density estimates, a maximum of 1 and <1 harbour porpoise are predicted to experience auditory injury respectively (<0.001% MU).

246. For the installation of jacket (pin) piles within the array area (Array SW, NW, NE locations), the maximum instantaneous PTS-onset impact range was 490m at the NE piling location when using the maximum hammer energy. When using the DAS density estimate, this equates to a maximum of 1 harbour porpoise (<0.001% MU) predicted to experience auditory injury. When using the Lacey et al. (2022) and SCANS IV density estimates, a maximum of 1 and <1 harbour porpoise are predicted to experience auditory injury respectively (<0.001% MU).

247. Results for cumulative PTS-onset were also presented in Table 11-26 For installation of monopiles within the array area at a single location, the maximum cumulative PTS-onset impact range was 3.0km for the installation of monopiles at the NE location. This equates to a maximum of 36 harbour porpoise (0.01% MU) predicted to experience auditory injury when using the DAS density estimate. When using the Lacey et al. (2022) and SCANS IV density estimates, a maximum of 30 and 14 harbour porpoise are predicted to experience auditory injury respectively (0.009% MU (Lacey et al, 2022; 0.004% MU SCANS IV).

248. For installation of jacket (pin) piles within the array area, the maximum cumulative PTS-onset impact range was 2.0km for the installation of 6 pin piles at the NE location. This equates to a maximum of 16 harbour porpoise (0.005% MU) predicted to experience auditory injury when using the DAS density estimate. When using the Lacey et al. (2022) and SCANS IV density estimates, a maximum of 13 and 7 harbour porpoise are predicted to experience auditory injury respectively (0.004% MU (Lacey et al, 2022; 0.002% MU SCANS IV).

249. The SEL_{cum} impacted area is much larger for concurrent piling at the NE & SW locations compared to a single location. This is explained in the underwater noise modelling report (document reference 6.3.11.2)

"*When considering SEL_{cum} modelling, piling from multiple sources has the ability to increase impact ranges and areas significantly as, in this case, it introduces noise from double the number of pile strikes to the water. Unlike sequential piling […], fleeing receptors can be closer to a source for more pile strikes resulting in higher cumulative exposures*".

250. For concurrent installation of monopiles at the NE & SW locations, up to 456 harbour porpoise (0.132% MU) are predicted to experience auditory injury when using the DAS density estimate. When using the Lacey et al. (2022) and SCANS IV density estimates, a maximum of 368 and 179 harbour porpoise are predicted to experience auditory injury respectively (0.106% MU (Lacey et al, 2022; 0.052% MU SCANS IV).

251. For concurrent installation of jacket (pin) piles at the NE & SW locations, up to 365 harbour porpoise (0.105% MU) are predicted to experience auditory injury when using the DAS density estimate. When using the Lacey et al. (2022) and SCANS IV density estimates, a maximum of 292 and 142 harbour porpoise are predicted to experience auditory injury respectively (0.084% MU (Lacey et al, 2022; 0.041% MU SCANS IV).

252. Given the fact that auditory injury (PTS) is a permanent effect, despite the very small number of animals impacted, the unmitigated impact is assessed as Medium magnitude for the installation of monopiles and jacket (pin) piles at the ORCP area.

ORCP

253. For the installation of monopiles at the ORCP area, the maximum instantaneous PTS-onset impact range was 390m when using the maximum hammer energy. Irrespective of the harbour porpoise density estimate used in the assessment of PTS-onset from monopile installations at the ORCP location, it is predicted that a maximum of 1 harbour porpoise (<0.001% MU) shall experience auditory injury.

254. For the installation of jacket (pin) piles at the ORCP area, the maximum instantaneous PTS-onset impact range was 340m when using the maximum hammer energy. Irrespective of the harbour porpoise density estimate used in the assessment of PTS-onset from jacket (pin) pile installations at the ORCP location, it is predicted that a maximum of 1 harbour porpoise (<0.001% MU) shall experience auditory injury.

255. Results for cumulative PTS-onset were also presented in Table 11-26. For installation of monopiles within the ORCP area, the maximum cumulative PTS-onset impact range was 1.3km for the installation of monopiles. This equates to a maximum of 4 harbour porpoise (0.001% MU) predicted to experience auditory injury when using the DAS and/or Lacey et al. (2022) density estimates.

256. For installation of jacket (pin) piles within the ORCP area, the maximum cumulative PTS-onset impact range was 650m for the installation of 6 pin piles. This equates to a maximum of 1 harbour porpoise (<0.001% MU) predicted to experience auditory injury irrespective of the density estimate used in the assessment.

257. Given the fact that auditory injury (PTS) is a permanent effect, despite the very small number of animals impacted, the unmitigated impact is assessed as **Medium** magnitude for the installation of monopiles and jacket (pin) piles at the ORCP area.

ANS

258. For the installation of monopiles at the ANS area (ANS NW and SE locations), the maximum instantaneous PTS-onset impact range was 550m at the NW piling location when using the maximum hammer energy. Irrespective of the harbour porpoise density estimate used in the assessment of PTS-onset from monopile installations at the ANS NW location, it is predicted that a maximum of 1 harbour porpoise (<0.001% MU) shall experience auditory injury.

259. For the installation of jacket (pin) piles at the ANS area (ANS NW and SE locations), the maximum instantaneous PTS-onset impact range was 540m at the NW piling location when using the maximum hammer energy. Irrespective of the harbour porpoise density estimate used in the assessment of PTS-onset from jacket (pin) pile installations at the ANS NW location, it is predicted that a maximum of 1 harbour porpoise (<0.001% MU) shall experience auditory injury.

260. Results for cumulative PTS-onset were also presented in Table 11-26. For installation of monopiles within the ANS area, the maximum cumulative PTS-onset impact range was 2.6km for the installation of a single monopile at the NW location. This equates to a maximum of 27 harbour porpoise (0.008% MU) predicted to experience auditory injury when using the DAS density estimate. When using the Lacey et al. (2022) and SCANS IV density estimates, a maximum of 23 and 10 harbour porpoise are predicted to experience auditory injury respectively (0.007% MU (Lacey et al, 2022; 0.003% MU SCANS IV).

261. For installation of jacket (pin) piles within the ANS area, the maximum cumulative PTS-onset impact range was 2.6km for the installation of 4 pin piles at the NW location. This equates to a maximum of 27 harbour porpoise (0.008% MU) predicted to experience auditory injury when using the DAS density estimate. When using the Lacey et al. (2022) and SCANS IV density estimates, a maximum of 23 and 10 harbour porpoise are predicted to experience auditory injury respectively (0.007% MU (Lacey et al, 2022; 0.003% MU SCANS IV).

262. Given the fact that auditory injury (PTS) is a permanent effect, despite the very small number of animals impacted, the unmitigated impact is assessed as **Medium** magnitude for the installation of monopiles and jacket (pin) piles at the ORCP area.

Summary of impact magnitude

263. It should be noted that the predictions for PTS-onset assume that all animals within the PTS-onset range are impacted, which will overestimate the true number of impacted animals as only 18-19% of the animals are predicted to actually experience PTS at the PTS-onset threshold level {Donovan, 2017 #2992}. In addition, 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. For example, using the criteria of rise time being less than 25 milliseconds, these data revealed the probability of a signal being defined as "impulsive" to reduce to only 20% between ~2 and 5 km from the source. As such, it is unlikely that the sound will be fully impulsive at a maximum of 3.3 km from the pile and the method of the sound being modelled as fully impulsive (irrespective of the distance to the pile) is therefore highly precautionary and results in predictions that are unlikely to be realised.

264. Given the fact that auditory injury (PTS) is a permanent effect, despite the very small number of animals impacted per piling day, the unmitigated impact was assessed as **Medium** magnitude for the installation of both monopiles and pin piles at each of the array, ORCP and ANS locations. Therefore, auditory injury from piling 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.

265. Although the numbers and percentage of harbour porpoise predicted to be at risk from PTS onset are low (maximum of 483 harbour porpoise and 0.139% of the MU), harbour porpoise are EPS and under EPS legislation it is an offence to injure a single individual (this includes PTS auditory injury). Therefore, a piling MMMP will be required to reduce the effect significance of PTS to negligible levels. In addition to this embedded mitigation, it is also likely that the presence of novel vessels and associated construction activity will ensure that the vicinity of the pile is free of harbour porpoise by the time that piling begins (Benhemma-Le Gall *et al.* 2023). Therefore, the impact of PTS-onset from mitigated piling for harbour porpoise is assessed as having a **Negligible** magnitude given embedded mitigation planned during the construction of the Project.

Significance

266. The sensitivity of harbour porpoise to PTS-onset from piling has been assessed as **Medium**.

267. The unmitigated magnitude of PTS-onset to harbour porpoise from piling has been assessed as **Medium**. Therefore, the effect significance of PTS-onset to harbour porpoise from unmitigated piling is **Minor**, which is not significant in EIA terms.

268. The mitigated magnitude of PTS-onset to harbour porpoise from piling has been assessed as **Negligible**. Therefore, the effect significance of PTS-onset to harbour porpoise from mitigated piling is **Negligible (not significant)** in EIA terms.

Dolphins

Sensitivity

269. 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 6dB PTS in the 2-10kHz band for different percentiles of the elicited probability distribution are provided in Table 11-27. The data provided in should be interpreted as:

270. Experts estimated that the median decline in an individual mature female bottlenose dolphin's fertility was 0.43% (due to a 6dB PTS (a notch a few kHz wide and 6dB high) occurring somewhere in the hearing between 2-10kHz) (Plate 11.12).

271. Experts estimated that the median decline in an individual mature female bottlenose dolphin's survival was 1.6% (due to a 6dB PTS (a notch a few kHz wide and 6dB high) occurring somewhere in the hearing between 2-10kHz) (Plate 11.13).

272. Experts estimated that the median decline in an individual bottlenose dolphin juvenile survival was 1.32% (due to a 6dB PTS (a notch a few kHz wide and 6dB high) occurring somewhere in the hearing between 2-10kHz) (Plate 11.14).

273. Experts estimated that the median decline in an individual bottlenose dolphin dependent calf survival was 2.96% (due to a 6dB PTS (a notch a few kHz wide and 6dB high) occurring somewhere in the hearing between 2-10kHz).

274. 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, bottlenose dolphin have been assessed as having a Medium sensitivity to PTS.

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

276.

Table 11-27 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	1.60	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	3.30	5.19	11.24
Calf survival	0	0.29	0.93	1.77	2.96	4.96	7.81	10.69	14.79

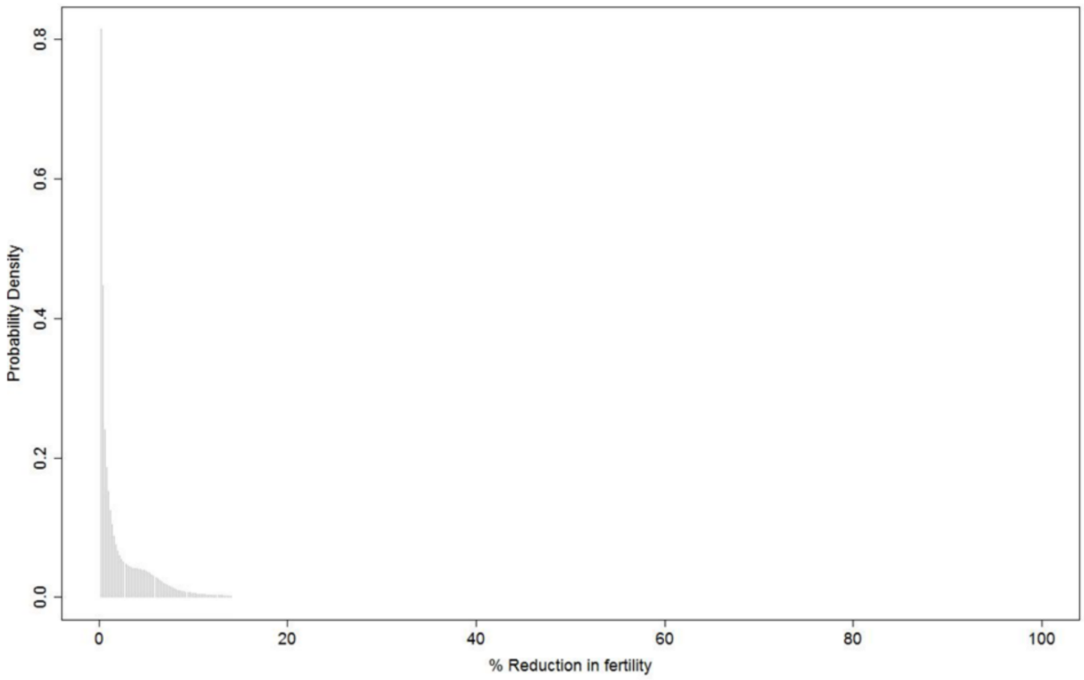

Plate 11.12: Probability distribution showing the consensus distribution for the effects on fertility of mature female bottlenose dolphin as a consequence of a maximum 6dB of PTS within a 2-10kHz band (Booth and Heinis, 2018).

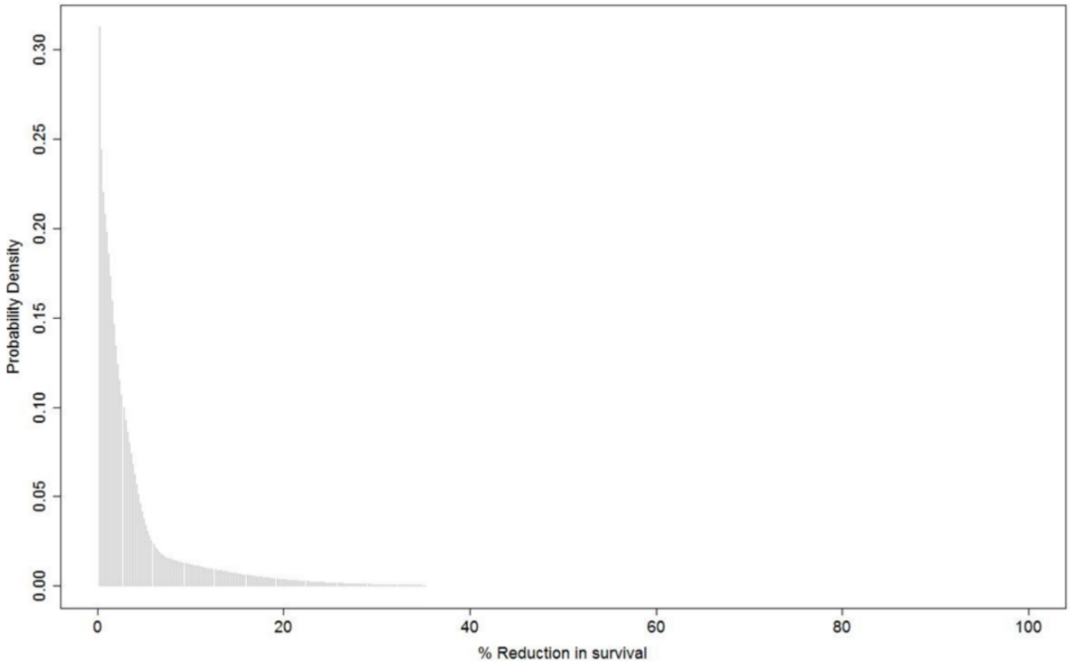

Plate 11.13: Probability distribution showing the consensus distribution for the effects on survival of mature female bottlenose dolphin as a consequence of a maximum 6dB of PTS within a 2-10kHz band (Booth and Heinis, 2018).

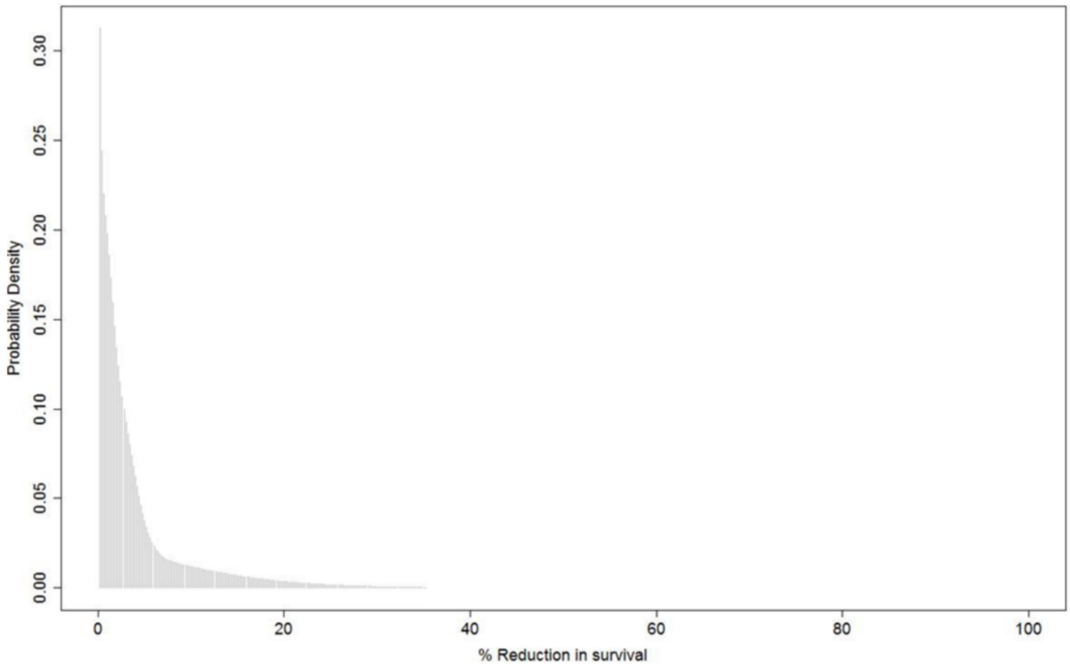

Plate 11.14: Probability distribution showing the consensus distribution for the effects on survival of juvenile or dependent calf bottlenose dolphin as a consequence of a maximum 6dB of PTS within a 2-10kHz band (Booth and Heinis, 2018).

Magnitude

277. The maximum instantaneous PTS-onset impact range is predicted to be <0.05 km at all modelled monopile and pin pile locations which results in no impact to either bottlenose or white-beaked dolphins. The maximum cumulative PTS-onset impact range is predicted to be <0.10 km at all modelled monopile and pin pile locations which also results in no impact to either bottlenose or white-beaked dolphins (see Table 11-28, Table 11-29, Table 11-30 and Table 11-31)

278. Due to the lack of predicted impact, the unmitigated magnitude of PTS onset to both bottlenose and white-beaked dolphins from piling has been assessed as **Negligible**, as there is no potential for any changes in the individual reproductive success or survival therefore no changes to the population size or trajectory. The addition of embedded mitigation will further ensure the magnitude continues to be assessed as **Negligible**.

Significance

279. The sensitivity of both bottlenose and white-beaked dolphins to PTS-onset from piling has been assessed as **Medium**.

280. The magnitude of PTS-onset to both bottlenose and white-beaked dolphins from both unmitigated and mitigated piling has been assessed as **Negligible**.

281. Therefore, the effect significance of PTS-onset to both bottlenose and white-beaked dolphin from both unmitigated and mitigated piling is **Negligible**, which is not significant in EIA terms.

Table 11-28: PTS-onset impact ranges, number of white-beaked dolphin and percentage of MU predicted to experience instantaneous PTS-onset during piling (unweighted SPLpeak dB re 1µPa) using the uniform DAS estimate (0.0006/km2), the SCANS III density surface (Lacey *et al.,* 2022) (grid cell specific) and the SCANS IV density estimate (0.0149/km2) (Gilles *et al.,* 2023)

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Monopile							
Area (km^2)	< 0.01	< 0.01	< 0.01	No cumulative effect	< 0.01	< 0.01	< 0.01
Max range (m)	< 50	< 50	< 50		< 50	< 50	< 50
# (DAS)	<1	<1	<1		<1	<1	<1
% MU (DAS)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01
# (Lacey *et al.,* 2022)	<1	<1	<1		<1	<1	<1
% MU (Lacey *et al.,* 2022)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01
# (SCANS IV)	<1	<1	<1		<1	<1	<1
% MU (SCANS IV)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Jacket							
Area (km^2)	< 0.01	< 0.01	< 0.01	No cumulative effect	< 0.01	< 0.01	< 0.01
Max range (m)	< 50	< 50	< 50		< 50	< 50	< 50
# (DAS)	<1	<1	<1		<1	<1	<1
% MU (DAS)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01
# (Lacey *et al.*, 2022)	<1	<1	<1		<1	<1	<1
% MU (Lacey *et al.*, 2022)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01
# (SCANS IV)	<1	<1	<1		<1	<1	<1
% MU (SCANS IV)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01

Table 11-29: PTS-onset impact ranges, number of white-beaked dolphin and percentage of MU predicted to experience cumulative PTS during piling (weighted SELss dB re 1µPa2s) using the uniform DAS estimate (0.0006/km2), the SCANS III density surface (Lacey *et al.,* 2022) (grid cell specific) and the SCANS IV density estimate (0.0149/km2) (Gilles *et al.,* 2023).

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Monopile x1							
Area (km^2)	< 0.1	< 0.1	< 0.1	No cumulative effect	< 0.1	< 0.1	< 0.1
Max range (m)	< 100	< 100	< 100		< 100	< 100	< 100
# (DAS)	<1	<1	<1		<1	<1	<1
% MU (DAS)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01
# (Lacey *et al.*, 2022)	<1	<1	<1		<1	<1	<1
% MU (Lacey *et al.*, 2022)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01
# (SCANS IV)	<1	<1	<1		<1	<1	<1
% MU (SCANS IV)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01
Monopile x2							
Area (km^2)	< 0.1	< 0.1	< 0.1	No cumulative effect	< 0.1	NA	
Max range (m)	< 100	< 100	< 100		< 100		
# (DAS)	<1	<1	<1		<1		
% MU (DAS)	< 0.01	< 0.01	< 0.01		< 0.01		

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
# (Lacey *et al.*, 2022)	<1	<1	<1		<1		
% MU (Lacey *et al.*, 2022)	< 0.01	< 0.01	< 0.01		< 0.01		
# (SCANS IV)	<1	<1	<1		<1		
% MU (using SCANS IV)	< 0.01	< 0.01	< 0.01		< 0.01		
Jacket x1							
Area (km^2)	< 0.1	< 0.1	< 0.1	No cumulative effect	< 0.1	< 0.1	< 0.1
Max range (m)	< 100	< 100	< 100		< 100	< 100	< 100
# (DAS)	<1	<1	<1		<1	<1	<1
% MU (DAS)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01
# (Lacey *et al.*, 2022)	<1	<1	<1		<1	<1	<1
% MU (Lacey *et al.*, 2022)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01
# (SCANS IV)	<1	<1	<1		<1	<1	<1
% MU (SCANS IV)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01
Jacket x6						Jacket x4	
Area (km^2)	< 0.1	< 0.1	< 0.1	No cumulative effect	< 0.1	< 0.1	< 0.1
Max range (m)	< 100	< 100	< 100		< 100	< 100	< 100
# (DAS)	<1	<1	<1		<1	<1	<1
% MU (DAS)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01
# (Lacey *et al.*, 2022)	<1	<1	<1		<1	<1	<1
% MU (Lacey *et al.*, 2022)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01
# (SCANS IV)	<1	<1	<1		<1	<1	<1
% MU (SCANS IV)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01

Table 11-30: PTS-onset impact ranges, number of bottlenose dolphin and percentage of MU predicted to experience instantaneous PTS-onset during piling (unweighted SPLpeak dB re 1µPa) using SCANS IV density estimate (0.0419/km2) (Gilles et al 2023).

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Monopile							
Area (km^2)	< 0.01	< 0.01	< 0.01	No cumulative effect	< 0.01	< 0.01	< 0.01
Max range (m)	< 50	< 50	< 50		< 50	< 50	< 50
# (SCANS IV)	<1	<1	<1		<1	<1	<1
% MU (SCANS IV)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01
Jacket							
Area (km^2)	< 0.01	< 0.01	< 0.01	No cumulative effect	< 0.01	< 0.01	< 0.01
Max range (m)	< 50	< 50	< 50		< 50	< 50	< 50
# (SCANS IV)	<1	<1	<1		<1	<1	<1
% MU (SCANS IV)	<0.1	<0.1	<0.1		<0.1	<0.1	<0.1

Table 11-31: PTS-onset impact ranges, number of bottlenose dolphin and percentage of MU predicted to experience cumulative PTS during piling (weighted SELss dB re 1µPa2s) using SCANS IV density estimate (0.0419/km2) (Gilles et al 2023).

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Monopile x1							
Area (km^2)	< 0.1	< 0.1	< 0.1	No cumulative effect	< 0.1	< 0.1	< 0.1
Max range (m)	< 100	< 100	< 100		< 100	< 100	< 100
# (SCANS IV)	<1	<1	<1		<1	<1	<1
% MU (SCANS IV)	<0.1	<0.1	<0.1		<0.1	<0.1	<0.1
Monopile x2							
Area (km^2)	< 0.1	< 0.1	< 0.1	No cumulative effect	< 0.1	NA	
Max range (m)	< 100	< 100	< 100		< 100		
# (SCANS IV)	<1	<1	<1		<1		
% MU (SCANS IV)	<0.1	<0.1	<0.1		<0.1		
Jacket x1							
Area (km^2)	< 0.1	< 0.1	< 0.1		< 0.1	< 0.1	< 0.1

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Max range (m)	< 100	< 100	< 100	No cumulative effect	< 100	< 100	< 100
# (SCANS IV)	<1	<1	<1		<1	<1	<1
% MU (SCANS IV)	<0.1	<0.1	<0.1		<0.1	<0.1	<0.1
Jacket x6						Jacket x4	
Area (km^2)	< 0.1	< 0.1	< 0.1	No cumulative effect	< 0.1	< 0.1	< 0.1
Max range (m)	< 100	< 100	< 100		< 100	< 100	< 100
# (SCANS IV)	<1	<1	<1		<1	<1	<1
% MU (SCANS IV)	<0.1	<0.1	<0.1		<0.1	<0.1	<0.1

Minke whale

Sensitivity

282. The PTS expert elicitation report (Booth & Heinis, 2018) provides a summary of the potential effect of piling noise on mammalian hearing and summarises the judgments of seven leading experts on marine mammal hearing and noise. The first day of the workshop was spent scoping the current state of knowledge of threshold shifts in response to low frequency broadband sound sources (before later focusing on species-specific judgments as part of the elicitation process). The experts agreed that *"it was important to realise that reduced hearing ability does not necessarily mean a less fit animal (i.e. an animal of lower fitness)."* The elicitation included harbour and grey seals – two species with good low-frequency hearing.

283. Following a review and discussion of the current literature, experts determined: *"Following exposure to low frequency broadband pulsed noise, TTS was typically observed 1.5 octaves (see Appendix 1 - Glossary) higher than the centre frequency of the exposure sound for seals and porpoise (Kastelein et al. 2012a, Kastelein et al. 2012b, Kastelein et al. 2013a, Finneran 2015). For piling noise and airgun pulses, most energy is between ~30 Hz- 500 Hz, with a peak usually between 100 – 300 Hz and energy extending above 2 kHz (e.g. Kastelein et al. 2015a, Kastelein et al. 2016)"*. Based on this, the experts concluded that if piling noise resulted in a threshold shift, that this would manifest in the mammalian ear as a notch in hearing sensitivity somewhere between 2-10 kHz. This assessment was not species-specific and was considered to apply to all marine mammals (including minke whales) based on the best available knowledge (TTS studies involving low frequency broadband pulsed noise stimuli).

284. 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. Ongoing studies to directly estimate the hearing of live minke whales provide initial results suggesting *"minke whales have a much higher frequency limit to their hearing range than previously believed based upon their ear anatomy and the frequencies at which they vocalize."* (Houser, pers. comm.[18])

285. Booth & Heinis (2018) highlighted that experts considered that if PTS occurs, this would occur as a notch in hearing loss in a narrow frequency band (occurring somewhere between 2-10 kHz). They stressed this was not a loss of hearing across this entire band. Booth & Heinis (2018) also summarise the mechanisms experts considered as to whether PTS could significantly affect vital rates: *"In considering how any PTS could affect vital rates (i.e. probability of survival, probability of fertility), experts discussed the mechanisms by which this could occur. In general, experts noted that where communication has a significant social or reproductive function, that this might be a means by which survival and/or reproduction are affected. Experts noted however that PTS would likely occur over a small frequency range and that much of the energy of communication signals either fell outside the likely range affected by PTS or that the loss of part of the signal would likely not affect detection of the communication signals."*

286. It is acknowledged that data on minke whale hearing and potential effects of threshold shifts on vital rates are lacking. However, given the current understanding of how PTS from piling is expected to manifest in the mammalian ear – and the mechanisms that could lead to an effect on vital rates (sensu Booth & Heinis, 2018) - it is unlikely that vital rates would be altered in a biologically meaningful way as a result of PTS from piling. Therefore, PTS from piling is unlikely to cause a change in both reproduction and survival rates; and minke whale are assessed as having a **Medium** sensitivity to PTS.

Magnitude

287. The predicted areas and maximum impact ranges for auditory injury (PTS-onset) from pile driving of a monopile and pin-piles for minke whale are outlined in Table 11-32 and Table 11-33. This includes the prediction of impact for each of the modelling locations.

288. As the maximum instantaneous PTS-onset impact range is predicted to be <50m at all modelled monopile and pin pile locations (Table 11-32), resulting in no impact to minke whales from instantaneous PTS. CTS-onset impacts are discussed in greater detail below.

---

[18] https://www.ffi.no/en/news/first-successful-hearing-tests-conducted-with-baleen-whales#:~:text=The%20results%20were%20surprising.,frequencies%20at%20which%20they%20vocalize

Table 11-32: PTS-onset impact ranges, number of minke whale and percentage of MU predicted to experience instantaneous PTS-onset during piling (unweighted SPLpeak dB re 1µPa) using the SCANS III density surface (Lacey *et al.,* 2022) (grid cell specific) and the SCANS IV density estimate (0.0068/km2) (Gilles *et al.,* 2023).

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Monopile							
Area (km^2)	< 0.01	< 0.01	0.01	No cumulative effect	<0.01	<0.01	<0.01
Max range (m)	< 50	< 50	< 50		< 50	< 50	< 50
# (Lacey *et al.,* 2022)	<1	<1	<1		<1	<1	<1
% MU (Lacey *et al.,* 2022)	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001
# (SCANS IV)	<1	<1	<1		<1	<1	<1
% MU (SCANS IV)	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001
Jacket							
Area (km^2)	< 0.01	< 0.01	< 0.01	No cumulative effect	<0.01	<0.01	<0.01
Max range (m)	< 50	< 50	< 50		< 50	< 50	< 50
# (Lacey *et al.,* 2022)	<1	<1	<1		<1	<1	<1
% MU (Lacey *et al.,* 2022)	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001
# (SCANS IV)	<1	<1	<1		<1	<1	<1
% MU (SCANS IV)	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001

Table 11-33: PTS-onset impact ranges, number of minke whale and percentage of MU predicted to experience cumulative PTS during piling (weighted SELss dB re 1µPa2s) using the SCANS III density surface (Lacey *et al.,* 2022) (grid cell specific) and the SCANS IV density estimate (0.0068/km2) (Gilles *et al.,* 2023).

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Monopile x1							
Area (km^2)	0.4	4.6	49.0	No cumulative effect	1.0	50	14
Max range (m)	680	1700	5000		1200	5000	2900
# (Lacey *et al.,* 2022)	<1	<1	<1		<1	1	<1
% MU (Lacey *et al.,* 2022)	<0.001	<0.001	0.001		<0.001	<0.001	<0.001
# (SCANS IV)	<1	<1	<1		<1	<1	<1
% MU (SCANS IV)	<0.001	<0.001	0.001		<0.001	<0.001	<0.001
Monopile x2							
Area (km^2)	0.4	4.6	49.0	No cumulative effect	1.0	NA	
Max range (m)	680	1700	5000		1200		
# (Lacey *et al.,* 2022)	<1	<1	<1		<1		
% MU (Lacey *et al.,* 2022)	<0.001	<0.001	0.001		<0.001		
# (SCANS IV)	<1	<1	<1		<1		
% MU (SCANS IV)	<0.001	<0.001	<0.001		<0.001		
Jacket x1							
Area (km^2)	< 0.1	0.6	21	No cumulative effect	< 0.1	48	13
Max range (m)	100	680	3300		300	5000	2800
# (Lacey *et al.,* 2022)	<1	<1	<1		<1	1	<1
% MU (Lacey *et al.,* 2022)	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001
# (SCANS IV)	<1	<1	<1		<1	<1	<1
% MU (SCANS IV)	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001
	Jacket x6					Jacket x4	
Area (km^2)	< 0.1	0.6	21	330	< 0.1	48	13
Max range (m)	100	680	3300	-	300	5000	2800
# (Lacey *et al.,* 2022)	<1	<1	<1	3	<1	1	<1

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
% MU (Lacey *et al.,* 2022)	<0.001	<0.001	<0.001	0.01	<0.001	<0.001	<0.001
# (SCANS IV)	<1	<1	<1	2	<1	<1	<1
% MU (SCANS IV)	<0.001	<0.001	<0.001	0.01	<0.001	<0.001	<0.001

Array

289. Results for cumulative PTS-onset were presented in Table 11-33 For installation of monopiles within the array area, the maximum cumulative PTS-onset impact range was 5.0km for the installation of a single, or 2 sequential monopiles at the NE location. This equates to a maximum of <1 minke whale (0.001% MU) predicted to experience auditory injury when using the Lacey et al. (2022) density estimate. When using the SCANS IV density estimates, a maximum of <1 minke whale are predicted to experience auditory injury (<0.001% MU).

290. For installation of jacket (pin) piles within the array area, the maximum cumulative PTS-onset impact area was 3.3km for the installation of a single, or 6 sequential pin piles at the NE location. This equates to a maximum of <1 minke whale (<0.001% MU) predicted to experience auditory injury using both the Lacey et al. (2022) and SCANS IV density estimates.

291. The SEL_{cum} impacted area is much larger for concurrent piling at the NE & SW locations compared to a single location. This is explained in the underwater noise modelling report *"When considering SELcum modelling, piling from multiple sources has the ability to increase impact ranges and areas significantly as, in this case, it introduces noise from double the number of pile strikes to the water. Unlike sequential piling […], fleeing receptors can be closer to a source for more pile strikes resulting in higher cumulative exposures".*

292. For concurrent installation of 2 sequential monopiles at the NE & SW locations, up to 4 minke whale (0.020% MU) are predicted to experience auditory injury when using the Lacey et al. (2022) density surface. When using the SCANS IV density estimate, a maximum of 3 minke whales are predicted to experience auditory injury (0.015% MU).

293. For concurrent installation of 6 sequential pin piles at the NE & SW locations, up to 3 minke whale (0.01% MU) are predicted to experience auditory injury when using the Lacey et al. (2022) density surface. When using the SCANS IV density estimate, a maximum of 2 minke whales are predicted to experience auditory injury (0.001% MU).

294. Given the fact that auditory injury (PTS) is a permanent effect, despite the very small number of animals impacted per piling day, the unmitigated impact is assessed as **Medium** magnitude for the installation of monopiles and jacket (pin) piles within the array area.

ORCP

295. For installation of monopiles within the ORCP area, the maximum cumulative PTS-onset impact range was 1.2km for the installation of a single, or 2 sequential monopiles. This equates to a maximum of <1 minke whale predicted to experience auditory injury (<0.001% MU) irrespective of the density estimate used.

296. For installation of jacket (pin) piles within the ORCP area, the maximum cumulative PTS-onset impact range was 300m for the installation of a single, or 6 sequential pin piles. This equates to a maximum of <1 minke whale predicted to experience auditory injury (<0.001% MU) irrespective of the density estimate used.

ANS

297. For installation of monopiles within the ANS area, the maximum cumulative PTS-onset impact range was 5km for the installation of a single monopile at the NW location. This equates to a maximum of 1 minke whale (0.005% MU) predicted to experience auditory injury when using the Lacey et al. (2022) density estimate. When using the SCANS IV density estimates, a maximum of <1 minke whale is predicted to experience auditory injury (<0.001% MU).

298. For installation of jacket (pin) piles within the ANS area, the maximum cumulative PTS-onset impact range was 5km for the installation of a single, or 4 sequential pin piles at the NW location. This equates to a maximum of 1 minke whale (0.005% MU) predicted to experience auditory injury when using the Lacey et al. (2022) density estimate. When using the SCANS IV density estimates, a maximum of <1 minke whale is predicted to experience auditory injury (<0.001% MU).

Summary of Impact Magnitude

299. It should be noted that the predictions for PTS-onset assume that all animals within the PTS-onset range are impacted, which will overestimate the true number of impacted animals as only 18-19% of the animals are predicted to actually experience PTS at the PTS-onset threshold level (Donovan *et al.* 2017). In addition, 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 the criteria of rise time being less than 25 milliseconds, these data revealed that the probability of a signal being defined as “impulsive” reduced to only 20% between ~2 and 5 km from the source. As such, it is unlikely that the sound will be fully impulsive at a maximum of 5.3km from the pile and the method of the sound being modelled as fully impulsive (irrespective of the distance to the pile) is therefore highly precautionary and results in predictions that are unlikely to be realised.

300. Given the fact that auditory injury (PTS) is a permanent effect, despite the very small number of animals impacted per piling day, the unmitigated impact was assessed as **Medium** magnitude for the installation of both monopiles and pin piles at each of the array. Therefore, auditory injury from piling 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.

301. Although the numbers and percentage of minke whale predicted to be at risk from PTS onset are low (maximum of 4 minke whale and 0.02% of the MU), minke whale are EPS and under EPS legislation it is an offence to injure a single individual (this includes PTS auditory injury). Therefore, a piling MMMP will be required to reduce the effect significance of PTS to negligible levels (see Table 11-19). Therefore, the impact of PTS-onset from mitigated piling for minke whales is assessed as having a **Negligible** magnitude given embedded mitigation planned during the construction of the Project.

Significance

302. The sensitivity of minke whales to PTS-onset from piling has been assessed as **Medium**.

303. The unmitigated magnitude of PTS-onset to minke whales from piling has been assessed as **Medium**. Therefore, the effect significance of PTS-onset to minke whales from unmitigated piling is **Minor**, which is not significant in EIA terms.

304. The mitigated magnitude of PTS-onset to minke whales from piling has been assessed as **Negligible**. Therefore, the effect significance of PTS-onset to minke whales from mitigated piling is **Negligible (not significant)** in EIA terms.

Seal sensitivity to PTS

305. The predicted decline in harbour and grey seals vital rates from the impact of a 6dB PTS in the 2-10kHz band for different percentiles of the elicited probability distribution are provided in Table 11-34. The data provided in Table 11-34 should be interpreted as:

- Experts estimated that the median decline in an individual mature female seal's survival was 0.39% (due to a 6dB PTS (a notch a few kHz wide and 6dB high) occurring somewhere in the hearing between 2-10kHz) (Plate 11.15.
- Experts estimated that the median decline in an individual mature female seal's fertility was 0.27% (due to a 6dB PTS (a notch a few kHz wide and 6dB high) occurring somewhere in the hearing between 2-10kHz) (Plate 11.16).
- Experts estimated that the median decline in an individual seal pup/juvenile survival was 0.52% (due to a 6dB PTS (a notch a few kHz wide and 6dB high) occurring somewhere in the hearing between 2-10kHz) (Plate 11.17Plate 11.18).

306. 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 **Medium** sensitivity to PTS.

Table 11-34 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

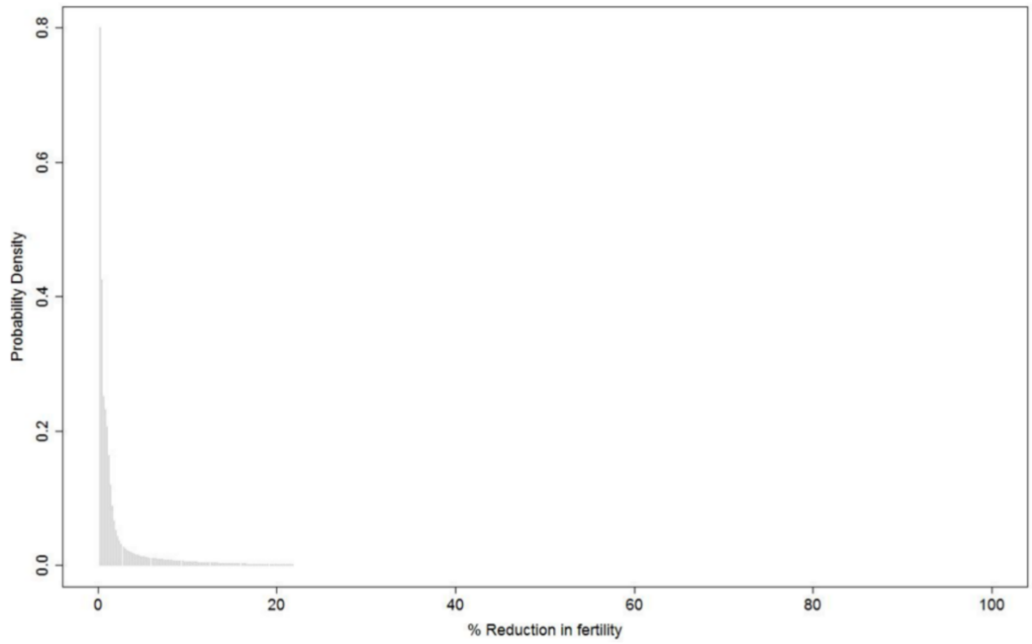

Plate 11.15: Probability distribution showing the consensus distribution for the effects on fertility of a mature female (harbour or grey) seal as a consequence of a maximum 6dB of PTS within a 2-10kHz band (Booth and Heinis, 2018).

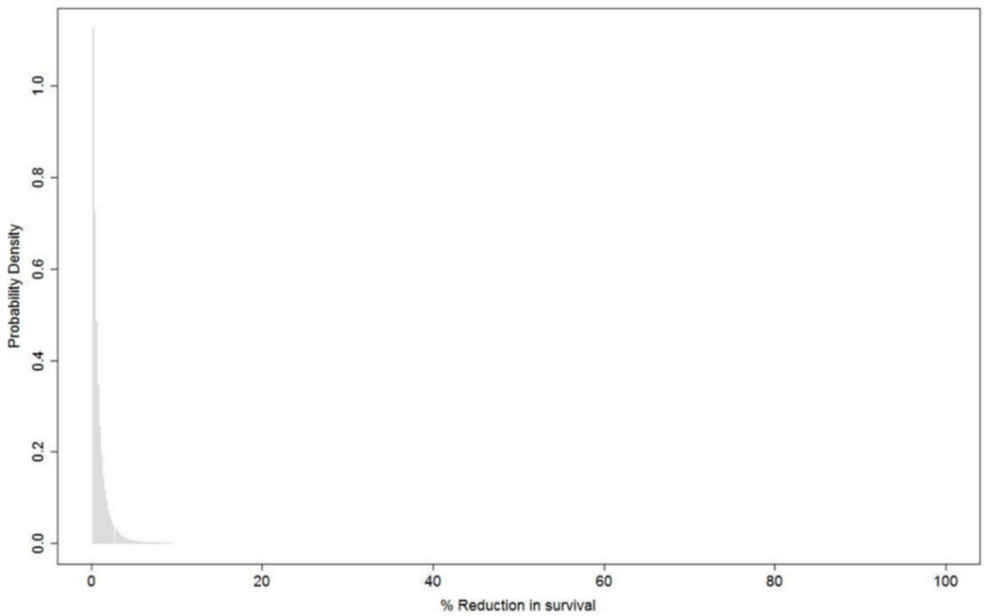

Plate 11.16: Probability distribution showing the consensus distribution for the effects on survival of a mature female (harbour or grey) seal as a consequence of a maximum 6dB of PTS within a 2-10kHz band (Booth and Heinis, 2018).

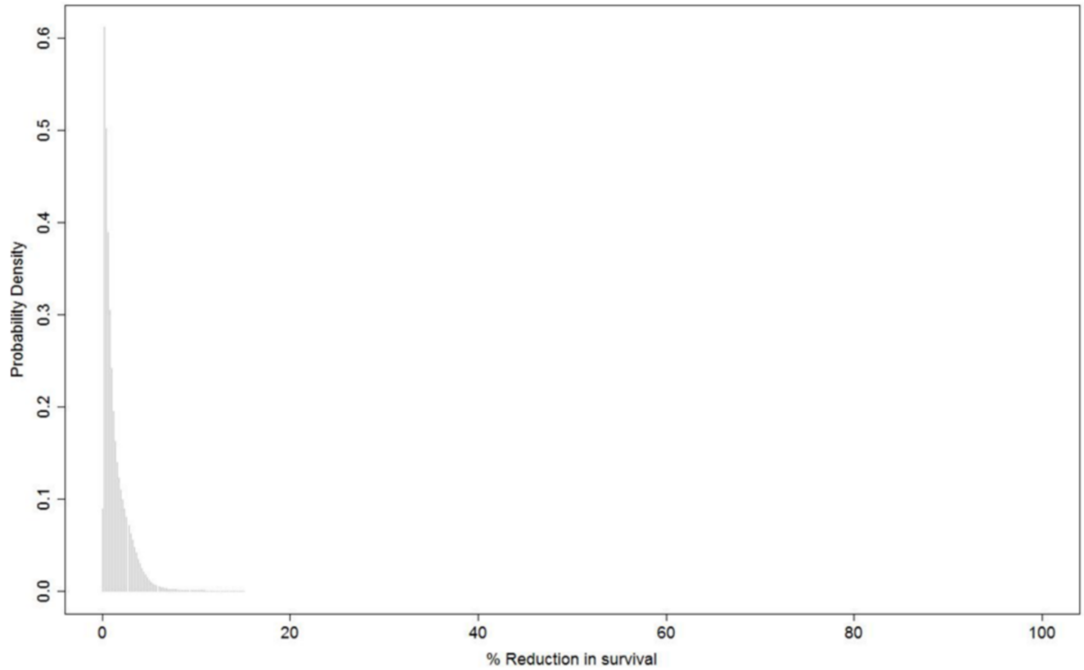

Plate 11.17 Probability distribution showing the consensus distribution for the effects on survival of juvenile or dependent pup (harbour or grey) seal as a consequence of a maximum 6dB of PTS within a 2-10kHz band (Booth and Heinis, 2018).

Magnitude

307. The maximum instantaneous PTS-onset impact range is predicted to be <50m at all modelled monopile and pin pile locations which results in no impact to either harbour or grey seals. The maximum cumulative PTS-onset impact range is predicted to be <100m at all modelled monopile and pin pile locations which also results in no impact to either harbour or grey seals.

308. Due to the lack of predicted impact, the unmitigated magnitude of PTS-onset to both harbour or grey seals from piling has been assessed as **Negligible**, as there is no potential for any changes in the individual reproductive success or survival therefore no changes to the population size or trajectory. The addition of embedded mitigation will further ensure the magnitude continues to be assessed as **Negligible**.

Table 11-35: PTS-onset impact ranges, number of grey seals and percentage of MU predicted to experience instantaneous PTS-onset during piling (unweighted SPLpeak dB re 1µPa) using the Carter *et al.,* (2020, 2022) grid cell specific density estimate.

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Monopile							
Area (km²)	< 0.01	< 0.01	< 0.01	No cumulative effect	< 0.01	< 0.01	< 0.01
Max range (m)	< 50	< 50	< 50		< 50	< 50	< 50
#	<1	<1	<1		<1	<1	<1
% MU	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001
Jacket							
Area (km²)	< 0.01	< 0.01	< 0.01	No cumulative effect	< 0.01	< 0.01	< 0.01
Max range (m)	< 50	< 50	< 50		< 50	< 50	< 50
#	<1	<1	<1		<1	<1	<1
% MU	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001

Table 11-36: PTS-onset impact ranges, number of grey seal and percentage of MU predicted to experience instantaneous PTS during piling (weighted SELss dB re 1µPa2s) using the Carter *et al.,* (2020, 2022) grid cell specific density estimate

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Monopile x1							
Area (km²)	< 0.1	< 0.1	< 0.1	No cumulative effect	< 0.1	< 0.1	< 0.1
Max range (m)	< 100	< 100	< 100		< 100	< 100	< 100
#	<1	<1	<1		<1	<1	<1
% MU	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001
Monopile x2							
Area (km²)	< 0.1	< 0.1	< 0.1	No cumulative effect	< 0.1	NA	
Max range (m)	< 100	< 100	< 100		< 100		
#	<1	<1	<1		<1		
% MU	<0.001	<0.001	<0.001		<0.001		
Jacket x1							
Area (km²)	< 0.1	< 0.1	< 0.1	No cumulative effect	< 0.1	< 0.1	< 0.1
Max range (m)	< 100	< 100	< 100		< 100	< 100	< 100

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
#	<1	<1	<1		<1	<1	<1
% MU	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001
Jacket x6						Jacket x4	
Area (km²)	< 0.1	< 0.1	< 0.1	No cumulative effect	< 0.1	< 0.1	< 0.1
Max range (m)	< 100	< 100	< 100		< 100	< 100	< 100
#	<1	<1	<1		<1	<1	<1
% MU	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001

Table 11-37: PTS-onset impact ranges, number of harbour seals and percentage of MU predicted to experience instantaneous PTS-onset during piling (unweighted SPLpeak dB re 1µPa) using the Carter *et al.,* (2020, 2022) grid cell specific density estimate

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Monopile							
Area (km²)	< 0.01	< 0.01	< 0.01	No cumulative effect	< 0.01	< 0.01	< 0.01
Max range (m)	< 50	< 50	< 50		< 50	< 50	< 50
#	<1	<1	<1		<1	<1	<1
% MU	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001
Jacket							
Area (km²)	< 0.01	< 0.01	< 0.01	No cumulative effect	< 0.01	< 0.01	< 0.01
Max range (m)	< 50	< 50	< 50		< 50	< 50	< 50
#	<1	<1	<1		<1	<1	<1
% MU	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001

Table 11-38: PTS-onset impact ranges, number of harbour seal and percentage of MU predicted to experience instantaneous PTS during piling (weighted SELss dB re 1µPa2s) using the Carter *et al.,* (2020, 2022) grid cell specific density estimate

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Monopile x1							

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Area (km^2)	< 0.1	< 0.1	< 0.1	No cumulative effect	< 0.1	< 0.1	< 0.1
Max range (m)	< 100	< 100	< 100		< 100	< 100	< 100
#	<1	<1	<1		<1	<1	<1
% MU	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001
Monopile x2							
Area (km^2)	< 0.1	< 0.1	< 0.1	No cumulative effect	< 0.1	NA	
Max range (m)	< 100	< 100	< 100		< 100		
#	<1	<1	<1		<1		
% MU	<0.001	<0.001	<0.001		<0.001		
Jacket x1							
Area (km^2)	< 0.1	< 0.1	< 0.1	No cumulative effect	< 0.1	< 0.1	< 0.1
Max range (m)	< 100	< 100	< 100		< 100	< 100	< 100
#	<1	<1	<1		<1	<1	<1
% MU	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001
Jacket x6						Jacket x4	
Area (km^2)	< 0.1	< 0.1	< 0.1	No cumulative effect	< 0.1	< 0.1	< 0.1
Max range (m)	< 100	< 100	< 100		< 100	< 100	< 100
#	<1	<1	<1		<1	<1	<1
% MU	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001

Significance

309. The sensitivity of both harbour and grey seals to PTS-onset from piling has been assessed as Medium.

310. Both the unmitigated and mitigated magnitude of PTS-onset to both harbour and grey seals from piling has been assessed as Negligible.

311. Therefore, both the unmitigated and mitigated effect significance of PTS-onset to harbour and grey seals from piling is Negligible, which is not significant in EIA terms

Pile driving – PTS summary

312. Table 11-39 presents a summary of the sensitivity, magnitude and significance of PTS from pile driving for marine mammals. The mitigated significance has been assessed as Negligible for all marine mammal species, which is not significant in EIA terms.

Table 11-39: Summary of marine mammal sensitivity, magnitude and significance of PTS from pile driving.

Species	Sensitivity	Unmitigated Magnitude	Unmitigated Significance	Mitigated Magnitude	Mitigated Significance
Harbour porpoise	Medium	Medium	Minor	Negligible	Negligible (**Not significant**)
Bottlenose dolphin	Medium	Negligible	Negligible	Negligible	Negligible (**Not significant**)
White-beaked dolphin	Medium	Negligible	Negligible	Negligible	Negligible (**Not significant**)
Minke whale	Medium	Medium	Minor	Negligible	Negligible (**Not significant**)
Harbour seal	Medium	Negligible	Negligible	Negligible	Negligible (**Not significant**)
Grey seal	Medium	Negligible	Negligible	Negligible	Negligible (**Not significant**)

11.6.1.4 Impact 4: Pile Driving – TTS

313. Full details of the underwater noise modelling and the resulting TTS-onset impact areas and ranges are detailed in document reference 6.3.11.2. As previously outlined (see Assessment Methodology), there are no thresholds to determine a biologically significant effect from TTS-onset. Therefore, the predicted ranges for the onset of TTS from piling are presented, but no assessment of magnitude, sensitivity or significance of effect is given. This approach was agreed with members of Marine Mammals Expert Topic Group (19th January 2022) and aligns with the advice provided in Natural England (2022).

314. The following section provides the quantitative assessment of the impact of TTS onset from pile driving on marine mammal species.

Harbour porpoise

Monopiles

315. Using instantaneous TTS-onset thresholds (SPL_{peak}), the maximum impact range for harbour porpoise was calculated at 1.3km at the array NE monopile location. This resulted in an impact to 9 harbour porpoise and 0.003% of the MU (Table 11-40 when using the DAS density estimate. When using the Lacey et al. (2022) and SCANS IV density estimates, a maximum of 7 and 3 harbour porpoise are predicted to experience TTS respectively (0.002% MU (Lacey et al, 2022; <0.001% MU SCANS IV).

316. Using the cumulative TTS-onset thresholds (SEL_{cum}) the maximum impact range for harbour porpoise during a single monopile piling event was calculated at 18km for the ANS NW monopile location. This equated to a maximum of 1,073 harbour porpoise and 0.31% of the MU (Table 11-41 Table 11-39).

During concurrent piling of 2 monopiles at the NE and SW locations, the maximum cumulative TTS-onset impact area was calculated at 1,300 km^2 for monopiles, resulting in impact to 2,124 harbour porpoise and 0.61% of the MU Table 11-41). When using the Lacey et al. (2022) and SCANS IV density estimates, a maximum of 1,628 and 785 harbour porpoise are predicted to experience auditory injury respectively (0.47% MU (Lacey et al, 2022; 0.23% MU SCANS IV).

Pin Piles

317. For the installation of jacket (pin) piles, the maximum impact range for instantaneous TTS-onset for harbour porpoise was calculated at 1.3km at the ANS NW piling location. This equated to a maximum of 9 harbour porpoise and 0.003% of the MU (Table 11-41) when using the DAS density estimate.

318. For concurrent piling of 6 pin piles at the array NE and SW locations, the maximum cumulative TTS-onset impact area was calculated at 1,200km2 for monopiles, resulting in impact to 1,926 harbour porpoise and 0.56% of the MU (Table 11-42). When using the Lacey et al., (2022) and SCANS IV density estimates, a maximum of 1,481 and 712 harbour porpoise are predicted to experience auditory injury respectively (0.43% MU (Lacey et al, 2022; 0.21% MU SCANS IV). For concurrent piling of four pin piles, the maximum cumulative TTS-onset impact area was calculated at 668.9km^2 for the ANS NW. This resulted in 1,090 harbour porpoise predicted to experience TTS (0.31% MU). When using the Lacey et al., (2022) and SCANS IV density estimates, a maximum of 918 and 403 harbour porpoise are predicted to experience cumulative TTS-onset respectively (0.26% MU (Lacey et al, 2022; 0.12% MU SCANS IV).

Table 11-40: TTS-onset impact ranges, number of harbour porpoise and percentage of MU predicted to experience instantaneous TTS-onset during piling (unweighted SPLpeak dB re 1µPa) using the uniform DAS estimate (1.63/km2), the SCANS III density surface (Lacey *et al.,* 2022) (grid cell specific) and the SCANS IV density estimate (0.6027/km2) (Gilles *et al.,* 2023).

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Monopile							
Area (km^2)	1.4	2.3	5.3	No additive effect	2.2	4.4	3.4
Max range (m)	740	950	1,300		850	1200	1100
# (DAS)	2	4	9		4	7	6
% MU (DAS)	<0.001	0.001	0.003		0.001	0.002	0.002
# (Lacey *et al.,* 2022)	2	3	7		3	6	4
% MU (Lacey *et al.,* 2022)	<0.001	0.001	0.002		<0.001	0.002	0.001
# (SCANS IV)	1	1	3		1	3	2
% MU (SCANS IV)	<0.001	<0.001	0.001		<0.001	<0.001	<0.001
Jacket							
Area (km^2)	1.1	1.7	4		1.6	5	3.3

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Max range (m)	630	820	1,100	No additive effect	740	1300	1100
# (DAS)	2	3	7		3	8	5
% MU (DAS)	<0.001	<0.001	0.002		<0.001	0.002	0.002
# (Lacey *et al.*, 2022)	1	2	5		2	7	3
% MU (Lacey *et al.*, 2022)	<0.001	<0.001	0.001		<0.001	0.002	<0.001
# (SCANS IV)	<1	1	2		1	3	2
% MU (SCANS IV)	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001

Table 11-41: TTS-onset impact ranges, number of harbour porpoise and percentage of MU predicted to experience cumulative TTS during piling (weighted SELss dB re 1µPa2s) using the uniform DAS estimate (1.63/km2), the SCANS III density surface (Lacey et al., 2022)) (Gilles *et al.*, 2023).

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Monopile x1							
Area (km^2)	130	240	530	No additive effect[19]	120	650	390
Max range (m)	7,600	11,000	16,000		9,100	18,000	13,000
# (DAS)	210	391	876		196	1,073	635
% MU (DAS)	0.06	0.13	0.253		0.06	0.31	0.18
# (Lacey et al. 2022)	161	311	675		174	903	427
% MU (Lacey et al. 2022)	0.05	0.09	0.195		0.05	0.26	0.12
# (SCANS IV)	78	144	324		72	397	235
% MU (SCANS IV)	0.02	0.04	0.093		0.02	0.11	0.07
Monopile x2							
Area (km^2)	130	240	530	1300	120	NA	
Max range (m)	7,600	11,000	16,000	-	9,100		
# (DAS)	210	391	877	2,052	196		
% MU (DAS)	0.06	0.13	0.253	0.592	0.06		
# (Lacey et al. 2022)	161	311	676	1,560	174		

[19] There is no additive effect when piling occurs at the two locations simultaneously, generally where the individual ranges are small enough that the distant site does not produce an influencing additional exposure.

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
% MU (Lacey et al. 2022)	0.05	0.09	0.195	0.450	0.05		
# (SCANS IV)	78	145	324	759	72		
% MU (SCANS IV)	0.02	0.04	0.093	0.219	0.02		
Jacket x1							
Area (km²)	91	180	420	No additive effect	89	650	390
Max range (m)	6,500	9,400	14,000		7,900	18,000	13,000
# (DAS)	151	297	697		145	1,073	635
% MU (DAS)	0.04	0.09	0.201		0.04	0.31	0.18
# (Lacey et al. 2022)	115	236	536		129	903	427
% MU (Lacey et al. 2022)	0.03	0.07	0.16		0.04	0.26	0.12
# (SCANS IV)	56	110	258		54	397	235
% MU (SCANS IV)	0.02	0.03	0.07		0.02	0.11	0.07
Jacket x6						Jacket x4	
Area (km²)	92	180	430	1,100	89	660	390
Max range (m)	6,500	9,400	14,000	-	7,900	19,000	13,000
# (DAS)	151	298	701	1,810	145	1,090	637
% MU (DAS)	0.04	0.09	0.202	0.522	0.04	0.31	0.18
# (Lacey et al. 2022)	115	236	539	1,375	129	918	429
% MU (Lacey et al. 2022)	0.03	0.07	0.156	0.397	0.04	0.26	0.12
# (SCANS IV)	56	110	259	669	54	403	236
% MU (SCANS IV)	0.02	0.03	0.075	0.193	0.02	0.12	0.07

Bottlenose dolphin

319. Using instantaneous TTS-onset thresholds (SPLpeak), the maximum impact range for bottlenose dolphin was calculated at <0.1km at all monopile and pin pile locations. This resulted in no impact from instantaneous TTS from pile driving being predicted for bottlenose dolphin (Table 11-45).

320. Using the cumulative TTS-onset thresholds (SELcum) the maximum impact range for bottlenose dolphin during a single piling event was calculated at <0.1km at all monopile and pin pile locations. This resulted in no impact from cumulative TTS from pile driving being predicted for bottlenose dolphin (Table 11-45).

White-beaked dolphin

321. Using instantaneous TTS-onset thresholds (SPLpeak), the maximum impact range for white-beaked dolphin was calculated at <0.1km at all monopile and pin pile locations. This resulted in no impact from instantaneous TTS from pile driving being predicted for white-beaked dolphin (Table 11-42).

322. Using the cumulative TTS-onset thresholds (SELcum) the maximum impact range for white-beaked dolphin during a single piling event was calculated at <0.1km at all monopile and pin pile locations. This resulted in no impact from cumulative TTS from pile driving being predicted for white-beaked dolphin (Table 11-43).

Table 11-42: TTS-onset impact ranges, number of white-beaked dolphin and percentage of MU predicted to experience instantaneous TTS-onset during piling (unweighted SPLpeak dB re 1µPa) using the uniform DAS estimate (0.0006/km2), the SCANS III density surface (Lacey *et al.,* 2022) (grid cell specific) and the SCANS IV density estimate (0.10149/km2) (Gilles *et al.,* 2023).

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Monopile							
Area (km^2)	< 0.1	< 0.1	< 0.1	No additive effect	< 0.1	< 0.1	< 0.1
Max range (m)	< 100	< 100	< 100		< 100	< 100	< 100
# (DAS)	<1	<1	<1		<1	<1	<1
% MU (DAS)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01
# (Lacey *et al.*, 2022)	<1	<1	<1		<1	<1	<1
% MU (Lacey *et al.*, 2022)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01
# (SCANS IV)	<1	<1	<1		<1	<1	<1
% MU (SCANS IV)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01
Jacket							
Area (km^2)	< 0.1	< 0.1	< 0.1	No additive effect	< 0.1	< 0.1	< 0.1
Max range (m)	< 100	< 100	< 100		< 100	< 100	< 100
# (DAS)	<1	<1	<1		<1	<1	<1
% MU (DAS)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01
# (Lacey *et al.*, 2022)	<1	<1	<1		<1	<1	<1
% MU (Lacey *et al.*, 2022)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01
# (SCANS IV)	<1	<1	<1		<1	<1	<1
% MU (SCANS IV)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01

Table 11-43: TTS-onset impact ranges, number of white-beaked dolphin and percentage of MU predicted to experience instantaneous TTS-onset during piling (unweighted SELss dB re 1µPa2s) using the uniform DAS estimate (0.0006/km2), the SCANS III density surface (Lacey *et al.,* 2022) (grid cell specific) and the SCANS IV density estimate (0.0149/km2) (Gilles *et al.,* 2023).

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Monopile x1							
Area (km²)	< 0.1	< 0.1	< 0.1	No additive effect	< 0.1	< 0.1	< 0.1
Max range (m)	< 100	< 100	< 100		< 100	< 100	< 100
# (DAS)	<1	<1	<1		<1	<1	<1
% MU (DAS)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01
# (Lacey *et al.,* 2022)	<1	<1	<1		<1	<1	<1
% MU (Lacey *et al.,* 2022)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01
# (SCANS IV)	<1	<1	<1		<1	<1	<1
% MU (SCANS IV)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01
Monopile x2							
Area (km²)	< 0.1	< 0.1	< 0.1	No additive effect	< 0.1	NA	
Max range (m)	< 100	< 100	< 100		< 100		
# (DAS)	<1	<1	<1		<1		
% MU (DAS)	< 0.01	< 0.01	< 0.01		< 0.01		
# (Lacey *et al.,* 2022)	<1	<1	<1		<1		
% MU (Lacey *et al.,* 2022)	< 0.01	< 0.01	< 0.01		< 0.01		
# (SCANS IV)	<1	<1	<1		<1		
% MU (SCANS IV)	< 0.01	< 0.01	< 0.01		< 0.01		
Jacket x1							
Area (km²)	< 0.1	< 0.1	< 0.1	No additive effect	< 0.1	< 0.1	< 0.1
Max range (m)	< 100	< 100	< 100		< 100	< 100	< 100
# (DAS)	<1	<1	<1		<1	<1	<1
% MU (DAS)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01
# (Lacey *et al.,* 2022)	<1	<1	<1		<1	<1	<1
% MU (Lacey *et al.,* 2022)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01
# (SCANS IV)	<1	<1	<1		<1	<1	<1

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
% MU (SCANS IV)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01
Jacket x6						Jacket x4	
Area (km²)	< 0.1	< 0.1	< 0.1	No additive effect	< 0.1	< 0.1	< 0.1
Max range (m)	< 100	< 100	< 100		< 100	< 100	< 100
# (DAS)	<1	<1	<1		<1	<1	<1
% MU (DAS)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01
# (Lacey *et al.*, 2022)	<1	<1	<1		<1	<1	<1
% MU (Lacey *et al.*, 2022)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01
# (SCANS IV)	<1	<1	<1		<1	<1	<1
% MU (SCANS IV)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01

Table 11-44: TTS-onset impact ranges, number of bottlenose dolphin and percentage of MU predicted to experience instantaneous TTS-onset during piling (unweighted SPLpeak dB re 1µPa) using SCANS IV density estimate (0.0419/km2) (Gilles et al 2023).

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Monopile							
Area (km²)	< 0.01	< 0.01	< 0.01	No additive effect	< 0.01	< 0.01	< 0.01
Max range (m)	< 50	< 50	< 50		< 50	< 50	< 50
# (SCANS IV)	<1	<1	<1		<1	<1	<1
% MU (SCANS IV)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01
Jacket							
Area (km²)	< 0.01	< 0.01	< 0.01	No additive effect	< 0.01	< 0.01	< 0.01
Max range (m)	< 50	< 50	< 50		< 50	< 50	< 50
# (SCANS IV	<1	<1	<1		<1	<1	<1
% MU (SCANS IV)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01

Table 11-45: TTS-onset impact ranges, number of bottlenose dolphin and percentage of MU predicted to experience cumulative TTS during piling (weighted SELss dB re 1µPa2s) using SCANS IV density estimate (0.0419/km2) (Gilles et al 2023).

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Monopile x1							
Area (km^2)	< 0.01	< 0.01	< 0.01	No additive effect	< 0.01	< 0.01	< 0.01
Max range (m)	< 50	< 50	< 50		< 50	< 50	< 50
# (SCANS IV	<1	<1	<1		<1	<1	<1
% MU (SCANS IV)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01
Monopile x2							
Area (km^2)	< 0.01	< 0.01	< 0.01	No additive effect	< 0.01	NA	
Max range (m)	< 50	< 50	< 50		< 50		
# (SCANS IV	<1	<1	<1		<1		
% MU (SCANS IV)	< 0.01	< 0.01	< 0.01		< 0.01		
Jacket x1							
Area (km^2)	< 0.01	< 0.01	< 0.01	No additive effect	< 0.01	< 0.01	< 0.01
Max range (m)	< 50	< 50	< 50		< 50	< 50	< 50
# (SCANS IV	<1	<1	<1		<1	<1	<1
% MU (SCANS IV)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01
Jacket x6						**Jacket x4**	
Area (km^2)	< 0.01	< 0.01	< 0.01	No additive effect	< 0.01	< 0.01	< 0.01
Max range (m)	< 50	< 50	< 50		< 50	< 50	< 50
# (SCANS IV	<1	<1	<1		<1	<1	<1
% MU (SCANS IV)	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01

Minke whale

11.6.1.5 Monopiles

323. Using instantaneous TTS-onset thresholds (SPL_{peak}), the maximum impact range for minke whale was calculated at <0.1km at all monopile locations. This resulted in no impact from instantaneous TTS from pile driving being predicted for minke whales (Table 11-46).

324. Using the cumulative TTS-onset thresholds (SEL_{cum}) the maximum impact range for minke whale during a single monopile piling event was calculated at 25km for the ANS NW monopile location. This equated to a maximum of 11 minke whale and 0.055% of the MU (Table 11-39).

325. Using the cumulative TTS-onset thresholds (SEL_{cum}) the maximum impact area for minke whales was 1,500km^2 during the concurrent piling of 2 sequential monopiles at the Array NE and SW locations. This equated to a maximum of 13 minke whales and 0.065% of the MU.

11.6.1.6 Pin Piles

326. Using instantaneous TTS onset thresholds (SPL_{peak}), the maximum impact range for minke whale was calculated at <0.1km at all pin pile locations. This resulted in no impact from instantaneous TTS from pile driving being predicted for minke whale (Table 11-46).

327. Using the cumulative TTS-onset thresholds (SEL_{cum}) the maximum impact range for minke whale during sequential piling of 4 jacket (pin) piles was 25km for the ANS NW location. This equated to a maximum of 11 minke whales and 0.055% of the MU (Table 11-47).

328. The maximum cumulative TTS-onset impact area was calculated at 1,300 km^2 for concurrent piling of 6 sequential pin piles at the array NE and SW locations, resulting in impact to 11 minke whales and 0.055% of the MU (Table 11-47).

Table 11-46: TTS-onset impact ranges, number of minke whale and percentage of MU predicted to experience instantaneous TTS-onset during piling (unweighted SPLpeak dB re 1µPa) using the SCANS III density surface (Lacey *et al.,* 2022) (grid cell specific) and the SCANS IV density estimate (0.068/km2) (Gilles *et al.,* 2023).

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Monopile							
Area (km^2)	0.02	0.02	0.04	No additive effect	0.02	0.03	0.02
Max range (m)	70	90	110		80	90	90
# (Lacey *et al.,* 2022)	<1	<1	<1		<1	<1	<1
% MU (Lacey *et al.,* 2022)	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001
# (SCANS IV)	<1	<1	<1		<1	<1	<1
% MU (SCANS IV)	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001
Jacket							
Area (km^2)	0.01	0.02	0.03	No additive effect	0.02	0.03	0.02
Max range (m)	60	70	100		70	100	90
# (Lacey *et al.,* 2022)	<1	<1	<1		<1	<1	<1
% MU (Lacey *et al.,* 2022)	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001
# (SCANS IV)	<1	<1	<1		<1	<1	<1
% MU (SCANS IV)	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001

Table 11-47: TTS-onset impact ranges, number of minke whale and percentage of MU predicted to experience cumulative TTS during piling (weighted SELss dB re 1µPa2s) using the SCANS III density surface (Lacey *et al.,* 2022) (grid cell specific) and the SCANS IV density estimate (0.0068/km2) (Gilles *et al.,* 2023).

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Monopile x1							
Area (km^2)	130	250	720	No additive effect	110	1,000	500
Max range (m)	8,600	12,000	19,000		9,300	25,000	15,000
# (Lacey *et al.,* 2022)	1	2	6		1	11	3
% MU (Lacey *et al.,* 2022)	0.005	0.010	0.030		0.005	0.055	0.015
# (SCANS IV)	1	2	5		<1	7	3
% MU (SCANS IV)	0.005	0.010	0.025		<0.005	0.035	0.015
Monopile x2							
Area (km^2)	130	250	720	1,500	110	NA	
Max range (m)	8,600	12,000	19,000	-	9,300		
# (Lacey *et al.,* 2022)	1	2	6	13	1		
% MU (Lacey *et al.,* 2022)	0.005	0.010	0.030	0.065	0.005		
# (SCANS IV)	1	2	5	10	<1		
% MU (SCANS IV)	0.005	0.010	0.025	0.050	<0.005		
Jacket x1							
Area (km^2)	83	180	560	No additive effect	69	1000	490
Max range (m)	7,000	9,800	17,000		7,800	25,000	15,000
# (Lacey *et al.,* 2022)	<1	2	5		<1	11	3
% MU (Lacey *et al.,* 2022)	<0.005	0.010	0.025		<0.005	0.055	0.015
# (SCANS IV)	<1	1	4		<1	7	3
% MU (SCANS IV)	<0.005	0.006	0.020		<0.005	0.035	0.015
Jacket x6						**Jacket x4**	
Area (km^2)	83	180	560	1,300	69	1000	490
Max range (m)	7,000	9,800	17,000	-	7,800	25,000	15,000
# (Lacey *et al.,* 2022)	<1	2	5	11	<1	11	3
% MU (Lacey *et al.,* 2022)	<0.005	0.010	0.025	0.055	<0.005	0.055	0.015
# (SCANS IV)	<1	1	4	9	<1	7	3
% MU (SCANS IV)	<0.005	0.005	0.020	0.045	<0.005	0.035	0.015

Harbour seal

329. Using the instantaneous TTS-onset thresholds (SPLpeak), the maximum impact range for harbour seal was calculated at 130m at the array NE monopile location. This resulted in no impact from instantaneous TTS from pile driving being predicted for harbour seal (Table 11-51).

330. Using the cumulative TTS-onset thresholds (SELcum) the maximum impact range for harbour seal during a single monopile piling event was calculated at 7km for the ANS NW monopile location. This equated to a maximum of one harbour seal and 0.02% of the MU (Table 11-50). However, the greatest number of harbour seals expected to experience cumulative TTS during a single monopile piling event was at the ORCP location, where 8 harbour seals (0.16% MU) were predicted to be impacted.

331. During concurrent piling of 2 sequential monopiles at the NE and SW locations, the maximum impact area was calculated at 450 km^2, resulting in cumulative TTS-onset impact to 17 harbour seals and 0.35% of the MU (Table 11-51).

332. Using the cumulative TTS-onset thresholds (SEL_{cum}) the maximum impact range for harbour seal during a single pin piling event was calculated at 6.9 km at the ANS NW location. This equated to a maximum of 1 harbour seal and 0.02% of the MU predicted to experience TTS-onset (Table 11-51).

333. Using the cumulative TTS-onset thresholds (SEL_{cum}) the maximum impact area for harbour seal during concurrent piling of pin piles was calculated at 410 km^2 for the concurrent piling of 6 sequential pin piles at the NE-SW piling locations. This equated to a maximum of 15 harbour seal and 0.31% of the MU predicted to experience TTS (Table 11-51).

Grey seal

334. Using instantaneous TTS-onset thresholds (SPL_{peak}), the maximum impact range for grey seal was calculated at 130 m at the NE monopile location. This resulted in no impact from instantaneous TTS from pile driving being predicted for grey seal (Table 11-48).

335. Using the cumulative TTS-onset thresholds (SEL_{cum}) the maximum impact range for grey seal during a single monopile piling event was calculated at 7 km for the ANS NW monopile location. This equated to a maximum of 111 grey seal and 0.17% of the MU (Table 11-49). During concurrent piling of 2 sequential monopiles at the NE and SW locations, the maximum impact area was calculated at 450 km^2, resulting in TTS impact to 316 grey seals and 0.48% of the MU (Table 11-48).

336. Using the cumulative TTS-onset thresholds (SEL_{cum}) the maximum impact range for grey seal during a single pin piling event was calculated at 6.9 km at the ANS NW location. This equated to a maximum of 110 grey seals and 0.17% of the MU predicted to experience TTS (Table 11-49).

337. Using the cumulative TTS-onset thresholds (SEL_{cum}) the maximum impact area for grey seal during concurrent piling of pin piles was calculated at 410 km^2 for the concurrent piling of 6 sequential pin piles at the NE-SW piling locations. This equated to a maximum of 289 grey seal and 0.44% of the MU predicted to experience TTS (Table 11-50).

Table 11-48: TTS-onset impact ranges, number of grey seals and percentage of MU predicted to experience instantaneous TTS-onset during piling (unweighted SPLpeak dB re 1µPa) using the Carter *et al.,* (2020, 2022) grid cell specific density estimate

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Monopile							
Area (km^2)	0.02	0.03	0.05	No additive effect	0.03	0.04	0.03
Max range (m)	80	100	130		100	110	100
#	<1	<1	<1		<1	<1	<1
% MU	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001
Jacket							
Area (km^2)	0.02	0.02	0.04	No additive effect	0.02	0.04	0.03
Max range (m)	70	80	110		80	120	100
#	<1	<1	<1		<1	<1	<1
% MU	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001

Table 11-49: TTS-onset impact ranges, number of grey seal and percentage of MU predicted to experience cumulative TTS during piling (weighted SELss dB re 1µPa2s) using the Carter et al., (2020, 2022) grid cell specific density estimate

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Monopile x1							
Area (km^2)	3.1	20	87	No additive effect[20]	9.3	110	50
Max range (m)	1,300	3,100	6,300		2,600	7,000	4,900
#	3	21	49		11	111	23
% MU	0.005	0.03	0.075		0.02	0.17	0.04
Monopile x2							
Area (km^2)	3.1	20	87	450	9.3	NA	
Max range (m)	1,300	3,100	6,300	-	2,600		
#	3	21	49	316	11		
% MU	0.005	0.03	0.075	0.482	0.02		
Jacket x1							
Area (km^2)	1.2	13	65		5.4	110	49

[20] There is no in-combination effect when piling occurs at the two locations simultaneously, generally where the individual ranges are small enough that the distant site does not produce an influencing additional exposure.

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Max range (m)	830	2,500	5,500	No additive effect	2,000	6,900	4,900
#	1	13	37		7	110	22
% MU	0.002	0.02	0.056		0.01	0.17	0.03
Jacket x6						Jacket x4	
Area (km²)	1.2	13	66	410	5.4	110	50
Max range (m)	830	2,500	5,500	-	2,000	7,100	4,900
#	1	13	38	289	7	112	22
% MU	0.002	0.02	0.058	0.441	0.01	0.17	0.03

Table 11-50: TTS-onset impact ranges, number of harbour seals and percentage of MU predicted to experience cumulative TTS-onset during piling (unweighted SPLpeak dB re 1µPa) using the Carter et al., (2020, 2022) grid cell specific density estimate.

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Monopile x1							
Area (km²)	3.1	20	87	No additive effect[21]	9.3	110	50
Max range (m)	1,300	3,100	6,300		2,600	7,000	4,900
#	1	1	3		8	1	1
% MU	0.02	0.02	0.062		0.16	0.02	0.02
Monopile x2							
Area (km²)	3.1	20	87	450	9.3	NA	
Max range (m)	1,300	3,100	6,300	-	2,600		
#	1	1	3	17	8		
% MU	0.02	0.02	0.062	0.349	0.16		
Jacket x1							
Area (km²)	1.2	13	65	No additive effect	5.4	110	49
Max range (m)	830	2,500	5,500		2,000	6,900	4,900
#	<1	1	2		4	1	1
% MU	<0.02	0.02	0.041		0.08	0.02	0.02
Jacket x6						Jacket x4	

[21] There is no in-combination effect when piling occurs at the two locations simultaneously, generally where the individual ranges are small enough that the distant site does not produce an influencing additional exposure.

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Area (km^2)	1.2	13	66	410	5.4	110	50
Max range (m)	830	2,500	5,500	-	2,000	7,100	4,900
#	<1	1	2	15	4	1	1
% MU	<0.02	0.02	0.041	0.308	0.08	0.02	0.02

11.6.1.7 Impact 5: Pile driving – Disturbance

Harbour porpoise

Sensitivity

338. Previous studies have shown that harbour porpoises are displaced from the vicinity of piling events. For example, studies at windfarms in the German North Sea have recorded large declines in porpoise detections close to the piling location (>90% decline at noise levels above 170dB) with decreasing effect with increasing distance from the pile (25% decline at noise levels between 145 and 150dB) (Brandt et al., 2016). The detection rates revealed that porpoise were only displaced from the piling area in the short term (one to three 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.

339. Studies using Digital Acoustic Recording Tags (DTAGs) have shown that 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). The authors state that porpoise therefore "operate on an energetic knife edge" and that they have "low resilience to disturbance". However, there are concerns with the methodologies used in the Wisniewska et al. (2016) paper that bring these conclusions into question. These concerns are summarised in a rebuttal to the original paper by Hoekendijk et al., (2018) which call for "a cautious, critical, and rational assessment of the results and interpretations". One of the key issues highlighted is that the porpoise were trapped in a pound net for 24+ hours before tagging and were not allowed to recover from stress and starvation once released. The high levels of foraging observed don't necessarily represent the typical foraging – i.e. they are not necessarily indicative of vulnerability to disturbance. Foraging behaviour after release may in part be a response to being captured and held. It is typical for the initial data recorded from tags to be excluded from analysis as it is not expected to be representative of typical behaviour (e.g. Wright et al., 2017). Given that the tags on the porpoise in Wisniewska et al. (2016) only recorded for 15-23 hours after tagging, it could be considered that all of the data are impacted by the response to being caught and tagged, and thus none of it is representative of typical behaviour. Wisniewska et al. (2018) responded to the rebuttal by Hoekendijk et al., (2018) by highlighting that it was unknown whether or not the captured porpoise fed while in the pound nets or whether this would have led to elevated stress. They state that the hunger levels of the released porpoise were unknown and that there was no evidence of prolonged response to the tagging circumstances. Further to this, a subsequent paper by Booth et al. (2019) used the Wisniewska et al. (2016) data combined with additional information on porpoise diet and the energy derived from different prey to highlight that the tagged animals likely were able to consume significant amounts of energy (well in excess of energetic requirements – based on the data available). Booth et al. (2019) disputes the conclusion that porpoise exist on an "energetic knife-edge" as Wisniewska et al. (2016) claim but do not justify in their paper

340. The results from Wisniewska et al. (2016) could also suggest that porpoises have an ability to respond to short-term reductions in food intake, implying a resilience to disturbance. As Hoekendijk et al. (2018) argue, this could help explain why 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 porpoises may well be able to compensate by moving quickly to alternative areas to feed, while at the same time increasing their feeding rates (Hoekendijk et al., 2018).

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

342. A study of tagged harbour porpoises has shown large variability between individual responses to an airgun stimulus (van Beest et al., 2018). Of the five porpoises tagged and exposed to airgun pulses at ranges of 420 – 690m (SEL 135–147dB re 1µPa2s), 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 individual variability in responses among harbour porpoises exposed to low frequency broadband pulsed noise (including both airguns and pile-driving).

343. At the most recent expert elicitation workshop in 2018 (Booth et al., 2019), experts assessed 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 (Booth et al., 2019). A Dynamic Energy Budget 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.

344. 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 (Plate 11.18, 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; 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.

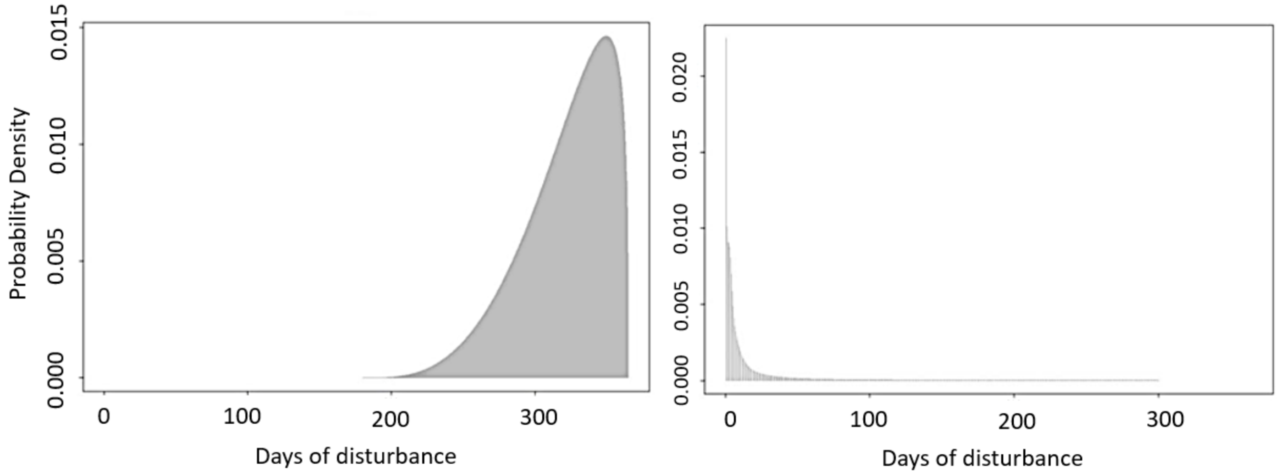

Plate 11.18: Probability distributions showing the consensus of the expert elicitation for harbour porpoise disturbance from piling (Booth *et al.,* 2019). Left: the number of days of disturbance (i.e. days on which an animal does not feed for six hours) a pregnant female could 'tolerate' before it has 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.

345. A recent study by Benhemma-Le Gall (2021) provided two key findings in relation to harbour porpoise response to pile driving. Porpoise were not completely displaced from the piling site: detections of clicks (echolocation) and buzzing (associated with prey capture) in the short-range (2km) did not cease in response to pile driving, and 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 porpoise that are displaced from the near-field, compensate by continuing foraging activities beyond the impact range (Plate 11.19). Therefore, porpoise that experience displacement are expected to be able to compensate for the lost foraging opportunities and increased energy expenditure of fleeing.

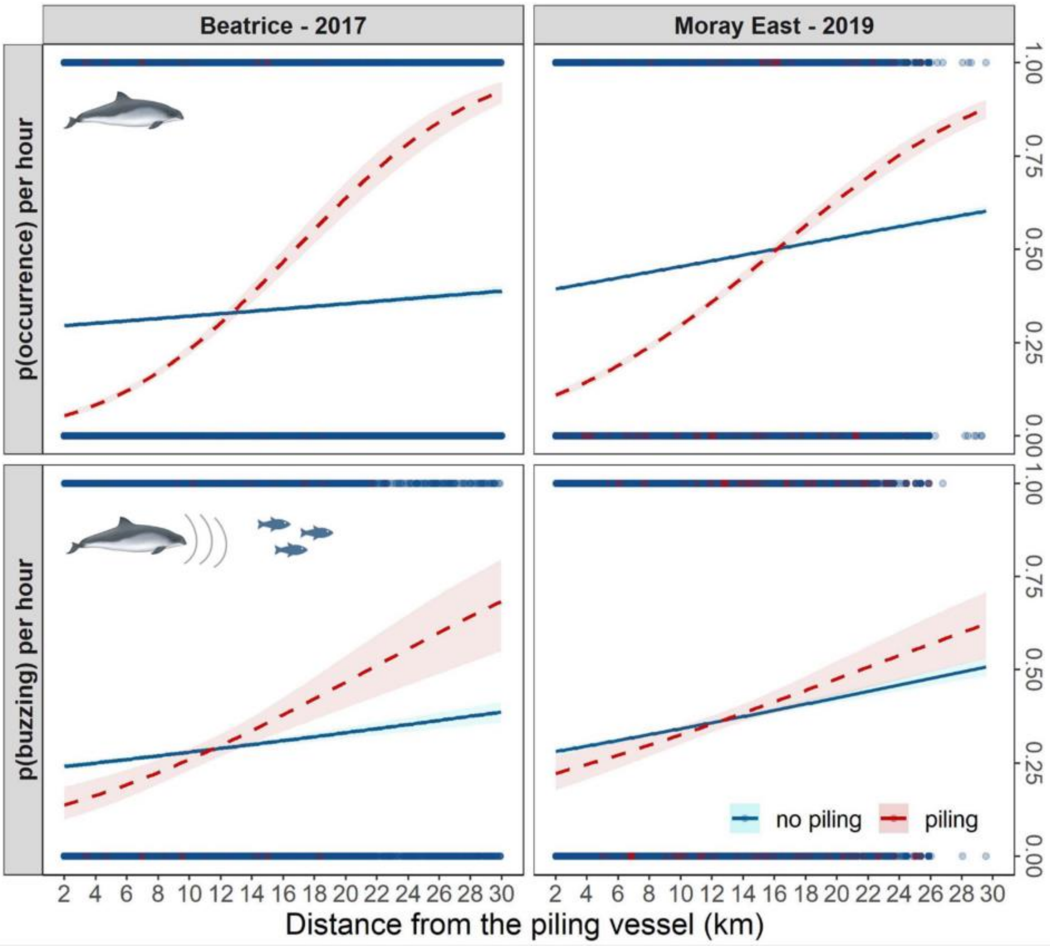

Plate 11.19: The probability of harbour porpoise occurrence and buzzing activity per hour during (dashed red line) and out with (blue line) pile-driving hours, in relation to distance from the pile-driving vessel at Beatrice (left) and Moray East (right).

346. Given all the evidence summarised above, it is expected that harbour porpoise are somewhat resilient to and can compensate for temporary disturbance. Therefore, harbour porpoises have been assessed as having a **Medium** sensitivity to disturbance from pile driving activities.

Magnitude

347. The results of disturbance to harbour porpoise from pile driving are presented in Table 11-51.

Array

348. The maximum disturbance impact from the installation of a single monopile within the array area is at the NE location, where up to 1,903 harbour porpoise are predicted to be disturbed per piling day (0.55% MU, using SCANS III density surface). The maximum disturbance impact from the installation of a single pin pile within the array area is at the NE location, where up to 1,702 harbour porpoise are predicted to be disturbed per piling day (0.49% MU, using SCANS III density surface).

349. For concurrent piling at NE & SE, up to 2,387 harbour porpoise are predicted to be disturbed per piling day for monopiles (0.69% MU, using SCANS III density surface) and 2,123 harbour porpoise are predicted to be disturbed per piling day for pin piles (0.61% MU, using SCANS III density surface).

350. When using the average summer site-specific density estimate, the maximum disturbance impact from the installation of a single monopile within the array area is at the NE location, where up to 3,989 harbour porpoise are predicted to be disturbed per piling day (1.15% MU). The maximum disturbance impact from the installation of a single pin pile within the array area is at the NE location, where up to 3,567 harbour porpoise are predicted to be disturbed per piling day (1.03% MU).

351. For concurrent piling at NE & SE, when using the average summer site-specific density estimate, up to 4,990 harbour porpoise are predicted to be disturbed per piling day for monopiles (1.44% MU) and 4,440 harbour porpoise are predicted to be disturbed per piling day for pin piles (1.28% MU).

ORCP

352. The disturbance impact from ORCP monopiles is 585 harbour porpoise predicted to be disturbed per piling day (0.17% MU, using SCANS III density surface). The maximum disturbance impact from ORCP pin piles is 524 harbour porpoise predicted to be disturbed per piling day (0.15% MU, using SCANS III density surface).

353. When using the average summer site-specific density estimate, the disturbance impact from ORCP monopiles is 1,079 harbour porpoise predicted to be disturbed per piling day (0.31% MU), and the maximum disturbance impact from ORCP pin piles is 964 harbour porpoise predicted to be disturbed per piling day (0.28% MU).

ANS

354. The maximum disturbance impact from ANS monopiles is at the NW location, where up to 2,758 harbour porpoise are predicted to be disturbed per piling day (0.80% MU, using SCANS III density surface). The maximum disturbance impact from ANS pin piles is at the NW location, where up to 2,720 harbour porpoise are predicted to be disturbed per piling day (0.78% MU, using SCANS III density surface).

355. When using the average summer site-specific density estimate, the maximum disturbance impact from ANS monopiles is 5,263 harbour porpoise predicted to be disturbed per piling day (1.52% MU), and the maximum disturbance impact from ANS pin piles is 5,190 harbour porpoise predicted to be disturbed per piling day (1.50% MU).

Table 11-51: Number of harbour porpoise and percentage of MU predicted to experience disturbance during piling using the SCANS III density surface (grid cell specific) (Lacey et al., 2022), the SCANS IV density estimate (0.6027/km2) (Gilles et al., 2023) and the 2.63 porpoise/km^2 average summer site-specific density.

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Monopiles							
# (Lacey et al. 2022)	607	1,043	1,903	2,387	585	2,758	1,348
% MU (Lacey et al. 2022)	0.18	0.30	0.55	0.69	0.17	0.80	0.39
# (SCANS IV)	289	476	914	1,144	247	1,206	751
% MU (SCANS IV)	0.08	0.14	0.26	0.33	0.07	0.35	0.22
# (Average summer site-specific density)	1,259	2,078	3,989	4,990	1,079	5,263	3,279
% MU (Average summer site-specific density)	0.363	0.600	1.15	1.44	0.311	1.518	0.946
Jacket (Pin) Piles							
# (Lacey et al. 2022)	514	913	1,702	2,123	524	2,720	1,323
% MU (Lacey et al. 2022)	0.15	0.26	0.49	0.61	0.15	0.78	0.38
# (SCANS IV)	245	417	817	1,018	221	1,189	738
% MU (SCANS IV)	0.07	0.12	0.24	0.29	0.06	0.34	0.21
# (Average summer site-specific density)	1,068	1,822	3,567	4,440	964	5,190	3,219
% MU (Average summer site-specific density)	0.308	0.526	1.03	1.28	0.278	1.497	0.929

356. The maximum number of piling days is expected to be 109 piling days for monopiles or 130 piling days of pin piled jackets within the indicative piling construction period (Q3 2027 – Q2 2029). Given the results of the expert elicitation on the likely effects of behavioural disturbance on harbour porpoise vital rates (Booth *et al.* 2019), exposure of an individual porpoise to 130 days of piling is very highly unlikely to result in an effect on fertility rates, though repeated disturbance could result in changes to calf survival rates. However, this only applies if the same individual mother-calf pair is disturbed repeatedly across multiple piling days. It is highly unlikely that the same individual mother-calf pair would repeatedly return to the area to receive repeated disturbance over multiple days. Therefore, it is expected that repeated disturbance leading to reductions in survival and reproductive rates is very unlikely.

iPCoD

357. To determine whether this level of disturbance is expected to result in population level impacts, iPCoD modelling was conducted. Modelling was conducted for two piling scenarios, the worst-case monopile and worst-case jacket scenario. Modelling has also been presented using both the Lacey et al. (2022) density surface results and the average summer site-specific DAS results (Table 11-52, Table 11-53)[22].

Table 11-52 Number of animals predicted to be disturbed per piling day for monopile WTGs and ANS.

Species	MU	Density	WTG monopile	ANS monopile
Harbour porpoise	346,601	Lacey et al., (2022) density surface	1,903	2,758
		2.63 porpoise/km^2 average summer site-specific density	3,989	5,263

Table 11-53 Number of animals predicted to be disturbed per piling day for jacket WTGs and ANS.

Species	MU	Density	WTG jacket	ANS jacket
Harbour porpoise	346,601	Lacey et al., (2022) density surface	1,702	2,720
		2.63 porpoise/km^2 average summer site-specific density	3,567	5,190

358. Table 11-54, Figure 20 and Figure 21 show the results for the iPCoD simulations for harbour porpoise using the Lacey et al., (2022) disturbance values. The results of the iPCoD modelling show that the level of disturbance from the construction of the Proposed Development is not sufficient to result in any changes at the population level from 1 to 18 years after the end of piling activities. The counter-factual metric indicates that the impacted population size remains at 99.9-100.0% of the unimpacted population size, and the population continues on a stable trajectory. Therefore, disturbance from piling from the Project would not result in a population level effect.

359. Table 11-55, Figure 22 and Figure 23 show the results for the iPCoD simulations for harbour porpoise using the summer site-specific average summer site specific density of 2.63 porpoise/km^2. The counter-factual metric indicates that the impacted population size remains at 99.7-100.0% of the unimpacted population size, and the population continues on a stable trajectory. Therefore, disturbance from piling at ODOW would not result in a population level effect.

[22] Note: the average summer density was added to the assessment at Natural England's request. The Applicant does not support the use of this site-specific density estimate beyond the bounds of the survey area, and does not consider it to be an appropriate density estimate to be used for the large scale disturbance from piling assessment.

Table 11-54 Results of the harbour porpoise iPCoD simulations using the disturbance values from Lacey et al., (2022) (95% CIs provided).

	Mean					Median		
	Un-impacted population size	95% CIs	Impacted population size	95% CIs	Impacted as % of un-impacted population size	Un-impacted population size	Impacted population size	Impacted as % of un-impacted population size
Jackets								
Before piling	346,602	346,602 346,602	346,602	346,602 346,602	100.00%	346,602	346,602	100.00%
End year 1 piling	347,324	320,490 371,762	347,322	320,490 371,762	100.00%	348,046	348,046	100.00%
End year 2 piling	347,746	309,709 381,440	347,652	309,697 381,427	99.97%	349,101	349,061	99.99%
1 year after pilings ends	347,284	302,844 387,262	347,166	302,817 387,258	99.97%	347,603	347,562	99.99%
6 years after piling ends	347,134	288,966 412,236	347,048	288,966 412,114	99.98%	345,971	345,947	99.99%
12 years after piling ends	349,054	271,282 434,929	348,968	271,282 434,929	99.98%	347,538	347,538	100.00%
18 years after piling ends	347,206	259,549 447,567	347,119	259,549 447,567	99.97%	344,210	344,146	99.98%
Monopiles								
Before piling	346,602	346,602 346,602	346,602	346,602 346,602	100.00%	346,602	346,602	100.00%
End Year 1 piling	347,574	317,394 372,562	347,573	317,394 372,562	100.00%	348,245	348,242	100.00%
End year 2 piling	347,356	312,165 381,727	347,314	312,110 381,727	99.99%	348,615	348,595	99.99%
1 year after pilings ends	346,910	304,447 388,270	346,853	304,410 388,202	99.98%	346,991	346,938	99.98%
6 years after piling ends	347,120	286,075 409,338	347,078	286,075 409,328	99.99%	346,392	346,353	99.99%
12 years after piling ends	346,695	270,929 425,147	346,653	270,929 425,147	99.99%	344,794	344,705	100.00%
18 years after piling ends	346,560	260,811 449,430	346,518	260,808 449,389	99.99%	344,241	344,235	99.96%

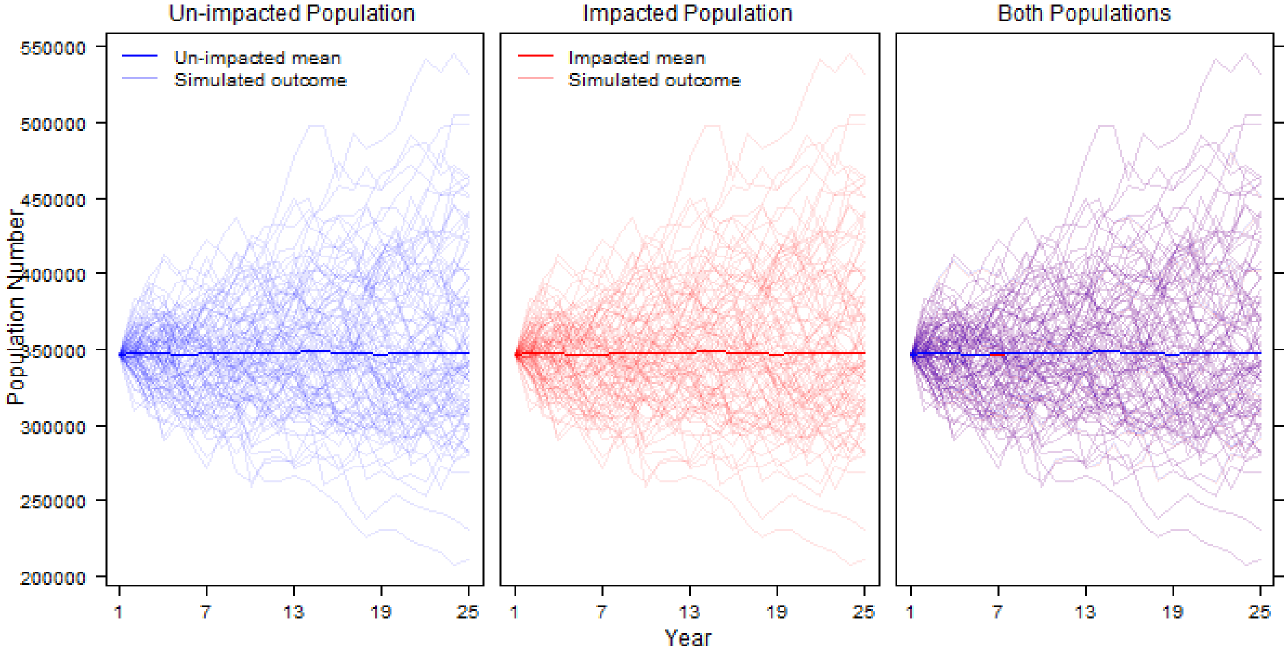

Figure 20 Results of the harbour porpoise iPCoD simulations for jacket foundations using the Lacey et al., (2022) disturbance values.

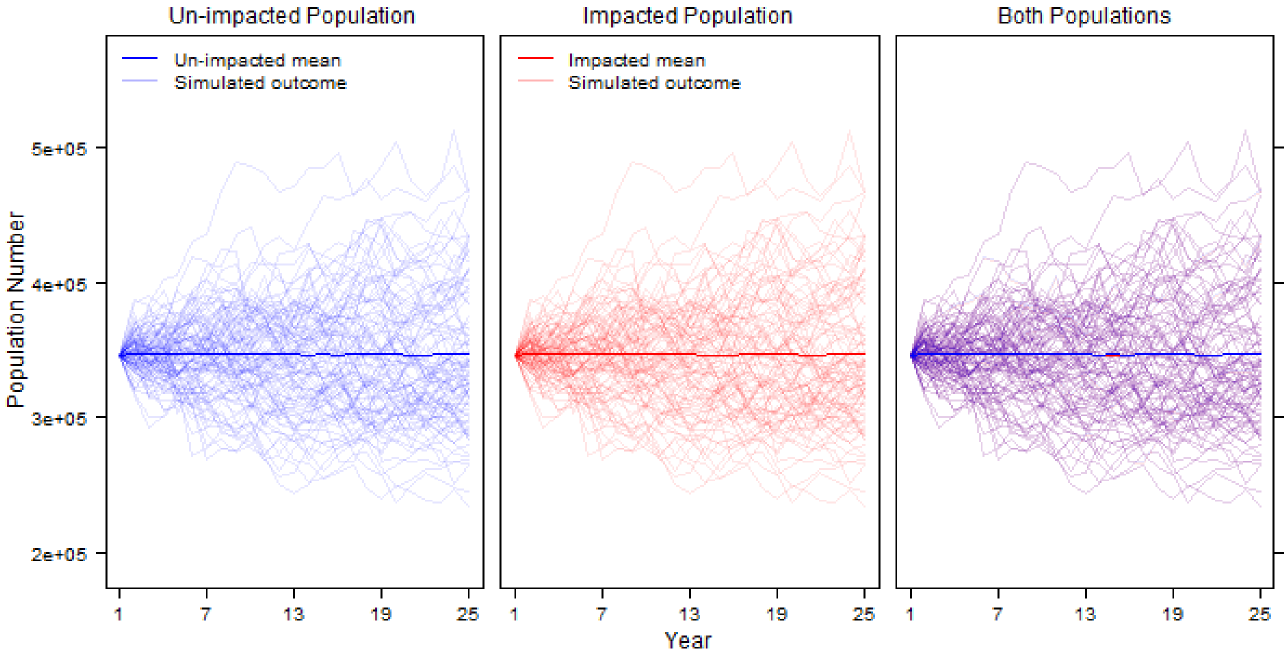

Figure 21 Results of the harbour porpoise iPCoD simulations for monopile foundations using the Lacey et al., (2022) disturbance values.

Table 11-55 Results of the harbour porpoise iPCoD simulations using the disturbance values based on the summer site-specific density estimates.

	Mean					Median		
	Un-impacted population size	95% CIs	Impacted population size	95% CIs	Impacted as % of un-impacted population size	Un-impacted population size	Impacted population size	Impacted as % of un-impacted population size
Jackets								
Before piling	346,602	346,602 346,602	346,602	346,602 346,602	100.00%	346,602	346,602	100.00%
End Year 1 piling	346,693	317,921 370,329	346,691	319,922 370,329	100.00%	347,723	347,723	100.00%
End year 2 piling	347,879	309,552 383,409	347,780	309,486 382,757	99.97%	347,364	347,307	99.98%
1 year after pilings ends	347,624	306,575 386,635	347,503	306,474 385,816	99.97%	348,447	348,384	99.98%
6 years after piling ends	347,331	287,537 410,404	347,240	287,537 409,534	99.97%	345,963	345,839	99.96%
12 years after piling ends	348,286	274,388 436,663	348,196	274,298 436,663	99.97%	347,311	347,238	99.98%
18 years after piling ends	348,671	256,444 458,666	348,579	256,444 483,458	99.97%	347,497	347,460	99.98%
Monopiles								
Before piling	346,602	346,602 346,602	346,602	346,602 346,602	100.00%	346,602	346,602	100.00%
End Year 1 piling	347,564	318,936 373,592	347,563	318,936 373,592	100.00%	348,106	348,103	100.00%
End year 2 piling	347,798	312,675 384,940	347,758	312,669 384,878	99.99%	348,276	348,165	99.97%
1 year after pilings ends	348,253	304,684 390,537	348,198	304,674 390,537	99.98%	348,730	348,730	100.00%
6 years after piling ends	346,797	289,031 412,203	346,758	289,031 412,202	99.99%	344,262	344,250	100.00%
12 years after piling ends	346,071	267,591 439,396	346,033	267,591 439,396	99.99%	341,983	341,948	99.99%
18 years after piling ends	346,166	260,584 457,592	346,127	260,584 457,553	99.99%	343,169	343,165	100.00%

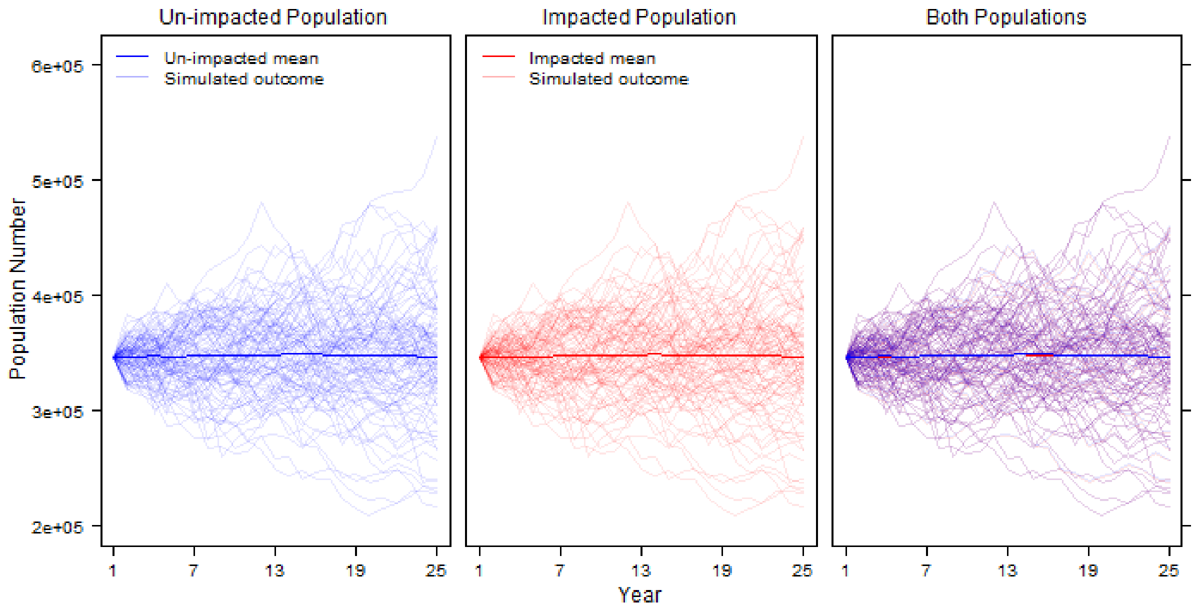

Figure 22 Results of the harbour porpoise iPCoD simulations for jacket foundations using the summer site-specific disturbance values.

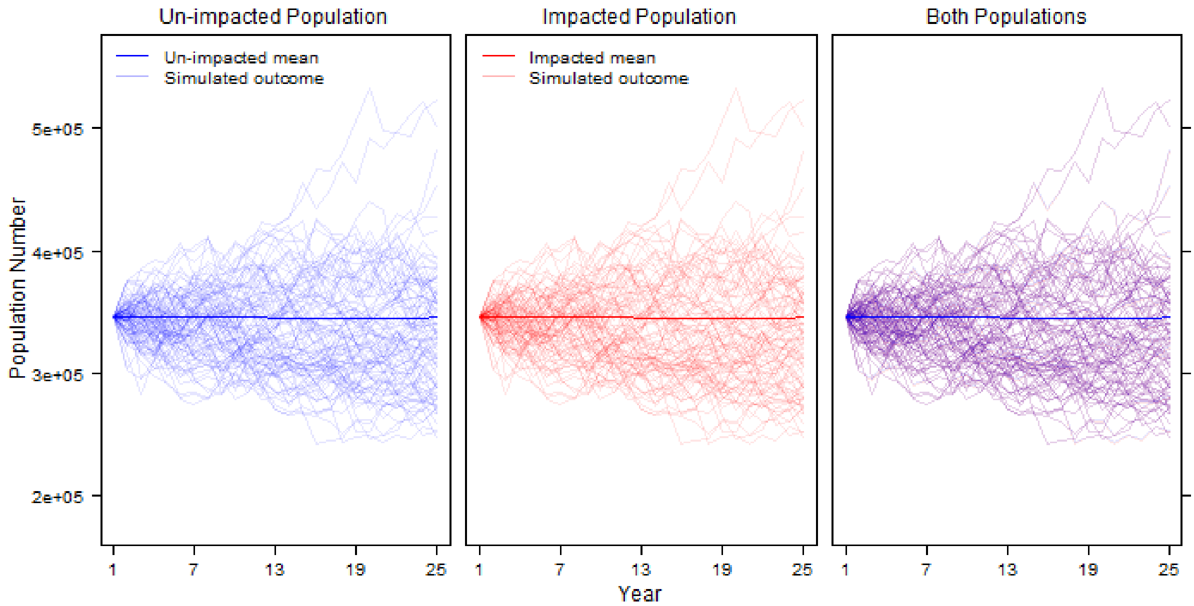

Figure 23 Results of the harbour porpoise iPCoD simulations for monopile foundations using the summer site-specific disturbance values.

360. The impact of disturbance is expected to result in short-term and/or intermittent and temporary behavioural effects in a small proportion of the population. As outlined above, survival and reproductive rates are very unlikely to be impacted to the extent that the population trajectory would be altered. The iPCoD modelling shows the disturbance has a low consequence since there is predicted to be no overall change to the population trajectory. Therefore, since modelling has shown that despite a small proportion of the population being impacted, the population trajectory would not be altered, and thus the impact of disturbance from pile driving is of **Low** magnitude for harbour porpoise.

Significance

361. The sensitivity of harbour porpoise to disturbance from piling has been assessed as **Medium**.

362. The magnitude of impact of disturbance from piling to harbour porpoise has been assessed as **Low**.

363. Therefore, the effect significance of disturbance from piling to harbour porpoise is **Minor**, which is **not significant** in EIA terms.

Bottlenose dolphin

Sensitivity

364. 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 (Pirotta 2013). In a recent 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 were observed; however, dolphins were not excluded from the vicinity of the piling activities (Graham et al., 2017b). In this study, the median peak-to-peak source levels recorded during impact piling were estimated to be 240dB re 1µPa (range ±8dB) with a single pulse source sound exposure level of 198dB re µPa2s. 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.

365. According to the opinions of the experts involved in the expert elicitation for iPCoD, which represents the current best available knowledge on the topic, disturbance would be most likely to affect bottlenose dolphin calf survival, where*: "Experts felt that disturbance could affect calf survival if 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., 2014).*

366. 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 (New *et al.* 2013). Therefore, while there remains the potential for disturbance and displacement to affect individual behaviour and therefore vital rates and population-level changes, bottlenose dolphins do have some capability to adapt their behaviour and tolerate certain levels of temporary disturbance. Therefore, since bottlenose dolphins are expected to be able to adapt their behaviour, with the impact most likely to result in potential changes in calf survival (but not expected to affect adult survival or future reproductive rates) bottlenose dolphins are considered to have a **Medium** sensitivity to behavioural disturbance from piling.

Magnitude

367. The results of disturbance to bottlenose dolphin from pile driving are presented in Table 11-60.

Dose-response function

Array

368. The maximum disturbance impact from the installation of a single monopile within the array area is at the NE location, where up to 64 bottlenose dolphins are predicted to be disturbed per piling day (3.17% MU) using the SCANS IV density estimate. Predictions using the inshore/offshore densities and the SCANS III density surface are considerably smaller (3 and 2 dolphins respectively).

369. The maximum disturbance impact from the installation of a single pin pile within the array area is at the NE location, where up to 57 bottlenose dolphins are predicted to be disturbed per piling day (2.82% MU) using the SCANS IV density estimate. Predictions using the inshore/offshore densities and the SCANS III density surface are considerably smaller (3 and 2 dolphins respectively).

370. For concurrent piling at NE & SE, up to 79 bottlenose dolphins are predicted to be disturbed per piling day for monopiles (3.91% MU) and 71 bottlenose dolphins are predicted to be disturbed per piling day for pin piles (3.51% MU) using the SCANS IV density estimate. Predictions using the inshore/offshore densities and the SCANS III density surface are considerably smaller (4 and 3 dolphins for both monopiles and pin piles respectively).

ORCP

371. The disturbance impact from the installation of a single monopile within the ORCP area is to 17 bottlenose dolphins per piling day (0.84% MU) using the both the inshore/offshore and the SCANS IV density estimates. Predictions using SCANS III density surface are considerably smaller (1 dolphin).

372. The disturbance impact from the installation of a single pin pile within the ORCP area is to 15 bottlenose dolphins per piling day (0.74% MU) using the both the inshore/offshore and the SCANS IV density estimates. Predictions using SCANS III density surface are considerably smaller (<1 dolphin).

ANS

373. The maximum disturbance impact from the installation of a single monopile ANS is at the NW locations where up to 84 bottlenose dolphins are predicted to be disturbed per piling day (4.15% MU) using the SCANS IV density estimate. Predictions using the inshore/offshore densities and the SCANS III density surface are considerably smaller (4 dolphins respectively).

374. The maximum disturbance impact from the installation of a single pin pile ANS is at the NW locations where up to 83 bottlenose dolphins are predicted to be disturbed per piling day (4.10% MU) using the SCANS IV density estimate. Predictions using the inshore/offshore densities and the SCANS III density surface are considerably smaller (4 dolphins respectively).

375. The harbour porpoise dose-response function has been used as a proxy for bottlenose dolphin response 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 bottlenose dolphins are less sensitive to disturbance compared to harbour porpoise. A literature review of (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 180dB 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 140dB re 1µPa. Another high frequency cetacean, Risso's dolphin, reported no behavioural response at received SPLs of 135dB 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 80dB re 1µPa in harbour porpoise and above 140dB 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.

376. Furthermore, the relatively dynamic social structure of bottlenose dolphins (Connor *et al.* 2001) and the fact that they have no significant predation threats and do not appear to face excessive competition for food with other marine mammal species, have potentially resulted in a higher tolerance to perceived threats or disturbances in their environment, which may make them less sensitive to disturbance compared to harbour porpoise.

377. In light of this, the level B harassment threshold has also been presented as an alternative disturbance threshold for bottlenose dolphins.

Level B Harassment

Array

378. The maximum disturbance impact from the installation of a single monopile within the array area is at the NE location, where up to 26 bottlenose dolphins are predicted to be disturbed per piling day (1.29% MU) using the SCANS IV density estimate. Predictions using the inshore/offshore densities and the SCANS III density surface are considerably smaller (1 and <1 dolphins respectively).

379. The maximum disturbance impact from the installation of a single pin pile within the array area is at the NE location, where up to 22 bottlenose dolphins are predicted to be disturbed per piling day (1.09% MU) using the SCANS IV density estimate. Predictions using the inshore/offshore densities and the SCANS III density surface are considerably smaller (1 and <1 dolphins respectively).

380. For concurrent piling at NE & SE, up to 32 bottlenose dolphins are predicted to be disturbed per piling day for monopiles (1.58% MU) and 27 bottlenose dolphins are predicted to be disturbed per piling day for pin piles (1.34% MU) using the SCANS IV density estimate. Predictions using the inshore/offshore densities and the SCANS III density surface are considerably smaller (2 and 1 dolphins for monopiles and 1 dolphin for pin piles respectively).

ORCP

381. The disturbance impact from the installation of a single monopile within the ORCP area is to 17 bottlenose dolphins per piling day (0.84% MU) using the both the inshore/offshore and the SCANS IV density estimates. Predictions using SCANS III density surface are considerably smaller (1 dolphin).

382. The disturbance impact from the installation of a single pin pile within the ORCP area is to 15 bottlenose dolphins per piling day (0.74% MU) using the both the inshore/offshore and the SCANS IV density estimates. Predictions using SCANS III density surface are considerably smaller (<1 dolphin).

ANS

383. The maximum disturbance impact from the installation of a single monopile ANS is at the NW locations where up to 31 bottlenose dolphins are predicted to be disturbed per piling day (1.53% MU) using the SCANS IV density estimate. Predictions using the inshore/offshore densities and the SCANS III density surface are considerably smaller (1 dolphin disturbed for each density scenario).

384. The maximum disturbance impact from the installation of a single pin pile ANS is at the NW locations where up to 30 bottlenose dolphins are predicted to be disturbed per piling day (1.48% MU) using the SCANS IV density estimate. Predictions using the inshore/offshore densities and the SCANS III density surface are considerably smaller (1 dolphin disturbed for each density scenario).

Table 11-56: Number of bottlenose dolphins and percentage of MU predicted to experience disturbance during piling using: 1) the split density estimates for inshore (0.110/km2) and offshore dolphins (0.002/km2), 2) the SCANS III density surface (grid cell specific) (Lacey *et al.,* 2022) and the SCANS IV uniform density estimate (0.0419/km2) (Gilles *et al.,* 2023).

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Disturbance using the harbour porpoise dose-response function							
Monopile							
# (inshore/ offshore)	1	2	3	4	17	4	2
% MU (inshore/ offshore)	0.05	0.10	0.15	0.20	0.84	0.20	0.10
# (Lacey et al. 2022)	1	1	2	3	1	4	1
% MU (Lacey et al. 2022)	0.05	0.05	0.10	0.15	0.05	0.20	0.05
# (SCANS IV)	20	33	64	79	17	84	52
% MU (SCANS IV)	0.99	1.63	3.17	3.91	0.84	4.15	2.57
Jacket							
# (inshore/ offshore)	1	1	3	4	15	4	2
% MU (inshore/ offshore)	0.05	0.05	0.15	0.20	0.74	0.20	0.10
# (Lacey et al. 2022)	1	1	2	2	<1	4	1
% MU (Lacey et al. 2022)	0.05	0.05	0.10	0.10	<0.01	0.20	0.05
# (SCANS IV)	17	29	57	71	15	83	51
% MU (SCANS IV)	0.84	1.43	2.82	3.51	0.74	4.10	2.52
Disturbance using the level B harassment thresholds							
Monopile							
# (inshore/ offshore)	<1	<1	1	2	<1	1	1
% MU (inshore/ offshore)	<0.05	<0.05	0.07	0.10	<0.05	0.05	0.05
# (Lacey et al. 2022)	<1	<1	<1	1	<1	1	<1
% MU (Lacey et al. 2022)	<0.05	<0.05	<0.05	0.05	<0.05	0.05	<0.05
# (SCANS IV)	6	12	26	32	7	31	20
% MU (SCANS IV)	0.30	0.59	1.29	1.58	0.35	1.53	0.99
Jacket							
# (inshore/ offshore)	<1	<1	1	1	<1	1	1
% MU (inshore/ offshore)	<0.05	<0.05	0.05	0.05	<0.05	0.05	0.05
# (Lacey et al. 2022)	<1	<1	<1	1	<1	1	<1

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
% MU (Lacey et al. 2022)	<0.05	<0.05	<0.05	0.05	<0.05	0.07	<0.05
# (SCANS IV)	5	10	22	27	6	30	19
% MU (SCANS IV)	0.25	0.49	1.09	1.34	0.30	1.48	0.94

iPCoD

385. To determine whether this level of disturbance is expected to result in population level impacts, iPCoD modelling was conducted. Modelling was conducted for two piling scenarios, the worst-case monopile and worst-case jacket scenario (Table 11-57, Table 11-58). Modelling has been presented using SCANS IV density estimate.

Table 11-57 Number of animals predicted to be disturbed per piling day for monopile WTGs and ANS.

Species	MU	Density	WTG monopile	ANS monopile
Bottlenose dolphin	2,022	SCANS IV	64	84

Table 11-58 Number of animals predicted to be disturbed per piling day for jacket WTGs and ANS.

Species	MU	Density	WTG jacket	ANS jacket
Bottlenose dolphin	2,022	SCANS IV	57	83

386. Table 11-59, Figure 24 and Figure 25 show the results for the iPCoD simulations for bottlenose dolphins using the SCANS IV density. This represents the worst-case scenario in terms of the number of days of disturbance. The results of the iPCoD modelling show that the level of disturbance from the construction of the Proposed Development is not sufficient to result in any changes at the population level from 1 to 18 years after the end of piling activities. The counter-factual metric indicates that the impacted population size remains at 99.46-100.00% of the unimpacted population size, and the population continues on a stable trajectory. Therefore, disturbance from piling at ODOW will not result in a population level effect.

Table 11-59 Results of the bottlenose dolphin iPCoD simulations using the SCANS IV density estimate

	Mean					**Median**		
	Un-impacted population size	**95% CIs**	**Impacted population size**	**95% CIs**	**Impacted as % of un-impacted population size**	**Un-impacted population size**	**Impacted population size**	**Impacted as % of un-impacted population size**

Jackets								
Before piling	2,024	2,024 2,024	2,024	2,024 2,024	100.00%	2,024	2,024	100.00%
End Year 1 piling	2,025	1,824 2,154	2,025	1,824 2,154	100.00%	2,032	2,032	100.00%
End year 2 piling	2,028	1,754 2,204	2,018	1,736 2,198	99.51%	2,042	2,034	99.61%
1 year after pilings ends	2,029	1,716 2,252	2,018	1,692 2,250	99.46%	2,044	2,037	99.66%
6 years after piling ends	2,032	1,582 2,398	2,023	1,572 2,388	99.56%	2,041	2,036	99.76%
12 years after piling ends	2,034	1,504 2,558	2,024	1,492 2,548	99.51%	2,045	2,032	99.36%
18 years after piling ends	2,037	1,404 2,646	2,027	1,402 2,646	99.51%	2,048	2,039	99.56%
Monopiles								
Before piling	2,024	2,024 2,024	2,024	2,024 2,024	100.00%	2,024	2,024	100.00%
End Year 1 piling	2,020	1,818 2,148	2,020	1,818 2,148	100.00%	2,030	2,030	100.00%
End year 2 piling	2,023	1,762 2,216	2,017	1,756 2,210	99.70%	2,034	2,030	99.80%
1 year after pilings ends	2,028	1,710 2,244	2,021	1,710 2,242	99.65%	2,045	2,038	99.66%
6 years after piling ends	2,033	1,640 2,414	2,028	1,630 2,388	99.75%	2,044	2,038	99.71%
12 years after piling ends	2,041	1,526 2,574	2,035	1,508 2,572	99.71%	2,043	2,039	99.80%
18 years after piling ends	2,045	1,440 2,635	2,039	1,436 2,634	99.71%	2,045	2,042	99.85%

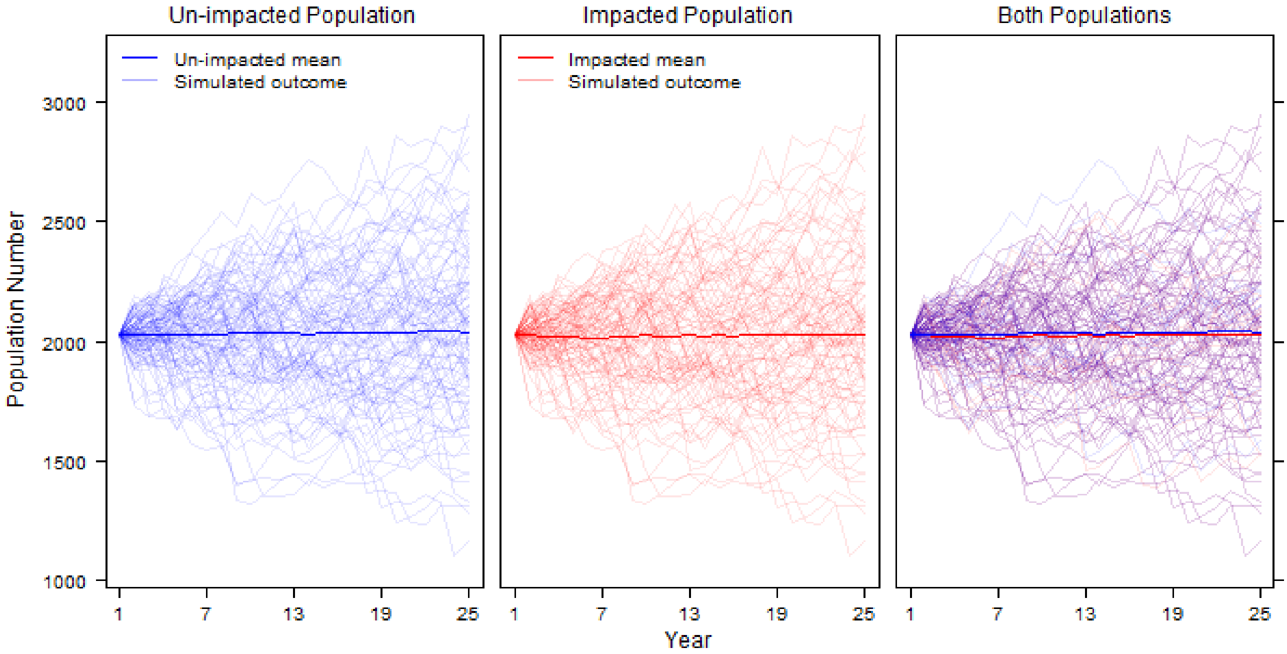

Figure 24 Results of the bottlenose dolphin iPCoD simulations for jacket foundations using the SCANS IV density estimate

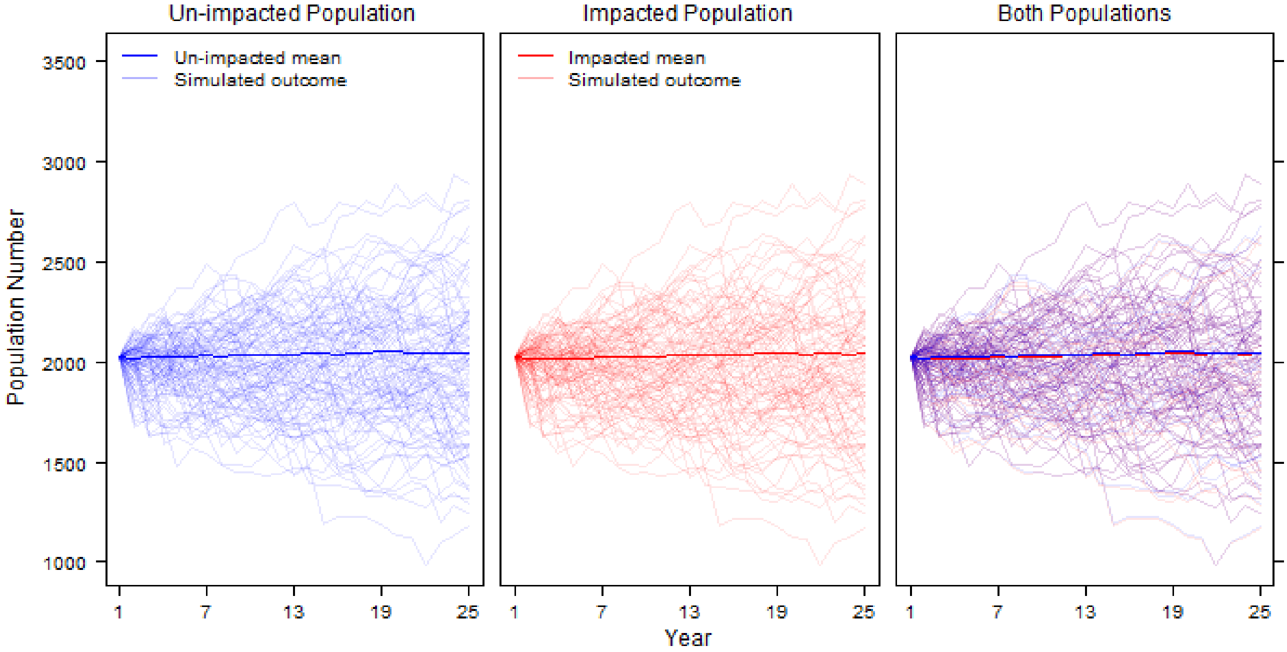

Figure 25 Results of the bottlenose dolphin iPCoD simulations for monopile foundations using the SCANS IV density estimate

Magnitude summary

387. The maximum number of piling days is expected to be 109 piling days for monopiles or 130 piling days of pin piled jackets within the indicative piling construction period (Q3 2027 – Q2 2029). The number of dolphins predicted to be disturbed per piling day varies by location, with significantly more animals predicted to be disturbed by piling at the ANS NW and the NE array modelling location compared to other modelling locations in the array and ORCP.

388. It is important to note that the population being impacted is the “offshore ecotype” located within the GNS MU, which is a much larger, wide-ranging population compared to the “coastal ecotype”. It is highly unlikely that the same individual would return repeatedly on each piling day and, therefore, it is expected that repeated disturbance leading to reductions in survival and reproductive rates is very unlikely. The impact of disturbance is expected to result in short-term and/or intermittent and temporary behavioural effects in a small proportion of the population. As outlined above, survival and reproductive rates are very unlikely to be impacted to the extent that the population trajectory would be altered. The iPCoD modelling shows the disturbance has a low consequence since there is predicted to be no overall change to the population trajectory. Therefore, since modelling has shown that despite a small proportion of the population being impacted, the population trajectory would not be altered, and thus the impact of disturbance from pile driving is of **Low** magnitude for bottlenose dolphins.

Significance

389. The sensitivity of bottlenose dolphin to disturbance from piling has been assessed as **Medium**.

390. The magnitude of impact of disturbance from piling to bottlenose dolphin has been assessed as **Low** .

391. Therefore, the effect significance of disturbance from piling to bottlenose dolphin is **Minor**, which is **not significant** in EIA terms.

White-beaked dolphin

Sensitivity

392. In the absence of any species-specific data for white-beaked dolphin, given that they are also grouped as high-frequency cetaceans, and are, therefore, likely to have similar hearing abilities as bottlenose dolphin. As a result, white-beaked dolphins are also considered to have a Medium sensitivity to behavioural disturbance from piling.

Magnitude

393. The results of disturbance to white-beaked dolphin from pile driving are presented in Table 11-60.

Dose-response function

Array

394. The maximum disturbance impact from the installation of a single monopile within the array area is at the NE location, where up to 23 white-beaked dolphins are predicted to be disturbed per piling day (0.05% MU) using the SCANS IV density estimate. Predictions using the SCANS III density surface are considerably smaller (1 dolphin, <0.01% MU).

395. The maximum disturbance impact from the installation of a single pin pile within the array area is at the NE location, where up to 20 white-beaked dolphins are predicted to be disturbed per piling day (0.05% MU) using the SCANS IV density estimate. Predictions using the SCANS III density surface are considerably smaller (<1 dolphin, <0.001% MU).

396. For concurrent piling at NE & SE, up to 28 white-beaked dolphins are predicted to be disturbed per piling day for monopiles (0.06% MU) and 25 white-beaked dolphins are predicted to be disturbed per piling day for pin piles (0.06% MU) using the SCANS IV density estimate. Predictions using the SCANS III density surface are considerably smaller (1 dolphin, <0.01% MU).

ORCP

397. The disturbance impact from the installation of a single monopile within the ORCP area is to 6 white-beaked dolphins per piling day (0.01% MU) using the SCANS IV density estimate. Predictions using SCANS III density surface are considerably smaller (<1 dolphin, <0.001% MU).

398. The disturbance impact from the installation of a single pin pile within the ORCP area is to 5 white-beaked dolphins per piling day (0.01% MU) using the SCANS IV density estimates. Predictions using SCANS III density surface are considerably smaller (<1 dolphin, <0.001% MU).

ANS

399. The maximum disturbance impact from the installation of a single monopile ANS is at the NW location where up to 30 white-beaked dolphins are predicted to be disturbed per piling day (0.07% MU) using the SCANS IV density estimate.

400. The maximum disturbance impact from the installation of a single pin pile ANS is at the NW location where up to 29 white-beaked dolphins are predicted to be disturbed per piling day (0.07% MU) using the SCANS IV density estimate.

401. As outlined for bottlenose dolphins, the harbour porpoise dose-response function is expected to over-predict impacts to dolphin species. In light of this, the level B harassment threshold has also been presented as an alternative disturbance threshold for white-beaked dolphins.

Level B Harassment

Array

402. The maximum disturbance impact from the installation of a single monopile within the array area is at the NE location, where up to 9 white-beaked dolphins are predicted to be disturbed per piling day (0.02% MU) using the SCANS IV density estimate.

403. The maximum disturbance impact from the installation of a single pin pile within the array area is at the NE location, where up to 8 white-beaked dolphins are predicted to be disturbed per piling day (0.02% MU) using the SCANS IV density estimate.

404. For concurrent piling at NE & SE, up to 11 white-beaked dolphins are predicted to be disturbed per piling day for monopiles (0.03% MU) and 10 white-beaked dolphins are predicted to be disturbed per piling day for pin piles (0.02% MU) using the SCANS IV density estimate.

ORCP

405. The disturbance impact from the installation of a single monopile within the ORCP area is to 3 white-beaked dolphins per piling day (0.01% MU) using the SCANS IV density estimate.

406. The disturbance impact from the installation of a single pin pile within the ORCP area is to 2 white-beaked dolphins per piling day (<0.01% MU) using the SCANS IV density estimates.

ANS

407. The maximum disturbance impact from the installation of a single monopile ANS is at the NW location where up to 11 white-beaked dolphins are predicted to be disturbed per piling day (0.03% MU) using the SCANS IV density estimate.

408. The maximum disturbance impact from the installation of a single pin pile ANS is at the NW location where up to 11 white-beaked dolphin is predicted to be disturbed per piling day (0.03% MU) using the SCANS IV density estimate.

Magnitude summary

409. The maximum number of piling days is expected to be 109 piling days for monopiles or 130 piling days of pin piled jackets within the indicative piling construction period (Q3 2027 – Q2 2029). 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 109 or 130 piling days over the 18-month 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. Therefore, it is highly unlikely that individuals would return to the site and be repeatedly disturbed, and as such, the likelihood of individuals receiving levels of disturbance high enough to effect vital rates is very low.

410. The impact of disturbance is expected to result in short-term and/or intermittent and temporary behavioural effects in a very small proportion of the population. Due to the low number and percentage of the MU predicted to experience disturbance, the magnitude of disturbance from pile driving is assessed as **Low**.

Significance

411. The sensitivity of white-beaked dolphin to disturbance from piling has been assessed as **Medium**.

412. The magnitude of impact of disturbance from piling to white-beaked dolphin has been assessed as **Low**.

413. Therefore, the effect significance of disturbance from piling to white-beaked dolphin is **Minor**, which is not significant in EIA terms.

Table 11-60: Number of white-beaked dolphins and percentage of MU predicted to experience disturbance during piling using the SCANS III density surface (grid cell specific) (Lacey et al., 2022) and the SCANS IV density estimate (0.0149/km2) (Gilles et al., 2023).

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Disturbance using the harbour porpoise dose-response function							
Monopile							
# (Lacey et al. 2022)	<1	<1	1	1	<1	1	<1
% MU (Lacey et al. 2022)	<0.001	<0.001	<0.01	<0.01	<0.001	<0.01	<0.001
# (SCANS IV)	7	12	23	28	6	30	19
% MU (SCANS IV)	0.02	0.03	0.05	0.06	0.01	0.07	0.04

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Jacket							
# (Lacey et al. 2022)	<1	<1	<1	1	<1	1	<1
% MU (Lacey et al. 2022)	<0.001	<0.001	<0.001	<0.01	<0.001	<0.01	<0.001
# (SCANS IV)	6	10	20	25	5	29	18
% MU (SCANS IV)	0.01	0.02	0.05	0.06	0.01	0.07	0.04
Disturbance using the level B harassment thresholds							
Monopile							
# (Lacey et al. 2022)	<1	<1	<1	<1	<1	<1	<1
% MU (Lacey et al. 2022)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
# (SCANS IV)	2	4	9	11	3	11	7
% MU (SCANS IV)	<0.01	0.01	0.02	0.03	0.01	0.03	0.02
Jacket							
# (Lacey et al. 2022)	<1	<1	<1	<1	<1	<1	<1
% MU (Lacey et al. 2022)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
# (SCANS IV)	2	4	8	10	2	11	7
% MU (SCANS IV)	<0.01	0.01	0.02	0.02	<0.01	0.03	0.02

Minke whale

Sensitivity

414. 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; 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 146dB re 1µPa (score 7[23]) and a received SPL of 158dB re 1µPa (score 8[24]). There is a study detailing minke whale responses to a Lofitech ADD which has a source level of 204dB re 1µPa @ 1m, which showed minke whales within 500m and 1,000m of the source exhibiting a sustained behavioural response. The estimated received level at 1,000m was 136.1dB re 1µPa (McGarry *et al.* 2017). There are no equivalent such studies of responses to pile driving noise.

415. Since minke whales are known to forage in UK waters in the summer months, there is the potential for displacement disrupting foraging behaviour which could potentially 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 short-term and temporary displacement from foraging areas much better than harbour porpoise, and individual minke whales are expected to be able to recover from any short-term and temporary displacement. Therefore, minke whales have been assessed as having a **Medium** sensitivity to disturbance from pile driving.

Magnitude

416. The results of disturbance to minke whales from pile driving are presented in Table 11-53.

Dose-response function

Array

417. The maximum disturbance impact from the installation of a single monopile within the array area is at the NE location, where up to 14 minke whales are predicted to be disturbed per piling day (0.07% MU) using the SCANS III density surface.

418. The maximum disturbance impact from the installation of a single pin pile within the array area is at the NE location, where up to 10 minke whales are predicted to be disturbed per piling day (0.05% MU) using the SCANS III density surface.

---

[23] 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".*

[24] 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".*

419. For concurrent piling at NE & SE, up to 17 minke whales are predicted to be disturbed per piling day for monopiles (0.08% MU) and 13 minke whales are predicted to be disturbed per piling day for pin piles (0.06% MU) using the SCANS III density surface.

ORCP

420. The disturbance impact from the installation of a single monopile within the ORCP area is to 4 minke whales per piling day (0.02% MU) using either the SCANS IV density estimate or the SCANS III density surface.

421. The disturbance impact from the installation of a single pin pile within the ORCP area is to 3 minke whales per piling day (0.01% MU) using the either the SCANS IV density estimate or the SCANS III density surface.

ANS

422. The maximum disturbance impact from the installation of a single monopile ANS is at the NW location where up to 23 minke whales are predicted to be disturbed per piling day (0.11% MU) using the SCANS III density surface.

423. The maximum disturbance impact from the installation of a single pin pile ANS is at the NW location where up to 22 minke whales are predicted to be disturbed per piling day (0.11% MU) using the SCANS III density surface.

424. As outlined for bottlenose dolphins, the harbour porpoise dose-response function is expected to over-predict impacts to minke whales given their different hearing groups. In light of this, the level B harassment threshold has also been presented as an alternative disturbance threshold for minke whales.

Level B Harassment

425. The maximum disturbance impact from the installation of a single monopile within the array area is at the NE location, where up to 5 minke whales are predicted to be disturbed per piling day (0.02% MU) using the SCANS III density surface.

426. The maximum disturbance impact from the installation of a single pin pile within the array area is at the NE location, where up to 5 minke whales are predicted to be disturbed per piling day (0.02% MU) using the SCANS III density surface.

427. For concurrent piling at NE & SE, up to 6 minke whales are predicted to be disturbed per piling day for monopiles (0.03% MU) and 5 minke whales are predicted to be disturbed per piling day for pin piles (0.02% MU) using the SCANS III density surface.

ORCP

428. The disturbance impact from the installation of a single monopile within the ORCP area is to 2 minke whales per piling day (0.01% MU) the SCANS III density surface.

429. The disturbance impact from the installation of a single pin pile within the ORCP area is to 1 minke whale per piling day (0.005% MU) using the either the SCANS IV density estimate or the SCANS III density surface.

ANS

430. The maximum disturbance impact from the installation of a single monopile ANS is at the NW location where up to 8 minke whales are predicted to be disturbed per piling day (0.04% MU) using the SCANS III density surface.

431. The maximum disturbance impact from the installation of a single pin pile ANS is at the NW location where up to 8 minke whales are predicted to be disturbed per piling day (0.04% MU) using the SCANS III density surface.

Table 11-61: Number of minke whales and percentage of MU predicted to experience disturbance during piling using the SCANS III density surface (grid cell specific) (Lacey et al., 2022) and the SCANS IV density estimate (0.0068/km2) (Gilles et al., 2023).

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Disturbance using the harbour porpoise dose-response function							
Monopile							
# (Lacey et al. 2022)	4	7	14	17	4	23	8
% MU (Lacey et al. 2022)	0.02	0.03	0.07	0.08	0.02	0.11	0.04
# (SCANS IV)	3	5	10	13	3	14	8
% MU (SCANS IV)	0.01	0.02	0.05	0.06	0.01	0.07	0.04
Jacket							
# (Lacey et al. 2022)	3	6	12	15	3	22	8
% MU (Lacey et al. 2022)	0.01	0.03	0.06	0.07	0.01	0.11	0.04
# (SCANS IV)	3	5	9	11	2	13	8
% MU (SCANS IV)	0.01	0.02	0.04	0.05	0.01	0.06	0.04
Disturbance using the level B harassment thresholds							
Monopile							
# (Lacey et al. 2022)	1	3	5	6	2	8	3
% MU (Lacey et al. 2022)	<0.01	0.01	0.02	0.03	0.01	0.04	0.01
# (SCANS IV)	1	2	4	5	1	5	3
% MU (SCANS IV)	<0.01	0.01	0.02	0.02	<0.01	0.02	0.01
Jacket							
# (Lacey et al. 2022)	1	2	5	5	1	8	3
% MU (Lacey et al. 2022)	<0.01	0.01	0.02	0.02	<0.01	0.04	0.01
# (SCANS IV)	1	2	4	4	1	5	3

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
% MU (SCANS IV)	<0.01	0.01	0.02	0.02	<0.01	0.02	0.01

iPCoD

432. To determine whether this level of disturbance is expected to result in population level impacts, iPCoD modelling was conducted. Modelling was conducted for two piling scenarios, the worst-case monopile and worst-case jacket scenario (Table 11-62, Table 11-63). Modelling has been presented using the Lacey et al. (2022) density estimate.

Table 11-62 Number of animals predicted to be disturbed per piling day for monopile WTGs and ANS.

Species	MU	Density	WTG monopile	ANS monopile
Minke whale	20,118	Lacey et al. (2022)	14	23

Table 11-63 Number of animals predicted to be disturbed per piling day for jacket WTGs and ANS.

Species	MU	Density	WTG jacket	ANS jacket
Minke whale	20,118	Lacey et al. (2022)	12	22

433. Table 11-64, Figure 26 and Figure 27 show the results for the iPCoD simulations for minke whales using the Lacey et al. (2022) density estimate. This represents the worst-case scenario in terms of the number of days of disturbance. The results of the iPCoD modelling show that the level of disturbance from the construction of the Proposed Development is not sufficient to result in any changes at the population level from 1 to 18 years after the end of piling activities. The counter-factual metric indicates that the impacted population size remains at 100% of the unimpacted population size, and the population continues on a stable trajectory. Therefore, disturbance from piling at ODOW will not result in a population level effect.

Table 11-64 Results of the minke whale iPCoD simulations using the Lacey et al. (2022) density estimate

	Mean					Median		
	Un-impacted population size	95% CIs	Impacted population size	95% CIs	Impacted as % of un-impacted population size	Un-impacted population size	Impacted population size	Impacted as % of un-impacted population size
Jackets								
Before piling	20,120	20,120 20,120	20,120	20,120 20,120	100%	20,120	20,120	100.00%
End Year 1 piling	20,081	17,912 21,875	20,081	17,912 21,875	100%	20,158	20,158	100.00%
End year 2 piling	20,014	17,452 22,617	20,014	17,452 22,617	100%	19,999	19,999	100.00%
1 year after pilings ends	19,993	17,233 22,718	19,993	17,233 22,718	100%	19,954	19,954	100.00%

6 years after piling ends	19,922	16,405 24,068	19,922	16,405 24,068	100%	19,699	19,699	100.00%
12 years after piling ends	19,860	15,594 25,127	19,860	15,594 25,127	100%	19,635	19,635	100.00%
18 years after piling ends	19,846	14,950 26,460	19,846	14,950 26,460	100%	19,553	19,553	100.00%
Monopiles								
Before piling	20,120	20,120 20,120	20,120	20,120 20,120	100%	20,120	20,120	100.00%
End Year 1 piling	20,077	17,850 21,772	20,077	17,850 21,772	100%	20,133	20,133	100.00%
End year 2 piling	20,112	17,500 22,488	20,112	17,500 22,488	100%	20,174	20,174	100.00%
1 year after pilings ends	20,066	17,182 22,870	20,066	17,182 22,870	100%	20,099	20,099	100.00%
6 years after piling ends	20,033	16,390 23,735	20,033	16,390 23,735	100%	20,069	20,069	100.00%
12 years after piling ends	19,921	15,700 25,153	19,921	15,700 25,153	100%	19,719	19,719	100.00%
18 years after piling ends	19,871	14,814 26,223	19,871	14,814 26,223	100%	19,500	19,500	100.00%

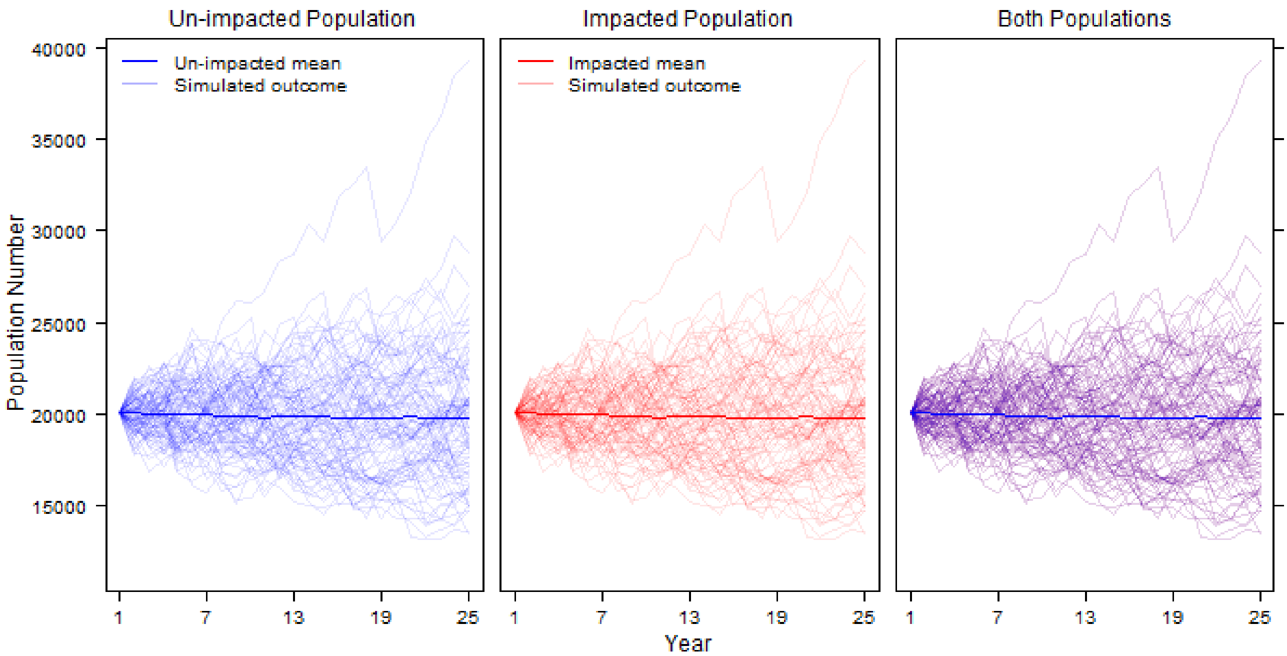

Figure 26 Results of the minke whale iPCoD simulations for jacket foundations using the Lacey et al. (2022) density estimate

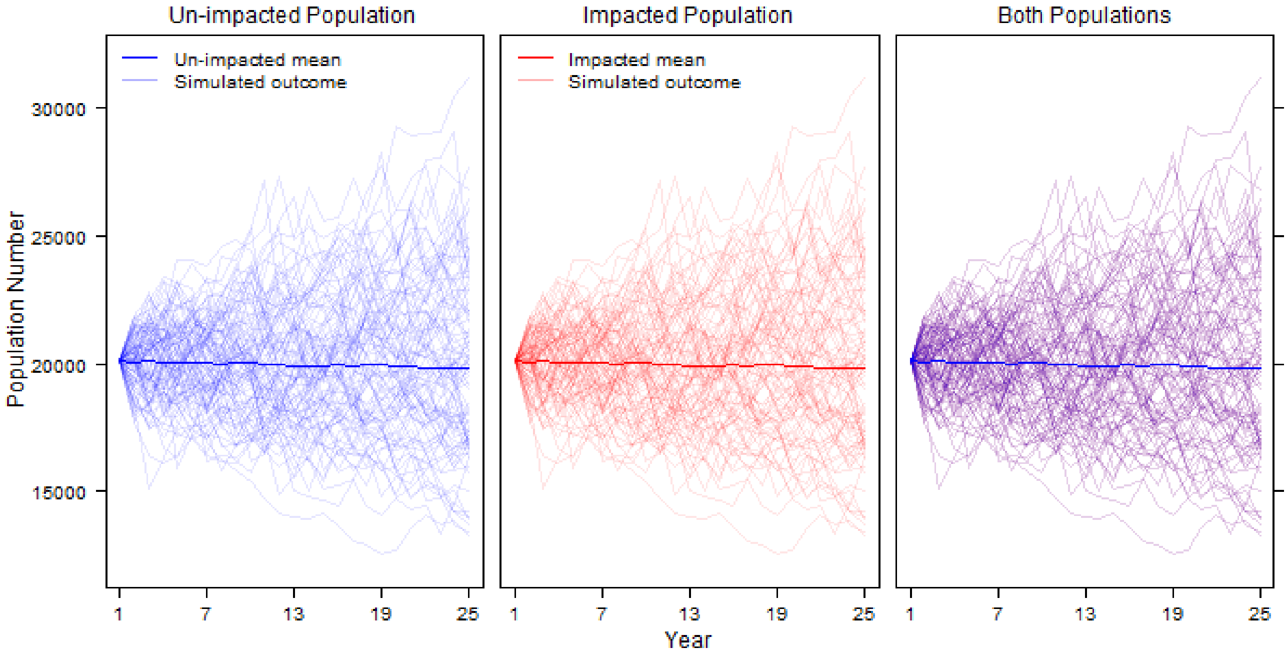

Figure 27 Results of the minke whale iPCoD simulations for monopile foundations using the Lacey et al. (2022) density estimate

Magnitude summary

434. The maximum number of piling days is expected to be 109 piling days for monopiles or 130 piling days of pin piled jackets within the indicative piling construction period (Q3 2027 – Q2 2029).

435. The impact of disturbance is expected to result in short-term and/or intermittent and temporary behavioural effects in a very small proportion of the population. Given the low expected density of minke whales in the area (even in the summer months), the number of animals predicted to be disturbed by pile driving on any given day is low (maximum 18 individuals), representing a low proportion of both MU (0.09%). The iPCoD modelling shows the disturbance has a low consequence since there is predicted to be no overall change to the population trajectory. Therefore, since modelling has shown that despite a small proportion of the population being impacted, the population trajectory would not be altered, and thus the impact of disturbance from pile driving is of **Low** magnitude for minke whales.

Significance

436. The sensitivity of minke whales to disturbance from piling has been assessed as **Medium**.

437. The magnitude of impact of disturbance from piling to minke whales has been assessed as **Low**.

438. Therefore, the effect significance of disturbance from piling to minke whales is **Minor**, which is **not significant** in EIA terms.

Harbour seal

Sensitivity

439. 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 25km 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, both harbour and grey 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.

440. At the most recent expert elicitation workshop in 2018 (Booth *et al.* 2019), experts assessed 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 (Plate 11.28 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 (Plate 11.28 right); however, again, there was a lot of uncertainty surrounding this estimate. 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.

441. Based on the evidence presented above, 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.

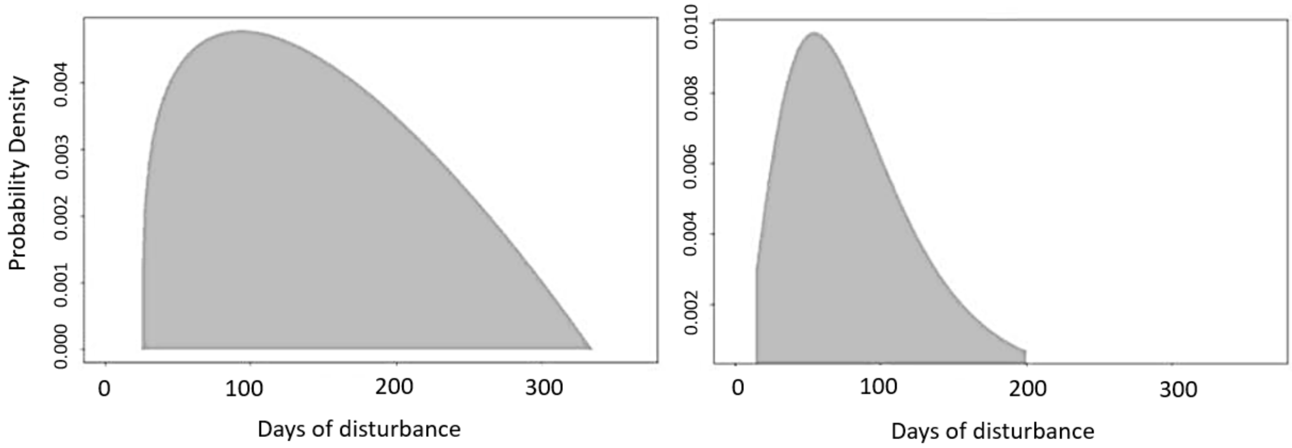

Plate 11.28: Probability distributions showing the consensus of the expert elicitation for harbour seal disturbance from piling. X-axis = days of disturbance; y-axis = probability density. Left: the number of days of disturbance (i.e. days on which an animal does not feed for six hours) a pregnant female 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 (2019).

Magnitude

442. The results of disturbance to harbour seals from pile driving are presented in Table 11-54. Given that harbour seal at-sea density changes significantly with distance from the coast, there is a large variation in the number of animals predicted to be disturbed per piling day across the various modelling locations.

Array

443. The maximum disturbance impact from the installation of a single monopile within the array area is at the NW location, where up to 21 harbour seals (95% CI: 2-38) are predicted to be disturbed per piling day (0.43% MU, 95% CI: 0.04-0.78%).

444. The maximum disturbance impact from the installation of a pin monopile within the array area is at the NW location, where up to 18 harbour seals (95% CI: 2-33) are predicted to be disturbed per piling day (0.37% MU, 95% CI: 0.04-0.68%).

ORCP

445. Piling at the ORCP location is predicted to impact significantly more harbour seals than piling within the array area or at the ANS locations due to the proximity of the ORCP area to higher densities in coastal waters.

446. The disturbance impact from the installation of a single monopile within the ORCP area is up to 154 harbour seals (95% CI: 20-182) predicted to be disturbed per piling day (3.16% MU, 95% CI: 0.41-3.74%).

447. The disturbance impact from the installation of a jacket (pin) pile within the ORCP area is up to 136 harbour seals (95% CI: 17-250) predicted to be disturbed per piling day (2.79% MU, 95% CI: 0.35-5.14%).

ANS

448. The maximum disturbance impact from the installation of a single monopile at the ANS locations was for up to 9 harbour seals (95% CI: 1-17) predicted to be disturbed per piling day (0.18% MU, 95% CI: 0.02-0.35%).

449. The maximum disturbance impact from the installation of a pin monopile at the ANS locations was for up to 9 harbour seals (95% CI: 1-17) predicted to be disturbed per piling day (0.18% MU, 95% CI: 0.02-0.35%)

Table 11-65: Number of harbour seals and percentage of MU predicted to experience disturbance during piling using the Carter et al., (2020, 2022) grid cell specific density estimates.

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Monopile							
# (95% CI)	17 (2 – 35)	21 (2 – 38)	11 (2-20)	28 (4-52)	154 (20 – 182)	9 (1 – 17)	9 (1 – 17)
% MU (95% CI)	0.35 (0.04 – 0.72)	0.43 (0.04 – 0.78)	0.23 (0.04-0.41)	0.58 (0.08 – 1.07)	3.16 (0.41 – 3.74)	0.18 (0.02 – 0.35)	0.18 (0.02 – 0.35)
Jacket							
# (95% CI)	14 (2 – 29)	18 (2 – 33)	10 (1-18)	24 (3-44)	136 (17 – 250)	9 (1 – 16)	9 (1 – 17)
% MU (95% CI)	0.29 (0.04 – 0.60)	0.37 (0.04 – 0.68)	0.21 (0.02-0.37)	0.49 (0.06-0.90)	2.79 (0.35 - 5.14)	0.18 (0.02 – 0.33)	0.18 (0.02 – 0.35)

iPCoD

450. To determine whether this level of disturbance is expected to result in population level impacts, iPCoD modelling was conducted. Modelling was conducted for two piling scenarios, the worst-case monopile and worst-case jacket scenario (Table 11-66, Table 11-67). Modelling has been presented using the Carter et al., (2020, 2022) grid cell specific density estimates.

Table 11-66 Number of animals predicted to be disturbed per piling day for monopile WTGs and ANS.

Species	MU	Density	WTG monopile	ANS monopile
Harbour seal	4,868	Carter et al., (2020, 2022) grid cell specific	11	9

Table 11-67 Number of animals predicted to be disturbed per piling day for jacket WTGs and ANS.

Species	MU	Density	WTG jacket	ANS jacket
Harbour seal	4,868	Carter et al., (2020, 2022) grid cell specific	10	9

451. Table 11-68, Figure 29 and Figure 30 show the results for the iPCoD simulations for harbour seals assuming a stable population, using the Carter et al., (2020, 2022) grid cell specific density estimates. This represents the worst-case scenario in terms of the number of days of disturbance. The results of the iPCoD modelling show that the level of disturbance from the construction of the Proposed Development is not sufficient to result in any changes at the population level from 1 to 18 years after the end of piling activities. The counter-factual metric indicates that the impacted population size remains at 100% of the unimpacted population size, and the population continues on a stable trajectory. Therefore, disturbance from piling at ODOW will not result in a population level effect.

Table 11-68 Results of the harbour seal iPCoD simulations assuming a stable population using the Carter et al., (2020, 2022) grid cell specific density estimates

	Mean					Median		
	Un-impacted population size	95% CIs	Impacted population size	95% CIs	Impacted as % of un-impacted population size	Un-impacted population size	Impacted population size	Impacted as % of un-impacted population size
Jackets								
Before piling	4,866	4,866 4,866	4,866	4,866 4,866	100.00%	4,866	4,866	100.00%
End Year 1 piling	4,864	4,428 5,206	4,864	4,428 5,206	100.00%	4,876	4,876	100.00%
End year 2 piling	4,861	4,370 5,354	4,861	4,370 5,354	100.00%	4,869	4,869	100.00%
1 year after pilings ends	4,860	4,284 5,406	4,860	4,284 5,406	100.00%	4,856	4,856	100.00%
6 years after piling ends	4,869	4,068 5,754	4,869	4,068 5,754	100.00%	4,854	4,854	100.00%
12 years after piling ends	4,875	3,870 6,086	4,875	3,870 6,086	100.00%	4,854	4,854	100.00%
18 years after piling ends	4,905	3,716 6,350	4,905	3,716 6,350	100.00%	4,865	4,865	100.00%
Monopiles								
Before piling	4,866	4,866 4,866	4,866	4,866 4,866	100.00%	4,866	4,866	100.00%
End Year 1 piling	4,855	4,450 5,198	4,855	4,450 5,198	100.00%	4,858	4,858	100.00%
End year 2 piling	4,860	4,386 5,304	4,860	4,386 5,304	100.00%	4,859	4,859	100.00%
1 year after pilings ends	4,868	4,362 5,416	4,868	4,362 5,416	100.00%	4,862	4,862	100.00%
6 years after piling ends	4,884	4,136 5,778	4,884	4,136 5,778	100.00%	4,874	4,874	100.00%
12 years after piling ends	4,911	3,920 5,978	4,911	3,920 5,978	100.00%	4,873	4,873	100.00%
18 years after piling ends	4,913	3,806 6,258	4,913	3,806 6,258	100.00%	4,870	4,870	100.00%

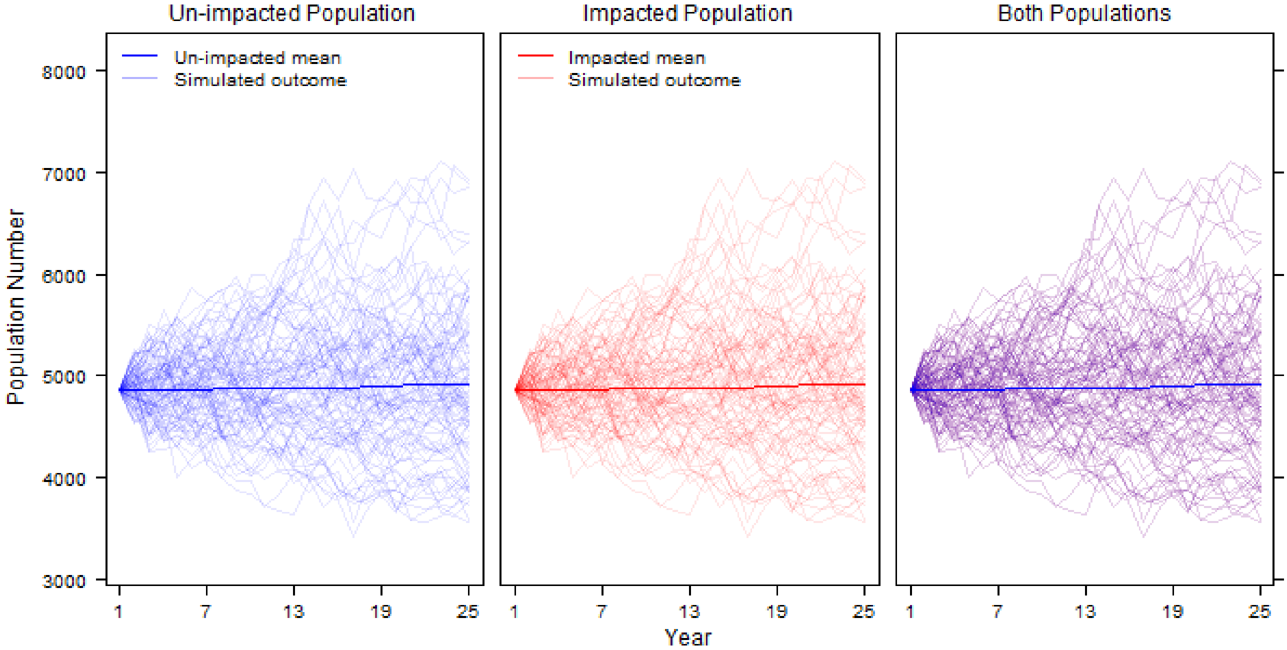

Figure 29 Results of the harbour seal iPCoD simulations for jacket foundations, assuming a stable population using the Carter et al., (2020, 2022) grid cell specific density estimates

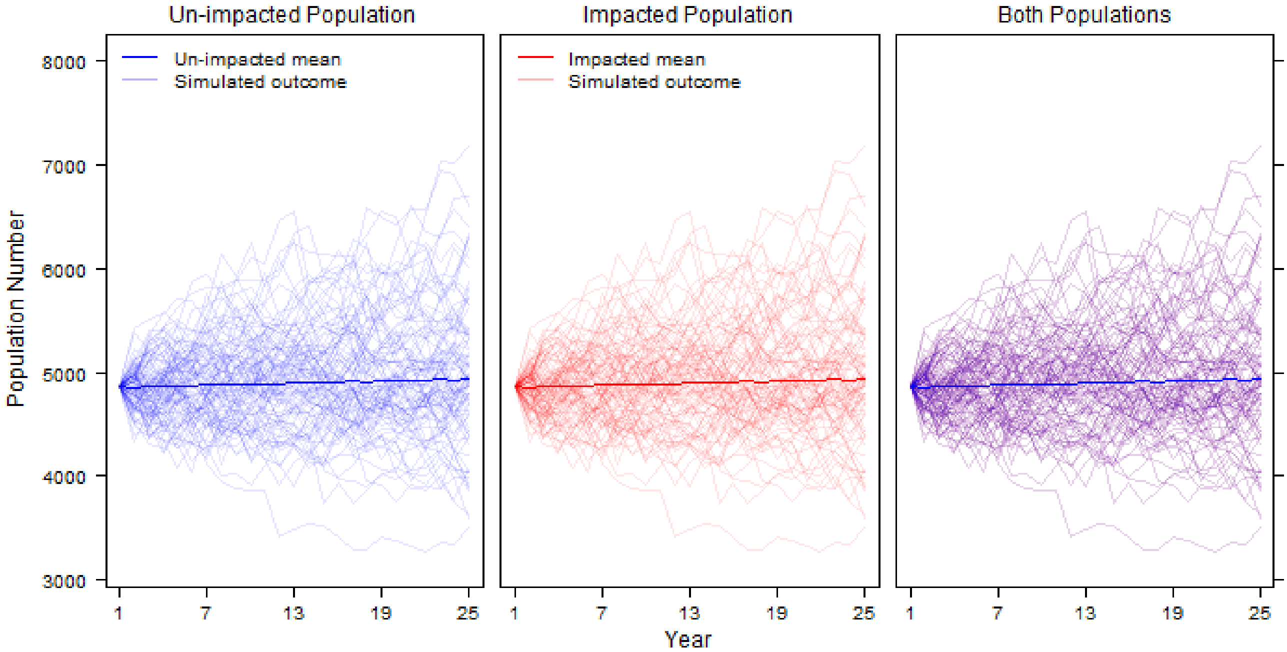

Figure 30 Results of the harbour seal iPCoD simulations for monopile foundations, assuming a stable population using the Carter et al., (2020, 2022) grid cell specific density estimates

452. For the southeast England MU, the modelling using the updated disturbance values was also conducted assuming a declining harbour seal population. When interpreting the iPCoD results for the southeast England MU, it is therefore necessary to understand that the un-impacted baseline MU is predicted to significantly decline in the absence of any impacts. Table 11-69, Figure 31 and Figure 32 show the results for the iPCoD simulations for harbour seals assuming a declining population. The counter-factual metric indicates that the impacted population size remains at 100% of the unimpacted population size, and the population continues on the same declining trajectory. Therefore, disturbance from piling at ODOW will not result in a population level effect.

Table 11-69 Results of the harbour seal iPCoD simulations assuming a declining population, and using the Carter et al., (2020, 2022) grid cell specific density estimates

	Mean					Median		
	Un-impacted population size	95%CIs	Impacted population size	95%CIs	Un-impacted population size	Impacted population size	Un-impacted population size	Impacted population size
Jackets								
Before piling	4,868	4,868 4,868	4,868	4,868 4,868	100.00%	4,868	4,868	100.00%
End Year 1 piling	4,363	3,976 4,682	4,363	3,976 4,682	100.00%	4,379	4,379	100.00%
End year 2 piling	3,907	3,450 4,282	3,907	3,450 4,282	100.00%	3,920	3,920	100.00%
1 year after pilings ends	3,507	3,044 3,944	3,507	3,044 3,944	100.00%	3,506	3,506	100.00%
6 years after piling ends	2,025	1,612 2,510	2,025	1,612 2,510	100.00%	2,012	2,012	100.00%
12 years after piling ends	1,046	738 1,406	1,046	738 1,406	100.00%	1,035	1,035	100.00%
18 years after piling ends	538	350 780	538	350 780	100.00%	528	528	100.00%
Monopiles								
Before piling	4,868	4,868 4,868	4,868	4,868 4,868	100.00%	4,868	4,868	100.00%
End Year 1 piling	4,358	3,998 4,678	4,358	3,998 4,678	100.00%	4,368	4,368	100.00%
End year 2 piling	3,917	3,468 4,342	3,917	3,468 4,342	100.00%	3,919	3,919	100.00%
1 year after pilings ends	3,505	3,064 3,964	3,505	3,064 3,964	100.00%	3,498	3,498	100.00%
6 years after piling ends	2,028	1,588 2,546	2,028	1,588 2,546	100.00%	2,012	2,012	100.00%
12 years after piling ends	1,048	750 1,396	1,048	750 1,396	100.00%	1,038	1,038	100.00%
18 years after piling ends	541	340 786	541	340 786	100.00%	534	534	100.00%

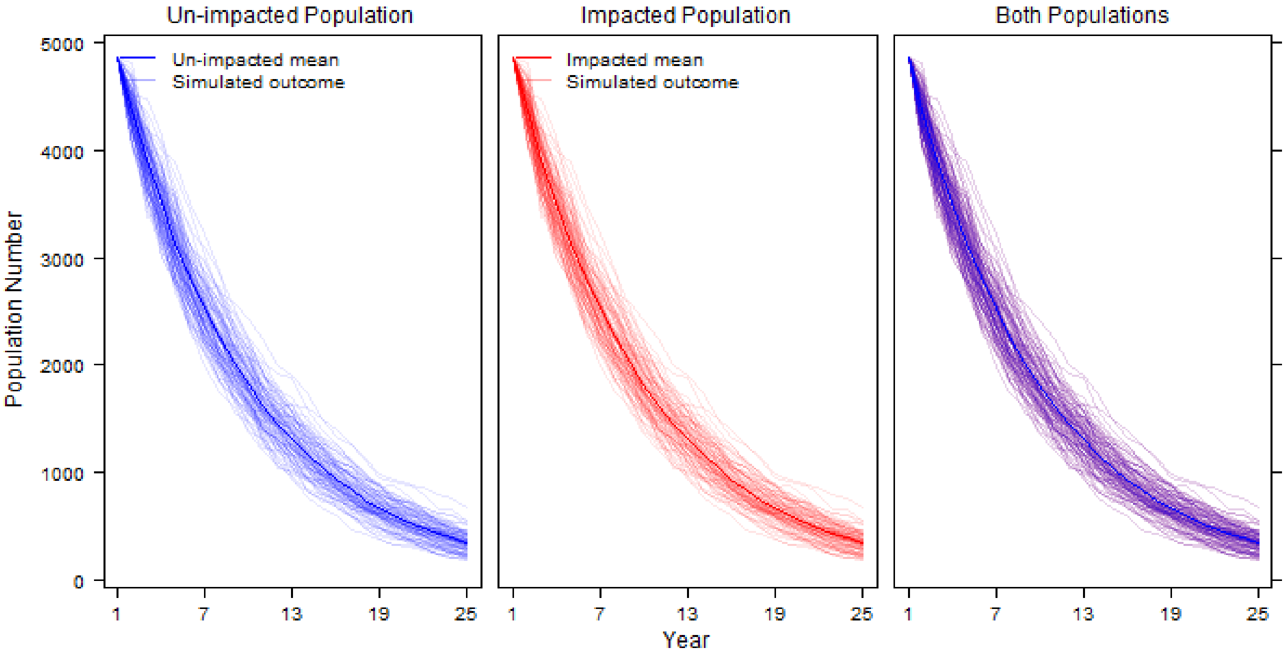

Figure 31 Results of the harbour seal iPCoD simulations for jacket foundations, assuming a declining population, using the Carter et al., (2020, 2022) grid cell specific density estimates

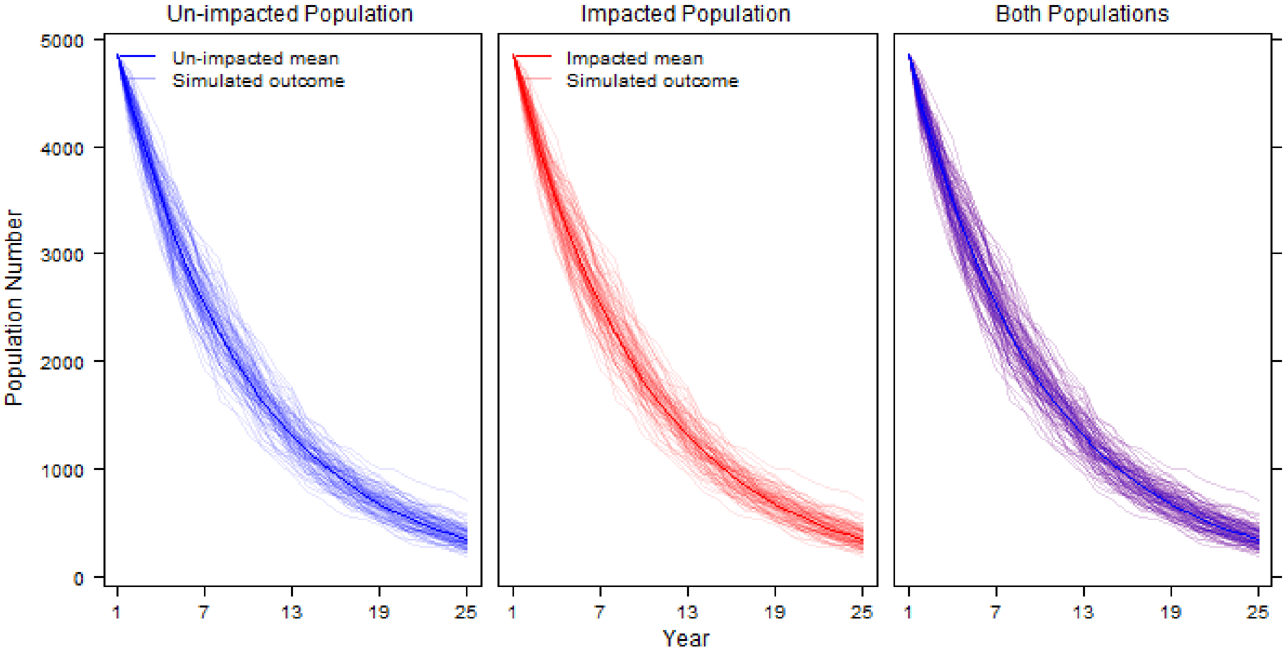

Figure 32 Results of the harbour seal iPCoD simulations for monopile foundations, assuming a declining population, using the Carter et al., (2020, 2022) grid cell specific density estimates

Summary

453. The maximum number of piling days is expected to be 109 piling days for monopiles or 130 piling days of pin piled jackets within the indicative piling construction period (Q3 2027 – Q2 2029):

- Monopile: 100 (WTG) + 7 (OPs) + 2 (ANS) = 109 piling days total

- Pin pile: 100 (WTG) + 28 (OPs) + 2 (ANS) = 130 piling days total

454. Therefore, across the vast majority of the piling days (98% monopile piling days, 97% pin-pile piling days), the number of harbour seals predicted to experience disturbance is low. For pile driving in the ORCP area, a significantly higher number of animals are predicted to be disturbed per piling day, but it is important to note that the number of piling days at these locations will be minimal (2 piling days for monopiles equating to 2% of all piling days or 4 piling days for pin-piles equating to 3% of all piling days).

455. Overall, the impact of disturbance is expected to result in short-term and/or intermittent and temporary behavioural effects in a small proportion of the population; with only a low proportion of piling days at the ORCP predicted to impact a higher proportion of the MU. The iPCoD modelling shows the disturbance has a low consequence since there is predicted to be no overall change to the population trajectory. Therefore, since modelling has shown that despite a small proportion of the population being impacted, the population trajectory would not be altered, and thus the impact of disturbance from pile driving is of **Low** magnitude for harbour seals.

Significance

456. The sensitivity of harbour seals to disturbance from piling has been assessed as **Medium**.

457. The magnitude of impact of disturbance from piling to harbour seals has been assessed as **Low**.

458. Therefore, the effect significance of disturbance from piling to harbour seals is **Minor**, which is **not significant** in EIA terms.

Grey seal

Sensitivity

459. There are still limited data on grey seal behavioural responses to pile driving. The key dataset on this topic is presented in Aarts (2018) where 20 grey seals were tagged in the Wadden Sea to record their responses to pile driving at two offshore windfarms: 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.

460. The distances at which seals responded varied significantly; in one instance a grey seal showed responses at 45km from the pile location, while other grey seals showed no response when within 12km. Potential reasons for these differences in responses include differences in hearing sensitivity between individuals, differences 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 the North Sea would respond in a similar way, and therefore the data are considered to be applicable.

461. The expert elicitation workshop 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 to reduce fertility (Plate 11.33 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 (Plate 11.33 right); however, there was a lot of uncertainty surrounding this estimate.

462. 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.

463. In an experimental study on captive seals, Hastie (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.

464. Based on the evidence presented above, due to observed responsiveness to piling, and their life-history characteristics, grey seals have been assessed as having Low sensitivity to disturbance and resulting displacement from foraging grounds during pile-driving events.

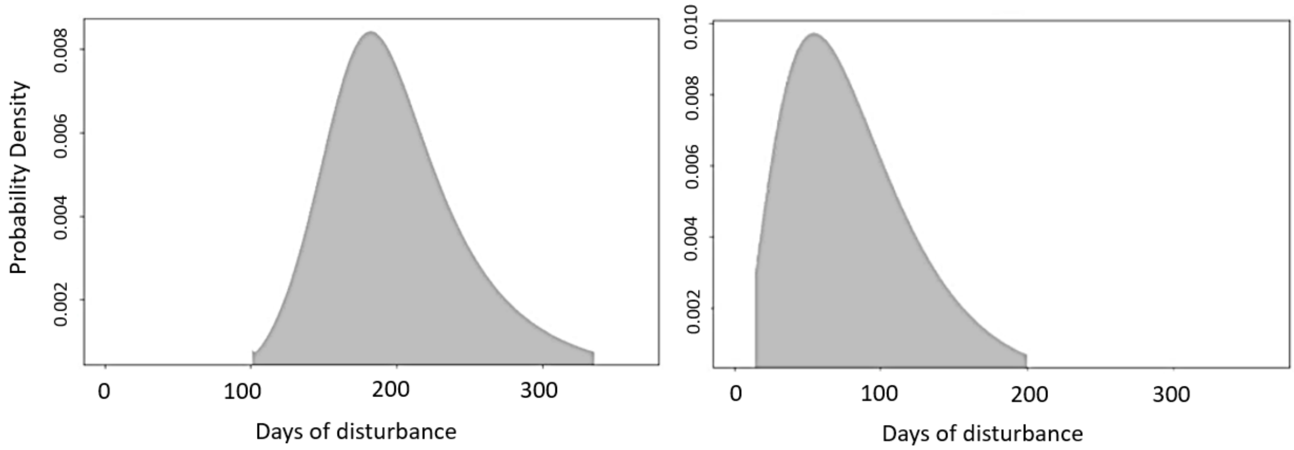

Plate 11.33: Probability distributions showing the consensus of the expert elicitation for grey seal disturbance from piling (Booth *et al.,* 2019). Left: the number of days of disturbance (i.e. days on which an animal does not feed for six hours) a pregnant female could 'tolerate' before it has any 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.

Magnitude

465. The results of disturbance to grey seals from pile driving are presented in Table 11-74. Grey seal at-sea density changes significantly with distance from the Humber Estuary high density area, therefore, there is a large variation in the number of animals predicted to be disturbed per piling day across the various modelling locations.

Array

466. The maximum disturbance impact from the installation of a single monopile within the array area is at the NE location, where up to 326 grey seals (95% CI: 41-602) are predicted to be disturbed per piling day (0.50% MU, 95% CI: 0.06-0.92%).

467. The maximum disturbance impact from the installation of a jacket (pin) pile within the array area is at the NE location, where up to 286 grey seals (95% CI: 35-529) are predicted to be disturbed per piling day (0.44% MU, 95% CI: 0.05-0.81%).

ORCP

468. The disturbance impact from the installation of a single monopile within the ORCP area is up to 214 grey seals (95% CI: 28-463) predicted to be disturbed per piling day (0.33% MU, 95% CI: 0.04-0.71%).

469. The disturbance impact from the installation of a jacket (pin) pile within the ORCP area is up to 174 grey seals (95% CI: 23-378) predicted to be disturbed per piling day (0.27% MU, 95% CI: 0.04-0.58%).

ANS

470. Piling at the NW ANS location is predicted to impact significantly more grey seals than piling at any other modelled location due to the proximity of the ANS NW location to higher densities in coastal waters extending out of the Humber Estuary.

471. The maximum disturbance impact from the installation of a single monopile at the ANS NW location was for up to 724 grey seals (95% CI: 88-1,377) predicted to be disturbed per piling day (1.11% MU, 95% CI: 0.13-2.10%). For the ANS SE location the predicted number disturbed was much lower (222 grey seals, 95% CI: 27-430) given its southern location much further from the Humber Estuary area of high density.

472. The maximum disturbance impact from the installation of a jacket (pin) pile at the ANS NW location was for up to 709 grey seals (95% CI: 87-1,355) predicted to be disturbed per piling day (1.08% MU, 95% CI: 0.13-2.07%). For the ANS SE location the predicted number disturbed was much lower (216 grey seals, 95% CI: 26-421) given its southern location much further from the Humber Estuary area of high density.

Table 11-70: Number of grey seals and percentage of MU predicted to experience disturbance during piling using the Carter et al., (2020, 2022) grid cell specific density estimates

	Array SW	Array NW	Array NE	Concurrent Array NE-SW	ORCP	ANS NW	ANS SE
Monopile							
# (95% CI)	159 (25 – 411)	302 (37 – 596)	326 (41-602)	514 (62-954)	193 (26 – 368)	724 (88 – 1377)	222 (27 – 430)
% MU (95% CI)	0.24 (0.04 – 0.63)	0.46 (0.06 – 0.91)	0.50 (0.06-0.92)	0.78 (0.09-1.46)	0.29 (0.04 – 0.56)	1.11 (0.13 – 2.10)	0.34 (0.04 – 0.66)
Jacket							
# (95% CI)	123 (20 – 347)	250 (31 – 506)	286 (35-529)	440 (51-821)	162 (21 – 315)	709 (87 – 1355)	216 (26 – 421)
% MU (95% CI)	0.19 (0.03 – 0.53)	0.38 (0.05 – 0.77)	0.44 (0.05-0.81)	0.67 (0.08-1.25)	0.25 (0.03 – 0.48)	1.08 (0.13 – 2.07)	0.33 (0.04 – 0.64)

iPCoD

473. To determine whether this level of disturbance is expected to result in population level impacts, iPCoD modelling was conducted. Modelling was conducted for two piling scenarios, the worst-case monopile and worst-case jacket scenario (Table 11-71, Table 11-72). Modelling has been presented using SCANS IV density estimate.

Table 11-71 Number of animals predicted to be disturbed per piling day for monopile WTGs and ANS.

Species	MU	Density	WTG monopile	ANS monopile

Grey seal	65,505	Carter et al., (2020, 2022) grid cell specific	326	724

Table 11-72 Number of animals predicted to be disturbed per piling day for jacket WTGs and ANS.

Species	MU	Density	WTG jacket	ANS jacket
Grey seal	65,505	Carter et al., (2020, 2022) grid cell specific	286	704

474. Table 11-73, Figure 34 and Figure 35 show the results for the iPCoD simulations for grey seals using the Carter et al., (2020, 2022) grid cell specific density. The results of the iPCoD modelling show that the level of disturbance from the construction of the Proposed Development is not sufficient to result in any changes at the population level from 1 to 18 years after the end of piling activities. The counter-factual metric indicates that the impacted population size remains at 100% of the unimpacted population size, and the population continues on the same increasing trajectory. Therefore, disturbance from piling at ODOW will not result in a population level effect.

Table 11-73 Results of the grey seal iPCoD simulations using the Carter et al., (2020, 2022) grid cell specific density estimate

	Mean					Median		
	Un-impacted population size	95% CIs	Impacted population size	95% CIs	Impacted as % of un-impacted population size	Un-impacted population size	Impacted population size	Impacted as % of un-impacted population size
Jackets								
Before piling	65,502	65,502 65,502	65,502	65,502 65,502	100%	65,502	65,502	100%
End Year 1 piling	65,687	60,280 69,831	65,687	60,280 69,831	100%	65,977	65,977	100%
End year 2 piling	66,052	59,252 71,833	66,052	59,252 71,833	100%	66,375	66,375	100%
1 year after pilings ends	66,652	58,692 73,194	66,652	58,692 73,194	100%	66,993	66,993	100%
6 years after piling ends	68,922	56,474 80,109	68,922	56,474 80,109	100%	69,155	69,155	100%
12 years after piling ends	71,329	54,251 90,162	71,329	54,251 90,162	100%	70,923	70,923	100%
18 years after piling ends	73,964	54,981 96,336	73,964	54,981 96,336	100%	23,202	73,202	100%
Monopiles								
Before piling	65,502	65,502 65,502	65,502	65,502 65,502	100%	65,502	65,502	100%
End Year 1 piling	65,860	59,654 70,075	65,860	59,654 70,075	100%	66,108	66,108	100%
End year 2 piling	66,235	58,717 71,900	66,235	58,717 71,900	100%	66,637	66,637	100%
1 year after pilings ends	66,706	58,271 73,122	66,706	58,271 73,122	100%	67,071	67,071	100%
6 years after piling ends	68,713	56,396 80,336	68,713	56,396 80,336	100%	68,763	68,763	100%

12 years after piling ends	71,103	54,967 89,711	71,103	54,967 89,711	100%	71,002	71,002	100%
18 years after piling ends	73,977	54,132 97,407	73,977	54,132 97,407	100%	73,157	73,157	100%

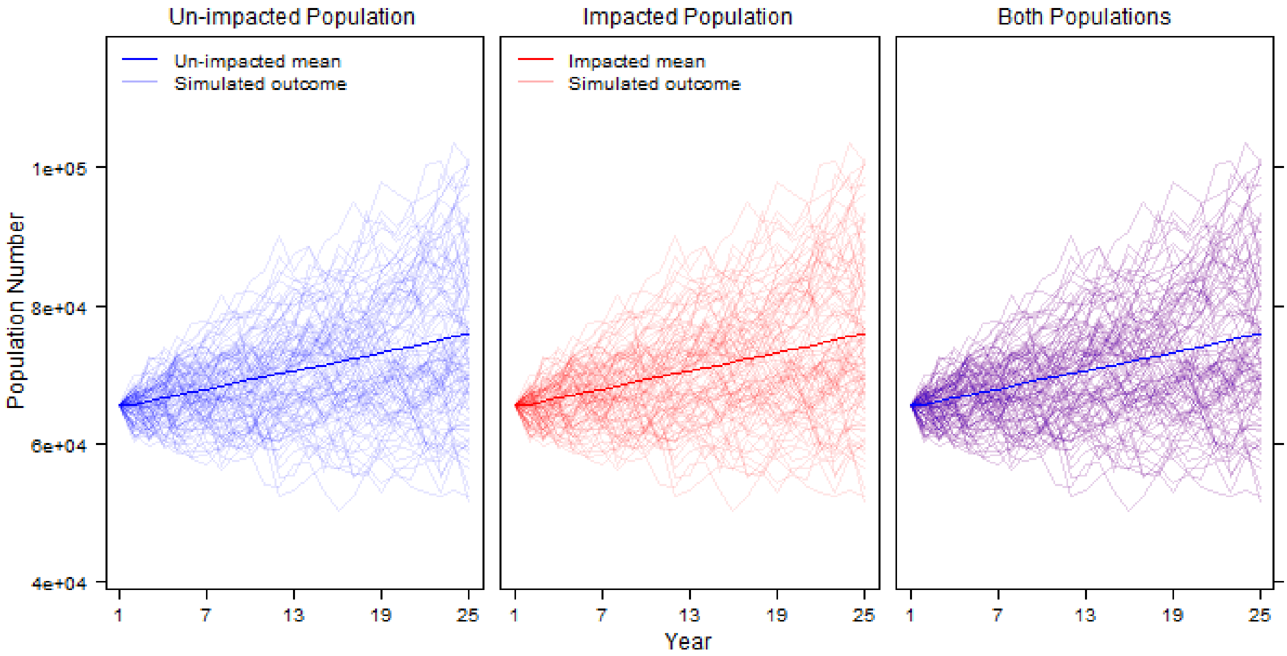

Figure 34 Results of the grey seal iPCoD simulations for jacket foundations using the Carter et al., (2020, 2022) grid cell specific density estimate

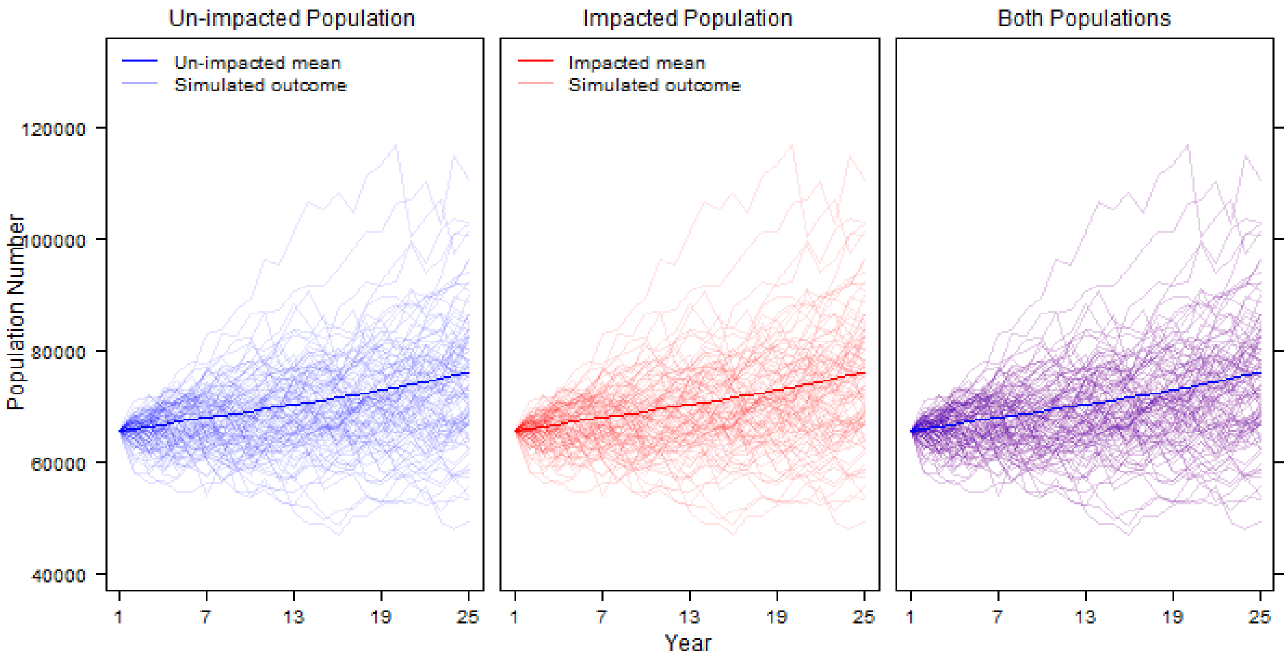

Figure 35 Results of the grey seal iPCoD simulations for monopile foundations using the Carter et al., (2020, 2022) grid cell specific density estimate

Summary

475. The maximum number of piling days is expected to be 109 piling days for monopiles or 130 piling days of pin piled jackets within the piling construction period (Q3 2027 – Q2 2029):

- Monopile: 100 (WTG) + 7 (OOPs) + 2 (ANS) = 109 piling days total
- Pin pile: 100 (WTG) + 28 (OPs) + 2 (ANS) = 130 piling days total

476. Therefore, across the vast majority of the piling days (>99% piling days), the number of grey seals predicted to experience disturbance is low. For pile driving at the ANS NW location, a significantly higher number of animals are predicted to be disturbed per piling day, but it is important to note that the number of piling days at these locations will be minimal (1 piling day each, equating to <1% of all piling days).

477. The iPCoD modelling shows the disturbance has a low consequence since there is predicted to be no overall change to the population trajectory. Therefore, since modelling has shown that despite a small proportion of the population being impacted, the population trajectory would not be altered, and thus the impact of disturbance from pile driving is of **Low** magnitude for grey seals.

Significance

478. The sensitivity of grey seals to disturbance from piling has been assessed as **Low**.

479. The magnitude of impact of disturbance from piling to grey seals has been assessed as **Low.**

480. Therefore, the effect significance of disturbance from piling to grey seals is **Minor**, which is **not significant** in EIA terms.

Pile driving – disturbance summary

481. Table 11-76 present a summary of the sensitivity, magnitude and significance of disturbance from pile driving for marine mammals. The significance has been assessed as Minor for all marine mammal species, which is not significant in EIA terms.

Table 11-74: Summary of marine mammal sensitivity, magnitude and significance of disturbance from pile driving.

Species	Sensitivity	Magnitude	Significance
Harbour porpoise	Medium	Low	**Minor (Not significant)**
Bottlenose dolphin	Medium	Low	**Minor (Not significant)**
White-beaked dolphin	Medium	Low	**Minor (Not significant)**
Minke whale	Medium	Low	**Minor (Not significant)**
Harbour seal	Medium	Low	**Minor (Not significant)**
Grey seal	Low	Low	**Negligible (Not significant)**

11.6.1.8 Impact 6: PTS from other construction activities

482. The following section provides the quantitative assessment of the impact of injury (PTS) from other construction activities on marine mammal species detailed in document reference 6.3.11.2 (Table 11-77).

Table 11-75: PTS impact ranges for the different construction noise sources using the non-impulsive criteria from Southall *et al.* (2019).

Southall *et al.* (2019) weighted SEL_{cum}	Cable laying	Backhoe dredging	Suction dredging	Drilling	Trenching	Rock placement
173dB (VHF)	<100 m	<100 m	<100 m	<100 m	<100 m	<100 m
198dB (HF)	<100 m	<100 m	<100 m	<100 m	<100 m	<100 m
199dB (LF)	<100 m	<100 m	<100 m	<100 m	<100 m	<100 m
201dB (PCW)	<100 m	<100 m	<100 m	<100 m	<100 m	<100 m

Sensitivity

Dredging

483. Dredging is described as a continuous broadband sound source, with the main energy below 1kHz; however, the frequency and sound pressure level can vary considerably depending on the equipment, activity, and environmental characteristics (Todd et al., 2015). For the Project, dredging will potentially be required for seabed preparation work for foundations as well as for export cable, array cable and interlink cable installations. The source level of dredging has been described to vary between SPL 172 - 190dB re 1μPa @ 1m with a frequency range of 45Hz to 7kHz (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 porpoise, dolphins and seals, the hearing sensitivity below 1kHz 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 porpoise, dolphins and seals to PTS from dredging is assessed as Medium.

484. 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 2kHz (Edds-Walton, 2000; Mellinger et al., 2000; Gedamke et al., 2001; Risch et al., 2013; Risch et al., 2014). Tubelli (2012) estimated the most sensitive hearing range (the region with thresholds within 40dB of best sensitivity) to extend from 30 to 100Hz up to 7.5 to 25kHz, depending on the specific model used. Therefore, the sensitivity of minke whale to PTS from dredging is precautionarily assessed as High.

Trenching

485. 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 energy between 100Hz – 1kHz and in general the sound levels were generally only 10-15dB above background levels (Nedwell et al., 2003). For porpoise, dolphins and seals, the hearing sensitivity below 1kHz 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 porpoise, dolphins and seals to PTS from trenching is assessed as Medium. 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 High.

Cable laying

486. 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 165-180dB re 1µPa, with the majority of energy below 1kHz (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 porpoise, dolphins and seals, the hearing sensitivity below 1kHz 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 porpoise, dolphins and seals to PTS from cable laying is assessed as Medium. 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 High.

Drilling

487. The continuous sound produced by drilling has been likened to that produced by dredging activity; low frequency noise caused by rotating machinery (Greene, 1987). Recordings of drilling at the North Hoyle offshore windfarm suggest that the sound produced has a fundamental frequency at 125Hz (Nedwell et al., 2003). For porpoise, dolphins and seals, the hearing sensitivity below 1kHz 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 porpoise, dolphins and seals to PTS from drilling noise is assessed as Medium. 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 precautionarily assessed as High.

Summary

488. MMO (2015) provide information on the acoustic properties of anthropogenic continuous noise sources; this includes noise sources such as dredging, drilling and shipping. For all three activities, the main energy is listed as being <1kHz. For porpoise, dolphins and seals species considered here, the hearing sensitivity below 1kHz is relatively poor and thus it is expected that a PTS at these low frequency ranges would result in little impact to vital rates and, therefore, their sensitivity is assessed as Medium. As minke whales have a greater hearing sensitivity below 1kHz, meaning their hearing range is more likely to overlap with other construction, activities their sensitivity has precautionarily been assessed as High.

Magnitude

489. For all nonpiling construction activities assessed (Table 11-77), the PTS onset impact ranges are <100m. Therefore, non-piling construction noise sources will have a local spatial extent and are transient and intermittent. Therefore, the magnitude of impact of PTS from non-piling construction noise is considered Negligible.

Significance

490. The sensitivity of porpoise, dolphins and seals to PTS from other construction activities has been assessed as Medium and minke whales have precautionarily been assessed as having a High sensitivity.

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

492. Therefore, the effect significance of PTS from other construction activities is Negligible for porpoise, dolphins and seals and Minor for minke whales, which is not significant in EIA terms.

Table 11-76: Summary of marine mammal sensitivity, magnitude and significance of PTS from other construction activities.

Species	Sensitivity	Magnitude	Significance
Harbour porpoise	Medium	Negligible	**Negligible (Not significant)**
Bottlenose dolphin	Medium	Negligible	**Negligible (Not significant)**
White-beaked dolphin	Medium	Negligible	**Negligible (Not significant)**
Minke whale	High	Negligible	**Minor (Not significant)**
Harbour seal	Medium	Negligible	**Negligible (Not significant)**
Grey seal	Medium	Negligible	**Negligible (Not significant)**

Impact 7: TTS from other construction activities

493. The TTS-onset impact areas and ranges for other construction activities are detailed in document reference 6.3.11.2. As previously outlined, there are no thresholds to determine a biologically significant effect from TTS-onset. As with the results for piling, the predicted ranges for the onset of TTS from other construction activities are presented, but no assessment of magnitude, sensitivity or significance of effect is given.

494. For harbour porpoise, the TTS-onset impact ranges are predicted to be greatest for rock placement at 990 m, followed by suction dredging at 230 m, and <100m for the other construction activities (Table 11-79). For all other species, all impact ranges are predicted to be <100m (Table 11-79).

495. Overall, non-piling construction noise sources will have a local spatial extent, short-term duration, and be intermittent, meaning that, with the most precautionary estimates, a fleeing marine mammal would have to remain within <100m at the start of the activity to acquire the necessary exposure to induce TTS as per Southall et al., (2019), which is extremely unlikely to happen.

Table 11-77: TTS impact ranges for the different construction noise sources using the non-impulsive criteria from Southall *et al.* (2019) for fleeing animal.

Southall *et al.* (2019) weighted SEL_{cum}	Cable laying	Backhoe dredging	Suction dredging	Drilling	Trenching	Rock placement
153dB (VHF)	100 m	<100 m	230 m	<100 m	<100 m	990 m
178dB (HF)	<100 m	<100 m	<100 m	<100 m	<100 m	<100 m
179dB (LF)	<100 m	<100 m	<100 m	<100 m	<100 m	<100 m
181dB (PCW)	<100 m	<100 m	<100 m	<100 m	<100 m	<100 m

11.6.1.9 Impact 8: Disturbance from other construction activities

Sensitivity

496. 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 (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).

497. Harbour porpoise occurrence decreased at the Beatrice and Moray East offshore windfarms during non-piling construction periods (Benhemma-Le Gall et al., 2021). The probability of detecting porpoise in the absence of piling decreased by 17% as the sound pressure levels from vessels during the construction period increased by 57dB (note: vessel activity included not only windfarm construction related vessels, but also other third party traffic such as fishermen, bulk carrier and cargo vessels). Despite this, harbour porpoise continued to regularly use both the Beatrice and Moray East sites throughout the three-year construction period. While a reduction in occurrence and buzzing was associated with increased vessel activity, this was of local scale and buzzing activity increased beyond a certain distance from the exposed areas, suggesting displaced animals resumed foraging once a certain distance from the noise source, or potential compensation behaviour for lost foraging or the increased energy expenditure of fleeing. While 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 porpoise to disturbance from other construction activities is considered to be Medium.

498. 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., 2017). A study conducted in northwest Ireland, construction related activity (including dredging) did not result in any evidence of a negative impact to common dolphins (Culloch et al., 2016). Therefore, their sensitivity to disturbance from other construction activities is assessed as Medium.

499. 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, their sensitivity to disturbance from other construction activities is assessed as Medium.

500. 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 windfarm, seal usage in the vicinity of construction activity was not significantly decreased during breaks in the piling activities and displacement was limited to within two hours of the piling activity (Russell et al., 2016a). There was no evidence of displacement during the overall construction period, 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 windfarm, 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 Project array area is located in a low density area for both species of seal, 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 construction activities is considered to be Low.

Magnitude

Dredging

501. Harbour porpoise: Dredging at a source level of 184dB re 1µPa at 1m resulted in avoidance up to 5km from the dredging site (Verboom, 2014). Conversely, Diederichs (2010) found much more localised impacts; using Passive Acoustic Monitoring there was short term avoidance (~3 hours) at distances of up to 600m 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 192dB re 1µPa) predicted a disturbance range of 400m, while a more conservative approach predicted avoidance of harbour porpoise up to 5km (McQueen et al., 2020).

502. Bottlenose dolphin: 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 1km radius of the dredging site (Pirotta et al., 2015). Dredging operations had no impact on sightings of Indo-Pacific bottlenose dolphins (Tursiops aduncus) in South Australia (Bossley et al., 2022).

503. 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 16kHz (Nachtigall et al., 2008) which is above the typical range for dredging. Localised, temporary avoidance of dredging activities is assumed.

504. 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).

505. Grey and harbour seal: Based on the generic threshold of behavioural avoidance of pinnipeds (140dB re 1µPa SPL) (Southall et al., 2007), acoustic modelling of dredging demonstrated that disturbance could be caused to individuals between 400m to 5km from site (McQueen et al., 2020).

Drilling

506. 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., 2021). For example, drilling and dredging playback experiments observed that 50% of bowhead whales exposed to noise levels of 115dB re 1µPa 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 level 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 122dB re 1µPa. 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 - 20km and will vary depending on the species (Greene Jr, 1986; LGL and Greeneridge, 1986; Richardson et al., 1990).

507. Whilst information is not available for the species of concern for the Project, 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 Project. Therefore, it is considered that drilling could potentially cause disturbance over distances of up to 510km from the noise source based on results for dredging, or potentially up to 20km based on results from the drilling literature, although this literature is considered slightly outdated.

Other

508. 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).

509. It is expected that any disturbance impact will be primarily driven by the underwater noise generated by the vessel during these non-piling construction related activities, and, as such, it is expected that any impact of disturbance is highly localised (within 5km). The indicative offshore construction period is expected to comprise:

- offshore export cable installation lasting up to 24 months,

- foundation installation lasting up to 19 months,
- array cable installation lasting up to 24 months,
- WTG installation lasting up to 19 months; and
- OP installation lasting up to 12 months.

510. This would be preceded by the construction of the ANS and establishment of the biogenic reef, if these are required over a period of 6 months, likely at least 1 year prior to the main construction sequence.

511. Given that there will be overlap in these activities, it is expected that offshore construction related work within the array area or within the Offshore ECC will occur within a 36-month period. Therefore, the duration of disturbance will be limited to three breeding cycles. This aligns with the definition of Low magnitude.

Significance

512. The sensitivity of cetaceans to disturbance from other construction activities has been assessed as Medium. The sensitivity of seals to disturbance from other construction activities has been assessed as **Negligible**.

513. The magnitude of the impact to all marine mammals for disturbance from other construction activities has been assessed as **Low** .

514. Therefore, the effect significance of disturbance to cetaceans from other construction activities is **Minor** and the effect significance of disturbance to seals from other construction activities is **Negligible**, which is not significant in EIA terms.

11.6.1.10 Impact 9: Vessel collisions

515. The area surrounding the Project already experiences high levels of vessel traffic (see Volume 1, Chapter 15: Shipping and Navigation). Volume 1, Chapter 3: Project Description shows there will be 174 total construction vessels and that during the busiest period for vessel traffic there would be up to 10 vessels (major installation and commissioning vessels) in a given 5km^2 active construction area. The introduction of additional vessels during construction of the Project is not a novel impact for marine mammals present in the area.

516. During construction of the windfarm, a potential source of impact from increased vessel activity is physical trauma from collision with a boat or ship. These injuries include blunt trauma to the body or injuries consistent with propeller strikes. The risk of collision of marine mammals with vessels would be directly influenced by the type of vessel and the speed with which it is travelling (Laist *et al*., 2001) and indirectly by ambient noise levels underwater and the behaviour the marine mammal is engaged in.

517. There is currently a lack of information on the frequency of occurrence of vessel collisions as a source of marine mammal mortality, and there is little evidence from marine mammals stranded in the UK that injury from vessel collisions is an important source of mortality. The UK Cetacean Strandings Investigation Programme (CSIP) documents the annual number of reported strandings and the cause of death for those individuals examined at post-mortem. The CSIP data shows that very few strandings have been attributed to vessel collisions[25], therefore, while there is evidence that mortality from vessel collisions can and does occur, it is not considered to be a key source of mortality highlighted from post-mortem examinations. However, it is important to note that the strandings data are biased to those carcases that wash ashore for collection and therefore may not be representative.

518. Harbour porpoises, dolphins and seals are relatively small and highly mobile, and given observed responses to noise, are expected to detect vessels in close proximity and largely avoid collision. Minke whales have previously shown displacement in areas with high vessel density in response to noise (Anderwald *et al*., 2013), which can reduce the chance of impact collision. Predictability of vessel movement by marine mammals is known to be a key aspect in minimising the potential collision risks imposed by vessel traffic (Nowacek *et al*., 2001; Lusseau, 2003; Lusseau, 2006). The adoption of a VMP based on best practice vessel handing protocols (e.g. following the Codes of Conduct provided by the WiSe Scheme[26], Scottish Marine Wildlife Watching Code[27] or Guide to Best Practice for Watching Marine Wildlife[28]) during construction will minimise the potential for any potential collision risk. It is highly likely that a proportion of vessels will be stationary or slow moving throughout construction activities for significant periods of time. Therefore, the actual increase in vessel traffic moving around the site and to/from port to the site will occur over short periods of the offshore construction activity, thus minimising the risk of collisions.

519. It is not expected that the level of vessel activity during construction would cause an increase in the risk of mortality from collisions. The adoption of a VMP based on best practice vessel handing protocols (e.g. following the Codes of Conduct provided by the WiSe Scheme, Scottish Marine Wildlife Watching Code or Guide to Best Practice for Watching Marine Wildlife) during construction will minimise the potential for any impact. Therefore, the risk of vessel collisions occurring is of **Negligible** magnitude.

520. All marine mammal receptors are deemed to be of low vulnerability given that vessel collision is not considered to be a key source of mortality highlighted from post-mortem examinations of stranded animals. However, should a collision event occur, this has the potential to kill the animal. As a result of the low vulnerability to a strike but the serious consequences of a strike, marine mammal receptors are considered to have a **Very High** sensitivity to vessel collisions.

---

[25] CSIP (2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018)
[26] [redacted]
[27] [redacted]
[28] [redacted]

521. The magnitude of the impact has been assessed as **Negligible** and the sensitivity of receptors as **Very High**. Therefore, the significance of the effect of collisions from vessels is concluded to be of **Minor**, which is not significant in terms of the EIA regulations.

11.6.1.11 Impact 10: Vessel disturbance

522. As stated above, the area surrounding the Project already experiences high levels of vessel traffic (see Volume 2, Chapter 15: Shipping and Navigation for full details). Volume 1, Chapter 3: Project Description shows there will be 131 total construction vessels per year. Therefore, the introduction of additional vessels during construction the Project is not a novel impact for marine mammals present in the area.

523. Vessel noise levels from construction vessels will result in an increase in non-impulsive, continuous sound in the vicinity of the Project array, typically in the range of 10 – 100Hz (although higher frequencies may also be produced) (Sinclair *et al*., 2021) with an estimated source level of 161 – 168 SEL_{cum} dB re 1µPa@1m (RMS). It is anticipated there will be maximum of 174 construction vessels in total. There are very few studies that indicate a critical level of activity in relation to risk of collisions 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. Vessel traffic in the Project area, even considering the addition of the Project construction traffic will still be well below this figure. The adoption of a VMP based on best practice vessel handing protocols (e.g. following the Codes of Conduct provided by the WiSe Scheme, Scottish Marine Wildlife Watching Code or Guide to Best Practice for Watching Marine Wildlife) during construction will minimise the potential for any disturbance impact. Therefore, the impact is expected to be of **Low** magnitude.

524. Harbour porpoise have a high frequency generalised hearing range (275Hz – 160kHz) and, therefore, the majority of additional vessel traffic noise will fall below their range of hearing. However, they are known to exhibit an avoidance response to vessels that contain low levels of high frequency components (Dyndo *et al*., 2015). Studies have shown that, whilst there may be short-term effects on foraging, harbour porpoise show a quick recovery time to responses to vessel traffic, remaining in heavily trafficked areas (Wisniewska *et al.,* 2018). There appears to be little fitness cost to exposure to vessel noise and any local scale responses taken to avoid vessels. It is also likely that porpoise may become habituated where vessel movements are regular and predictable.

525. Previous modelling of bottlenose dolphin in the Moray Firth in response to increase vessel traffic from offshore wind development found it to have no negative impact on the local population (Lusseau *et al*., 2011). There is also evidence of bottlenose dolphins becoming habituated to increased boat traffic, particularly larger commercial vessels which have predictable patterns of movement and do not actively disrupt feeding behaviour as a recreational or tourist vessel may (Sini *et al*., 2005). As both HF cetaceans with similar hearing abilities, it is anticipated that bottlenose and white beaked dolphin will react similarly to construction vessel traffic. The generalised hearing range of high frequency cetaceans 150Hz – 160kHz (Southall *et al*., 2019) is also above the anticipated frequency range of much of the construction vessel noise.

526. Minke whales have a low frequency generalised hearing range of 7Hz – 35kHz which falls within the expected frequency range of construction vessel traffic. They have been shown to exhibit a decrease in foraging activity in response to whale watching vessels (Christiansen *et al*., 2013). However, these vessels were specifically following minke whales and, therefore, it is not known how they would respond to construction vessels that would be following a pre-determined route and not directly interacting with the animals. As generalist feeders with a varied diet, it is not expected that any temporary displacement resulting from vessel activity in relation to the Project will lead to any significant effect on individual energy budgets and subsequently fitness.

527. Evidence suggests that any behavioural changes and displacement are likely to be temporary and that some species (harbour porpoise particularly) may even become habituated to the construction vessel presence due to their more predictable movements and therefore exhibit less of a response over time. Based on modelling conducted by Southall *et al*., (2019), harbour porpoise would have to be <100m from a large vessel for a 24-hour period to experience either TTS or PTS (Table 54 in Volume 2, Appendix 3.2: Underwater Noise Assessment). These impacts are unlikely as it is far more likely that any marine mammal within the injury zone would move away from the vicinity of the vessel and the construction activity. The sensitivity of cetacean species under consideration to vessel disturbance has, therefore, been assessed as **Medium**.

528. Jones *et al*., (2017) presents an analysis of the predicted co-occurrence of ships and seals at sea which demonstrates that UK wide there is a large degree of predicted co-occurrence, particularly within 50km of the coast close to seal haul-outs. There is no evidence relating decreasing seal populations with high levels of co-occurrence between ships and animals. In fact, in areas where seal populations are showing high levels of growth (e.g. southeast England) ship co-occurrences are highest (Jones *et al*., 2017). Thomsen *et al*., (2006) estimated that both harbour and grey seals will respond to both small (~2kHz) and large (~0.25kHz) vessels at approximately 400 m. The sensitivity of grey and harbour seals for vessel disturbance has, therefore, been assessed as **Low**.

529. The magnitude of the impact has been assessed as **Low** and the sensitivity of receptors as **Medium** (cetaceans) or **Low** (grey seals and harbour seals). Therefore, the significance of the effect of disturbance from vessels is concluded to be of **Minor** for cetaceans and **Negligible** significance for grey and harbour seals, neither of which is significant in terms of the EIA regulations.

11.6.1.12 Impact 11: Indirect impacts on prey

530. Given that marine mammals are dependent on fish prey, there is the potential for indirect effects on marine mammals as a result of impacts upon fish species or the habitats that support them. The key prey species for each marine mammal receptor are listed in Table 11-80.

531. Regarding fish prey species, the worst-case impacts from the construction of the Project have been assessed in section 10.7 of Chapter 10 (document reference 6.1.10). Potential impacts from underwater noise will arise from the piling of foundations and UXO clearance during the construction phase. There is the potential for fish mortality and potential mortal injury, recoverable injury, TTS, behavioural impacts and auditory masking arising from underwater noise from these activities. Taking into consideration the implementation of embedded mitigation, no significant effects on fish prey species were concluded. In addition, there is the potential for direct impacts to occur on fish prey species inclusive of direct damage and crushing, temporary habitat loss, increase in SSC and deposition leading to smothering, and potential accidental contamination arising from seabed disturbances, as per Chapter 10 (document reference 6.1.10). All such impacts were assessed, and no significant effects were concluded on fish prey species.

532. Fishing pressure may be reduced during construction at the Project due to the required safety distances of 500m around infrastructure under construction and fishing effort may be displaced into the surrounding area. However, it would not be expected that any changes in fishing activities in this area would lead to changes in populations of these species as any increase would be very localised and any population level effects would be minimised by fisheries management measures.

Table 11-78: Key prey species of the marine mammal receptors

Species	Prey species	Reference
Harbour porpoise	Whiting, sandeel, herring, haddock, saith, pollock, bobtail squid	Pierce *et al.,* (2007)
Bottlenose dolphin	Cod, saith, whiting, salmon, mackerel, haddock, pout, squid	Santos *et al.,* (2001) De Pierrepont *et al.,* (2005)
White beaked dolphin	Haddock, whiting, cod, herring, mackerel	Canning *et al.,* (2008)
Minke whale	Sandeel, herring, sprat, mackerel, goby, Norway pout/poor cod	Pierce *et al.,* (2004)
Harbour seal	Sandeel, whiting, dragonet, cod, herring, sprat, dover sole, plaice, lemon sole, dab, flounder, goby, bullrout, sea scorpion, octopus, squid	Wilson and Hammond (2016) SCOS (2021)
Grey seal	Sandeel, cod, whiting, haddock, ling, plaice, sole, flounder, dab	SCOS (2021)

533. Due to the lack of significant effect on prey species and the generalist/opportunist nature of the receptors in question, together with the low numbers of marine mammals in vicinity of the Project, the impact magnitude of indirect impacts on prey availability during construction is considered to be negligible , indicating that the potential is for very short-term and recoverable effects, with no potential for survival and reproductive rates to be impacted to the extent that the population trajectory will be altered.

534. Changes to prey availability could increase the energy expenditure required for feeding through increased effort. However, as marine mammals are generalists they can switch prey species removing the requirement for additional energy expenditure. No impact on survival and reproduction is predicted and therefore the sensitivity of the receptor is considered to be low.

535. The magnitude of the impact has been assessed as negligible and the sensitivity of receptors as low. Therefore, the significance of the indirect effect of changes in fish abundance/distribution is concluded to be of negligible (not significant) in terms of the EIA regulations.

11.6.1.13 Impact 12: Water quality impacts

536. Disturbance to water quality as a result of construction activities can have both direct and indirect impacts on marine mammals. Indirect impacts include effects on prey species. Direct impacts include the impairment of visibility and therefore foraging ability which might be expected to reduce foraging success.

- During construction of the Project, sediment will be disturbed and released into the water column. This will give rise to suspended sediment plumes and localised changes in bed levels as material settles out of suspension. The main activities resulting in disturbance of seabed sediments are:
- Pre-lay cable trenching;
- Sandwave clearance;
- Cable installation;
- Dredge spoil disposal; and
- Drill arisings release.

537. The maximum distance (and therefore the overall spatial extent) that any local plume effects might be (temporarily) experienced can be reasonably estimated as the spring tidal excursion distance. The assessment provided in Volume 1, Chapter 7: Marine Physical Processes found that:

- Within 5m of the activity, Suspended Sediment Concentration (SSC) might be millions of mg/l or more locally, i.e. more sediment than water in parts of the local plume. The effect is very localised and of very short duration.
- During the first half tidal cycle (~six hours), the width of the plume increases through dispersion to between 500 and 2000m, all non-silt sediments have settled to the seabed, and SSC consequentially reduces rapidly to 50mg/l.
- After 20 hours SSC will have reduced to below 5mg/l, with no measurable SSC during peak high current speed conditions.

538. Marine mammals are well known to forage in tidal areas where water conditions are turbid and visibility conditions poor. For example, harbour porpoise and harbour seals in the UK have been documented foraging in areas with high tidal flows (Pierpoint 2008, Marubini *et al*., 2009, Hastie *et al*., 2016); therefore, low light levels, turbid waters and suspended sediments are unlikely to negatively impact marine mammal foraging success. It is important to note that it is hearing, not vision that is the primary sensory modality for most marine mammals. When the visual sensory systems of marine mammals are compromised, they are able to sense the environment in other ways, for example, seals can detect water movements and hydrodynamic trails with their mystacial vibrissae; while odontocetes primarily use echolocation to navigate and find food in darkness.

539. Volume 1, Chapter 7: Marine Physical Processes concluded that the magnitude of the maximum potential increase in SSC resulting from construction activities is negligible and the impact will be short-term, intermittent and of localised extent and reversible. Therefore, there is expected to be no significant increase in the level of SSC from the construction of the Project. The magnitude of this impact is therefore considered to be **Negligible** .

540. Short-term increased turbidity is not anticipated to impact marine mammals which rely primarily on hearing, resulting in **Low** sensitivity to changes in water quality.

541. The magnitude of the impact has been assessed as **Negligible** and the sensitivity of receptors as **Low**. Therefore, the significance of the effect of changes in water quality is concluded to be **Negligible (not significant)** in terms of the EIA regulations.

11.6.1.14 Impact 13: Disturbance at seal haul-outs

542. Both grey and harbour seals are known to haul out at Donna Nook, the Wash, Blakeney Point, Horsey and Scroby Sands. There is the potential for disturbance to seals at haul out sites from the construction of the proposed development as a result of the transit of vessels. Previous studies have demonstrated the disturbance effects of vessels on harbour seals at haul-out sites. For example, controlled disturbance vessel trials have shown that harbour seals would reduce the amount of time hauled out around the point of disturbance and they would embark on a foraging trip before hauling out again at the next low-tide cycle (Paterson *et al*., 2015). This was also shown in Andersen *et al*., (2011) where extended inter-haul-out trips occurred directly after a disturbance event. This is particularly important in terms of energetic consequences if this disturbance occurs at a time that is critical for seals to be hauled out, such as during the annual moult or the breeding season.

543. The other primary concern with respect to hauled out seals is the potential proximity of construction vessels, as vessel traffic is known to disturb seals at haul out sites and often result in the animals flushing into the water (Jansen *et al*., 2015). Andersen *et al*., (2011) showed that flushing out at Danish haul out sites occurred at distances of 510-830m from approaching vessels. The local haul out sites listed above are all situated more than 1km away from the landfall site of export cables at Wolla Bank, and are already exposed to relatively high levels of vessel activities and it is therefore considered that there will be a *de minimis* disturbance effect to seals at haul out caused by the additional vessels for the Project (see the vessel disturbance assessment above, and Table 11-16). Additionally, the vessel transit routes for the Project are based on the assumption of the Humber being the main port for construction and operation and maintenance activities, which would bring vessels in closest proximity to the seal haul out sites. The main commercial routes for cargo vessels, tankers, operation and maintenance vessels in the area are from Humber Ports to Rotterdam (Netherlands), Cuxhaven (Germany), Bremenhaven/Hamburg (Germany) and Hornsea Offshore Windfarms which are the likely routes that could be followed. These routes do not pass past any haul out sites en route to the Project.

544. Heart rate responses to incidental and experimental vessel disturbance have previously been used assess harbour seal disturbance (Karpovich *et al*., 2015). Hauled out seals exhibited a vigilance behaviour (head-lift) and experienced a 4 bpm vessel^{-1} increase as a result of incidental vessel traffic, and a 5 bpm vessel^{-1} increase from experimental vessel disturbance. This increase in heart rate could be a result of the seal switching from a sleeping to awake status as the vessel approached or could indicate that the seal is experiencing a stress response. If seals remained hauled out, their heart rate continued to increase with each additional vessel that approached; if seals entered the water following the disturbance, the heart rate decreased, suggesting they are shifting to an energetically conservative state in response to the disturbance event. However, the effect of the heart rate increase was still noticeable in the following haul out, indicating that the disturbance has a prolonged energetic cost for harbour seals (Karpovich *et al*., 2015). The sensitivity of harbour seals to disturbance at haul-outs is therefore classified as **High**.

545. Bishop *et al*. (2015) reported that breeding male grey seals exhibit similar activity (behavioural) budgets across varying exposures to human activity. Male grey seals exhibited similar time budgets for non-active behaviours (i.e., resting or alert) versus active behaviours (i.e., aggressions or attempted copulation) suggesting strong selection pressures for overarching conservation of energy, in the presence or absence of human activities and/or disturbance. Bishop *et al*. (2015) reported that selection for this lack of a behavioural response is likely driven by the increased mating success of males who maintain their position amongst groups of females for the longest time because of reduced energy expenditure, irrespective of human activity. Although Bishop *et al*. (2015) classified alert behaviours under the non-active category, as Karpovich *et al*. (2015) indicated, increased alertness/vigilance and in turn, increased stress levels, can increase the heart rate of seals (irrespective of sex) and thus, energy expenditure. Should vessel disturbance to grey seals, male or female, be repetitive, this could lead to increased heart rates over time and a prolonged energetic cost. The sensitivity of grey seals to disturbance at haul-out sites is therefore classified as **High**.

546. The impact is predicted to be of local spatial extent, short term duration, intermittent and is reversible. In line with best-practise vessel management measures, where possible vessel traffic associated with the Project will follow existing shipping routes and are therefore unlikely to transit close to the key haul out sites (at Donna Nook and within the Wash). The magnitude is therefore considered to be **Negligible** , indicating that the potential is for very short-term and recoverable effects, with no potential for survival and reproductive rates to be impacted to the extent that the population trajectory will be altered.

547. Overall, the sensitivity of seals to disturbance has been assessed as **High** and the magnitude is predicted to be **Negligible** . Therefore, the resulting impact significance for disturbance to seal haul outs is **Minor (not significant)** in EIA terms.

Operation and Maintenance

548. This section presents the assessment of impacts arising from the operational and maintenance phases of the Project.

11.6.1.15 Impact 14: Operational noise

PTS & TTS

Sensitivity

549. Operational noise derived from operational wind turbines is primarily low frequency (well below 1kHz) (Thomsen 2006). For the majority of marine mammal species, the hearing sensitivity below 1kHz 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 all marine mammals except minke whale to PTS from operational noise is assessed as Low.

550. The low frequency noise produced during operations 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 2kHz (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 40dB of best sensitivity) to extend from 30 to 100Hz up to 7.5 to 25kHz, depending on the specific model used. Therefore, the sensitivity of minke whale to PTS from operational noise is assessed as Medium.

Magnitude

551. The PTS and TTS-onset impact areas and ranges for operational noise are detailed in Volume 2, Appendix 3.2: Underwater Noise Assessment. Table 11-79 shows that both PTS and TTS impact ranges are <100 m. Therefore, the magnitude of impact of PTS from operational noise is considered **Negligible** .

Table 11-79: Operational WTG noise impact ranges using the non-impulsive noise criteria from Southall *et al.* (2019).

Southall *et al.* (2019) weighted SEL_{cum}		12 MW	18 MW
PTS (non-impulsive)	173dB (VHF)	<100 m	<100 m
	198dB (HF)	<100 m	<100 m
	199dB (LF)	<100 m	<100 m
	201dB (PCW)	<100 m	<100 m
TTS (non-impulsive)	153dB (VHF)	<100 m	<100 m
	178dB (HF)	<100 m	<100 m
	179dB (LF)	<100 m	<100 m
	181dB (PCW)	<100 m	<100 m

Significance

552. The sensitivity of marine mammals to PTS from operational noise has been assessed as Low, with exception of minke whales which have been assessed as having a Medium sensitivity.

553. The magnitude of the impact of PTS to marine mammals from operational noise has been assessed as Negligible .

554. Therefore, the effect significance of PTS from operational noise is assessed as Negligible for porpoise, dolphins and seals to Minor for minke whale, which is not significant in EIA terms.

Disturbance

Sensitivity

555. Operational noise is primarily low frequency (well below 1kHz) (Thomsen 2006). For the majority of marine mammal species, the hearing sensitivity below 1kHz is relatively poor and, thus, it is expected that a disturbance at this frequency would result in little impact to vital rates. Therefore, the sensitivity of porpoise, dolphins and seals to disturbance from operational noise is assessed as Low.

556. The low frequency noise produced during operations 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 2kHz (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 40dB of best sensitivity) to extend from 30 to 100Hz up to 7.5 to 25kHz, depending on the specific model used. Furthermore, 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. 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. Therefore, it has been precautionarily assumed that minke whales have a Medium sensitivity to disturbance from operational noise.

Magnitude

557. A number of studies have reported the presence of marine mammals within windfarm footprints. For example, at the Horns Rev and Nysted offshore windfarms in Denmark, long-term monitoring showed that both harbour porpoise and harbour seals were sighted regularly within the operational OWFs, and within two years of operation, the populations had returned to levels that were comparable with the wider area (Diederichs et al., 2008). Similarly, a monitoring programme at the Egmond aan Zee OWF in the Netherlands reported that significantly more porpoise activity was recorded within the OWF compared to the reference area during the operational phase (Scheidat et al., 2011) indicating the presence of the windfarm was not adversely affecting harbour porpoise presence. Other studies at Dutch and Danish OWFs (2011) and in the Moray Firth in Scotland (Fernandez-Betelu et al., 2022) also suggest that harbour porpoise may be attracted to increased foraging opportunities within operating offshore windfarms. The study conducted by Fernandez-Betelu et al. (2022) found the increased foraging activity and the occurrence of harbour porpoise happened at night, with the change in diel patten being specifically linked to the presence of an offshore structure. There was also a significant increase in porpoise presence and foraging activity near isolate offshore structures (Fernandez-Betelu et al., 2022). In addition, Russell et al. (2014) found that some tagged harbour and grey seals demonstrated grid-like movement patterns as these animals moved between individual WTGs, strongly suggestive of these structures being used for foraging. Previous reviews have also concluded that operational windfarm noise will have negligible barrier effects (Madsen et al.,2006; Teilmann et al., 2006a; Teilmann et al., 2006b; Cefas, 2010; Brasseur et al., 2012).

558. These studies were all conducted at windfarms with relatively small sized turbines, and thus there is uncertainty as to how applicable the results are to future larger turbine sizes. Tougaard (2020) and Stöber and Thomsen (2021) showed that as WTG size increases, the underwater sound pressure level also increases. Both studies highlighted that as the size of turbines continues to increase it is expected that the operational noise they produce will also increase. One important factor to consider is that all data used in the studies to date have been measured at geared turbines, and it is the gearbox that is one of the main contributing factors to the generated underwater noise levels. However, recent advances in technology mean that newer WTGs use direct drive technology rather than gears, which are expected to generate lower operational underwater noise levels (sound reduction of around 10dB compared to the same size geared turbine) (Stöber and Thomsen, 2021).

559. Therefore, while underwater sound is expected to increase with increasing turbine size, new direct drive technology means that new turbines will produce considerably less underwater noise compared to the older geared turbines. Additionally, as turbines increase in size fewer are required to be installed to meet a projects capacity. The Applicant acknowledges that there is still a lack of data on operational noise generated by larger size turbines; however, given the presence of marine mammals (both porpoise and seals) within operational windfarms, it is unlikely that operational noise is expected to be of a level that would result in any disturbance effect. As such, the magnitude of disturbance from operational noise is assessed as Negligible .

Significance

560. The sensitivity of marine mammals to disturbance from operational noise has been assessed as Low, with exception of minke whales which have been precautionarily assessed as having a Medium sensitivity.

561. The magnitude of the impact to marine mammals for disturbance from operational noise has been assessed as Negligible .

562. Therefore, the effect significance of disturbance from operational noise is assessed as Negligible for porpoise, dolphins and seals to Minor for minke whales, neither of which are significant in EIA terms.

11.6.1.16 Impact 15: Vessel Collisions

563. As stated in section 515, the area surrounding the Project already experiences a high amount of vessel traffic (see Volume 1, Chapter 15: Shipping and Navigation for full details). Volume 1, Chapter 3: Project Description states there will be an indicative peak number of 10 vessels within a 5km^2 area on site simultaneously during operation. The introduction of additional vessels during O&M of the Project is not a novel impact for marine mammals present in the area.

564. Predictability of vessel movement by marine mammals is known to be a key aspect in minimising the potential risks imposed by vessel traffic (Nowacek *et al*., 2001, Lusseau 2003, 2006). The adoption of a VMP based on best practice vessel handing protocols (e.g. following the Codes of Conduct provided by the WiSe Scheme, Scottish Marine Wildlife Watching Code or Guide to Best Practice for Watching Marine Wildlife) will minimise the potential for any impact. Additional traffic during operations includes an increased frequency and greater variety of vessel types than in the construction phase e.g. jack-up vessels, small O&M vessels, lift vessels, cable maintenance vessels and auxiliary vehicles, and will take place over a longer period of time e.g. lifetime of the Project. Therefore, vessel traffic increase will be greater during this phase. However, it is still highly likely that a proportion of vessels will be stationary or slow moving throughout operations at the Project for significant periods of time.

565. It is not expected that the level of vessel activity during operations would cause an increase in the risk of mortality from collisions. The adoption of a VMP during O&M will minimise the potential for any impact. Therefore, the risk of vessel collisions occurring is of **Negligible** magnitude.

566. All marine mammal receptors are deemed to be of low vulnerability given that vessel collision is not considered to be a key source of mortality highlighted from post-mortem examinations of stranded animals. However, should a collision event occur, this has the potential to kill the animal, from which they have no ability to recover from. As a result of the low vulnerability to a strike but the serious consequences of a strike, marine mammal receptors are considered to have a **Very High** sensitivity to vessel collisions.

567. The magnitude of the impact has been assessed as **Negligible** and the sensitivity of receptors as **Very High**. Therefore, the significance of the effect of collisions from O&M vessels is concluded to be of **Minor (not significant)** in terms of the EIA regulations.

11.6.1.17 Impact 16: Vessel disturbance

568. As stated in paragraph 515, the area surrounding the Project already experiences a high amount of vessel traffic (see Volume 1, Chapter 15: Shipping and Navigation for full details). Volume 1, Chapter 3: Project Description states the MDS is 36 vessels. Therefore, the introduction of additional vessels during O&M of the Project is not a novel impact for marine mammals present in the area.

569. Vessel noise levels from vessels during operations will result in an increase in non-impulsive, continuous sound in the vicinity of the Project array, typically in the range of 10 – 100Hz (although higher frequencies may also be produced) (Sinclair *et al*., 2021) with an estimated source level of 161 – 168 SEL_{cum} dB re 1 µPa@1m (RMS). It is anticipated that numerous different vessel types would be conducting round trips to and from port and the Project array area, but peak numbers for jack-up vessels would be two and service offshore vessels would be four.

570. 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 5km^2 area). Vessel traffic in the Project area, even considering the addition of the Project O&M traffic will still be well below this figure. The adoption of a VMP based on best practice vessel handing protocols (e.g. following the Codes of Conduct provided by the WiSe Scheme, Scottish Marine Wildlife Watching Code or Guide to Best Practice for Watching Marine Wildlife) during O&M will minimise the potential for any impact. Therefore, the impact is expected to be of **Low** magnitude.

571. All marine mammal receptors are deemed to be of low vulnerability given the existing evidence of behavioural responses to vessels (paragraph 529). Therefore, the sensitivity of marine mammal receptors to vessel disturbance is considered to be **Low**.

572. The magnitude of the impact has been assessed as **Low** and the sensitivity of receptors as **Low**. Therefore, the significance of the effect of disturbance from O&M vessels is concluded to be of **Negligible (not significant)** in terms of the EIA regulations.

11.6.1.18 Impact 17: Indirect impacts on prey

573. Any change in fish abundance and/or distribution as a result of the Project operations 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. The key prey species for each marine mammal receptor are listed in Table 11-78.

574. The presence of turbine infrastructure has the potential to impact on fish species by removing essential habitats (e.g. spawning, nursery and feeding habitats) (see Volume 1, Chapter 10: Fish and Shellfish Ecology). The Project array area overlaps with sandeel spawning grounds, but comparable habitats are present and widespread within the wider area.

575. Fishing pressure in the Project array area will be able to resume around and between infrastructure within the Project where possible, with a 50m operating distance advised for infrastructure, areas of cable protection and safety zones around infrastructure undergoing maintenance. However, individual decisions made by skippers of fishing vessels with their own perception of risk will determine the likelihood of whether fishing will resume in the array area. Additionally, the type and dimension of fishing gear will also influence whether fishing returns as some gear, such as twin-rigged trawls, require greater distances for safe operation. It would not be expected that any changes in fishing activities in this area would lead to changes in populations of prey species.

576. Any effects on fish species during the operational phase will be highly localised and therefore will have a **Negligible** magnitude on the prey availability for marine mammals.

577. 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 **Medium** sensitivity to changes in prey abundance and distribution.

578. The magnitude of the impact has been assessed as **Negligible** and the sensitivity of receptors as **Medium**. Therefore, the significance of the effect of changes in fish abundance/distribution during O&M the significance is concluded to be of **Negligible (not significant)** in terms of the EIA regulations.

11.6.1.19 Impact 18: Disturbance at seal haul-outs

579. Grey and harbour seals haul out at Donna Nook, the Wash, Blakeney Point, Horsey and Scroby Sands. There is the potential for disturbance to seals at haul out sites from the operational phase of the proposed development as a result of vessel traffic and transit of vessels (Paterson *et al*., 2015; Anderson *et al*., 2011; Jansen *et al*., 2015).

580. The vessel transit routes for the Project are based on the assumption of the Humber being the main port for operation and maintenance activities, which would bring vessels in closest proximity to the seal haul out sites.

581. Hauled out harbour seals exhibited a vigilance behaviour (head-lift) and experienced a 4 bpm vessel^{-1} increase in heart rate as a result of incidental vessel traffic, and a 5 bpm vessel^{-1} increase in heart rate from experimental vessel disturbance (Karpovich *et al*., 2015). The effect of the heart rate increase was still noticeable in following haul outs, indicating that the disturbance has a prolonged energetic cost for harbour seals, therefore the sensitivity of harbour seals to disturbance at haul-outs is therefore classified as **High**.

582. As detailed in paragraph 545, breeding male grey seals exhibit similar activity budgets across varying exposure to human activity which is considered to be driven by the increased mating success of males who maintain their position amongst groups of females for the longest time because of reduced energy expenditure, irrespective of human activity (Bishop *et al.,* 2015). Although Bishop *et al*. (2015) classified alert behaviours under the non-active category, increased alertness/vigilance and in turn, increased stress levels, can increase the heart rate of seals (irrespective of sex) and thus, energy expenditure. Should vessel disturbance to grey seals be repetitive, this could lead to increased heart rates over time and a prolonged energetic cost, therefore the sensitivity of grey seals to disturbance at haul-out sites is therefore classified as **High**.

583. The impact is predicted to be of local spatial extent, short term duration, intermittent and is reversible. In line with best-practise vessel management measures, where possible vessel traffic associated with the Project will follow existing shipping routes and are therefore unlikely to transit close to the key haul out sites (at Donna Nook and within the Wash). The magnitude is therefore considered to be **Negligible**

584. Overall, the sensitivity of seals to disturbance has been assessed as **High** and the magnitude is predicted to be **Negligible**. Therefore, the resulting impact significance for disturbance to seal haul outs is **Minor (not significant)** in EIA terms.

11.6.1.20 Impact 19 : Underwater noise from decommissioning

585. It is envisaged that piled foundations would be cut below seabed level, and the protruding section removed. Typical current methods for cutting piles are abrasive water jet cutters or diamond wire cutting. The final method chosen shall be dependent on the technologies available at the time of decommissioning.

586. 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 (Table 11-8) the significance of these impacts will be reduced. The impacts of decommissioning activities will likely be similar or of a lesser extent than during piling in the construction phase and therefore will be of negligible significance to **Minor** significance, which is **not significant** in terms of the EIA regulations.

11.6.1.21 Impact 20: Vessel collisions

587. As stated in section 515, the area surrounding the Project already experiences a high amount of vessel traffic (see Volume 1, Chapter 15: Shipping and Navigation). Volume 1, Chapter 3: Project Description states Project Description states that vessel numbers during decommissioning will be involve similar types and numbers of vessels as during construction. Therefore, the introduction of additional vessels during decommissioning of the Project is not a novel impact for marine mammals present in the area.

588. The adoption of a VMP based on best practice vessel handing protocols (e.g. following the Codes of Conduct provided by the WiSe Scheme, Scottish Marine Wildlife Watching Code or Guide to Best Practice for Watching Marine Wildlife) during decommissioning will minimise the potential for any impact. It is assumed that similar vessel types and number will be present in the Project array area as during the construction phase. Therefore, it is highly likely that a proportion of vessels will be stationary or slow moving throughout decommissioning activities for significant periods of time. Therefore, the actual increase in vessel traffic moving around the site and to/from port to the site will occur over short periods of the offshore decommissioning activity.

589. It is not expected that the level of vessel activity during decommissioning operations would cause an increase in the risk of mortality from collisions. The adoption of a VMP will minimise the potential for any impact. Therefore, the risk of vessel collisions occurring is of **Negligible** magnitude.

590. All marine mammal receptors are deemed to be of low vulnerability given that vessel collision is not considered to be a key source of mortality highlighted from post-mortem examinations of stranded animals. However, should a collision event occur, this has the potential to kill the animal, from which they have no ability to recover from. As a result of the low vulnerability to a strike but the serious consequences of a strike, marine mammal receptors are considered to have a **Very High** sensitivity to vessel collisions.

591. The magnitude of the impact has been assessed as **Negligible** and the sensitivity of receptors as **Very High**. Therefore, the significance of the effect of collision risk from decommissioning vessels is concluded to be of **minor (not significant)** in terms of the EIA regulations.

11.6.1.22 Impact 21: Vessel disturbance

592. Vessel noise levels from decommissioning vessels will result in an increase in non-impulsive, continuous sound in the vicinity of the Project array, typically in the range of 10 – 100Hz (although higher frequencies may also be produced) (Sinclair *et al*., 2021) with an estimated source level of 161 – 168dB re 1µPa@1m (RMS). It is anticipated that levels and types of vessel traffic during decommissioning would be similar to that during construction.

593. 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 5km^2 area). Vessel traffic in the Project area, even considering the addition of the Project decommissioning traffic will still be well below this figure. The adoption of a VMP based on best practice vessel handing protocols (e.g. following the Codes of Conduct provided by the WiSe Scheme, Scottish Marine Wildlife Watching Code or Guide to Best Practice for Watching Marine Wildlife) during decommissioning will minimise the potential for any impact. Therefore, the impact is expected to be of **Low** magnitude.

594. All marine mammal receptors are deemed to be of low vulnerability given the existing evidence of behavioural responses to vessels (see paragraph 529). Therefore, the sensitivity of marine mammal receptors to vessel disturbance is considered to be **Low**.

595. The magnitude of the impact has been assessed as **Low** and the sensitivity of receptors as **Low**. Therefore, the significance of the effect of disturbance from decommissioning vessels is concluded to be of **Negligible** significance for all cetaceans and seal species, which is **not significant** in terms of the EIA regulations.

11.6.1.23 Impact 22: Indirect impact on prey

596. Any change in fish abundance and/or distribution as a result of the Project decommissioning 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. The key prey species for each marine mammal receptor are listed in Table 11-78. 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 **Medium** sensitivity to changes in prey abundance and distribution.

597. Decommissioning of offshore infrastructure for the Project may result in temporarily elevated underwater noise levels and disturbance which may have effects on fish. However, the maximum noise levels and disturbance are anticipated to be far below that than during pile driving in the construction phase, therefore the impacts would also be less. The assessment provided in Volume 1, Chapter 10: Fish and Shellfish Ecology indicates that the overall adverse impacts to fish species from the decommissioning of the Project will be of negligible magnitude and thus the predicted impact on marine mammals is of **Negligible** magnitude.

598. The magnitude of the impact has been assessed as **Negligible** and the sensitivity of receptors as **Medium**. Therefore, the significance of the effect of changes in fish abundance/distribution is concluded to be of **Negligible** significance, which **is not significant** in terms of the EIA regulations.

11.6.1.24 Impact 23: Water quality impacts

599. During decommissioning, SSC could potentially be increased and associated deposition of material within the Project array and the offshore ECC from the following activities:

- Removal of foundation structures;
- Cutting off of monopiles and jacket foundation legs; and
- (Possible) removal of cables.

600. Any disturbance to the seabed will be localised and any resultant increase in SSC will be temporary. The changes in SSC and resultant water quality during decommissioning are anticipated to be lesser than those associated with construction. Short-term increased turbidity is not anticipated to impact marine mammals which rely primarily on hearing, resulting in **Low** sensitivity to changes in water quality.

601. The increase in SSC will be temporary and therefore the magnitude has been assessed as **Negligible** .

602. The magnitude of the impact has been assessed as **Negligible** and the sensitivity of receptors as **Low**. Therefore, the significance of the effect of changes in water quality is concluded to be of **Negligible (not significant**) in terms of the EIA regulations.

11.6.1.25 Impact 24 : Disturbance at seal haul-outs

603. Grey and harbour seals haul out at Donna Nook, the Wash, Blakeney Point, Horsey and Scroby Sands. There is the potential for disturbance to seals at haul out sites from the decommissioning phase of the proposed development as a result of vessel traffic and transit of vessels (Paterson *et al*., 2015; Anderson *et al*., 2011; Jansen *et al*., 2015).

604. The vessel transit routes for the Project are based on the assumption of the Humber being the main port for decommissioning activities (as has been assumed for construction and operation phases), which would bring vessels in closest proximity to the seal haul out sites.

605. Hauled out harbour seals exhibited a vigilance behaviour (head-lift) and experienced a 4 bpm vessel^{-1} increase in heart rate as a result of incidental vessel traffic, and a 5 bpm vessel^{-1} increase in heart rate from experimental vessel disturbance (Karpovich *et al.*, 2015). The effect of the heart rate increase was still noticeable in following haul outs, indicating that the disturbance has a prolonged energetic cost for harbour seals, therefore the sensitivity of harbour seals to disturbance at haul-outs is therefore classified as **High**.

606. As detailed in paragraph 545, breeding male grey seals exhibit similar activity budgets across varying exposure to human activity which is considered to be driven by the increased mating success of males who maintain their position amongst groups of females for the longest time because of reduced energy expenditure, irrespective of human activity (Bishop *et al*., 2015). Although Bishop *et al*. (2015) classified alert behaviours under the non-active category, increased alertness/vigilance and in turn, increased stress levels, can increase the heart rate of seals (irrespective of sex) and thus, energy expenditure. Should vessel disturbance to grey seals be repetitive, this could lead to increased heart rates over time and a prolonged energetic cost therefore the sensitivity of grey seals to disturbance at haul-out sites is therefore classified as **High**.

607. The impact is predicted to be of local spatial extent, short term duration, intermittent and is reversible. In line with best-practise vessel management measures, where possible vessel traffic associated with the Project will follow existing shipping routes and are therefore unlikely to transit close to the key haul out sites (at Donna Nook and within the Wash). The magnitude is therefore considered to be **Negligible**

608. Overall, the sensitivity of seals to disturbance has been assessed as **High** and the magnitude is predicted to be **Negligible**. Therefore, the resulting impact significance for disturbance to seal haul outs is **Minor (not significant)** in EIA terms.

11.7 Cumulative Impact Assessment

609. Cumulative effects can be defined as effects upon a single receptor when those from the Project are considered alongside other proposed and reasonably foreseeable projects and developments. This includes all projects that result in a comparative effect that is not intrinsically considered as part of the existing environment and is not limited to offshore wind projects. A screening process has identified a number of reasonably foreseeable projects and developments which may act cumulatively with the Project. The full list of such projects that have been identified in relation to the offshore environment are set out in. Volume 1, Chapter 5: Environmental Impact Assessment Methodology (document reference 6.1.5).

610. In assessing the potential cumulative impacts for the Project, it is important to consider that some projects, predominantly those 'proposed' or identified in development plans, may not actually be taken forward, or fully built out as described within their MDS. There is, therefore, a need to build in some consideration of certainty (or uncertainty) with respect to the potential impacts which might arise from such proposals. For example, those projects under construction are likely to contribute to cumulative impacts (providing effect or spatial pathways exist), whereas those proposals not yet approved are less likely to contribute to such an impact, as some may not achieve approval or may not ultimately be built due to other factors.

611. With this in mind, all projects and plans considered alongside the Project have been allocated into 'tiers' reflecting their current stage within the planning and development process. This allows the cumulative impact assessment to present several future development scenarios, each with a differing potential for being ultimately built out. This approach also allows appropriate weight to be given to each scenario (tier) when considering the potential cumulative impact. The proposed tier structure is intended to ensure that there is a clear understanding of the level of confidence in the cumulative effects assessment (CEA). An explanation of each tier is included in Table 11-80. This tier structure is in line with that recommended by Natural England (2022).

Table 11-80: Description of tiers of other developments considered within the marine mammal cumulative effect assessment (Natural England, 2022).

Tier	Consenting or construction stage
1	Built and operational projects should be included within the cumulative assessment where they have not been included within the environmental characterisation survey, i.e. they were not operational when baseline surveys were undertaken, and/or any residual impact may not have yet fed through to and been captured in estimates of "baseline" conditions.
2	Projects under construction.
3	Projects that have been consented (but construction has not yet commenced).
4	Projects that have an application submitted to the appropriate regulatory body that have not yet been determined.
5	Projects that have produced a PEIR and have characterisation data within the public domain.
6	Projects that the regulatory body are expecting an application to be submitted for determination (e.g. projects listed under the Planning Inspectorate programme of projects).
7	Projects that have been identified in relevant strategic plans or programmes.

11.7.1 Screening Projects

612. 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 on the basis of 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 (North Sea MU for porpoise, Greater North Sea MU for bottlenose dolphins, Celtic and Greater North Seas MU for white-beaked dolphins and minke whales, Southeast England MU for harbour seals, combined Southeast and Northeast MUs for grey seals).

613. The time period considered in the CEA for marine mammals is 2022-2032 inclusive. This allows for the quantification of impacts to the MUs both prior to the construction of the Project (since the baseline was collated) and during the potential construction window for the Project (the potential construction window for the Project is expected to be: UXO clearance in 2026 and piling in 2027-2029 inclusive).

614. The CEA methodology and long-list are described in Chapter 5 (document reference 6.1.5). 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.

615. Subsequently, the following offshore project types were screened out of the marine mammal CEA short list:

- Wave developments (none constructing between 2026-29);
- Cables and pipelines (all operational: ongoing impact and part of the baseline);
- Commercial fisheries (all operational: ongoing impact and part of the baseline);
- Shipping (all active: ongoing impact and part of the baseline);
- Aggregates (all operational: ongoing impact and part of the baseline);
- Oil and Gas (all active: ongoing impact and part of the baseline);
- Military, Aviation & Radar (all active: ongoing impact and part of the baseline); and
- Coastal (all active: ongoing impact and part of the baseline).

616. The marine mammal CEA short list therefore consists of the following offshore project types:

- Offshore windfarms (fixed and floating);
- Cables;
- Pipelines;
- Tidal developments; and
- Oil and Gas seismic surveys (including for Carbon Capture and Storage).

617. While this CEA has attempted to quantify potential impacts across all Tiers (1-7), the conclusions have been drawn based upon the quantitative assessment for Tiers 1-3 since these projects are consented and thus have the highest levels of data confidence in terms of potential construction timeline and the availability of a quantitative assessment for the animals disturbed.

Table 11-81: Marine mammal CEA short list. HP = harbour porpoise, BND = bottlenose dolphin, WD = white-beaked dolphin, MW = minke whale, HS = harbour seal and GS = grey seal. 'Y' indicates that the project is within the species-specific MU, 'N' indicates that the project is not within the species-specific MU (and is thus screened out for that specific species)

Project	Type	Status	IA?[29]	Tier	HP	BD	WD	MW	HS	GS
The Project	OWF	-	-	-	Y	Y	Y	Y	Y	Y
ANIAR Offshore Array - Phase 1	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
ANIAR Offshore Array - Phase 2	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
Arklow Bank 2	OWF	Pre-planning Application	YES	4	N	N	Y	Y	N	N
Arklow Bank Phase 1	OWF	Active	NO	1	N	N	Y	Y	N	N
Arven	OWF	Early Planning	NO	6	Y	Y	Y	Y	N	N
Aspen	OWF	Pre-planning Application	NO	6	Y	Y	Y	Y	N	N
Atlantic Marine Energy Test Site	OWF	Consented	YES	3	N	N	Y	Y	N	N

[29] Denotes whether or not the results of a quantitative impact assessment (ES or PEIR) were available to use in this CEA

Project	Type	Status	IA?[29]	Tier	HP	BD	WD	MW	HS	GS
Awel y Môr	OWF	Consented	YES	3	N	N	Y	Y	N	N
Ayre	OWF	Early Planning	NO	6	Y	Y	Y	Y	N	N
Baltic Eagle	OWF	In Construction	NO	2	N	N	N	N	N	N
Banba	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
Beech	OWF	Pre-planning Application	NO	6	Y	Y	Y	Y	N	N
Berwick Bank	OWF	Determination	YES	4	Y	Y	Y	Y	N	N
Blackwater	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
Blyth Demonstration Phases 2&3	OWF	Consented	YES	3	Y	Y	Y	Y	N	N
Borkum Riffgrund 1	OWF	Active	EU	1	Y	Y	Y	Y	N	N
Borkum Riffgrund 2	OWF	Active	EU	1	Y	Y	Y	Y	N	N
Borkum Riffgrund 3	OWF	Construction	EU	2	Y	Y	Y	Y	N	N
Borkum Riffgrund West 1	OWF	Active	EU	1	Y	Y	Y	Y	N	N
Borkum Riffgrund West 2	OWF	Construction	EU	2	Y	Y	Y	Y	N	N
Borkum Riffgrund West II	OWF	Active	EU	1	Y	Y	Y	Y	N	N
Borssele Kavel I	OWF	Active	EU	1	Y	Y	Y	Y	N	N
Borssele Kavel II	OWF	Active	EU	1	Y	Y	Y	Y	N	N
Borssele Kavel III	OWF	Active	EU	1	Y	Y	Y	Y	N	N
Borssele Kavel IV	OWF	Active	EU	1	Y	Y	Y	Y	N	N
Borssele Kavel V	OWF	Active	EU	1	Y	Y	Y	Y	N	N
Bowdun	OWF	Early Planning	NO	6	Y	Y	Y	Y	N	N
BP (AKA Flora)	OWF	Early Planning	NO	6	Y	Y	Y	Y	Y	Y
Broadshore	OWF	Early Planning	NO	6	Y	Y	Y	Y	N	N
Buchan	OWF	Early Planning	NO	6	Y	Y	Y	Y	N	N
Cailleach	OWF	Early Planning	NO	6	N	N	Y	Y	N	N

Project	Type	Status	IA?[29]	Tier	HP	BD	WD	MW	HS	GS
Caledonia	OWF	Application submitted	YES	4	Y	Y	Y	Y	N	N
Campion Wind	OWF	Early Planning	NO	6	Y	Y	Y	Y	N	N
Cedar	OWF	Early Planning	NO	6	Y	Y	Y	Y	N	N
Celtic One	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
Cenos	OWF	Application submitted	YES	4	Y	Y	Y	Y	N	N
Centre-Manche 1	OWF	Early Planning	EU	6	N	N	Y	Y	N	N
Centre-Manche 2	OWF	Early Planning	EU	6	N	N	Y	Y	N	N
Clarus	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
Clogher Head	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
Cluaran Deas Ear	OWF	Pre-planning Application	NO	6	Y	Y	Y	Y	N	N
CS006	CCS	Licensing Area	NO	7	Y	Y	Y	Y	N	N
CS007	CCS	Licensing Area	NO	7	Y	Y	Y	Y	N	N
Codling Wind Park	OWF	Application Submitted	YES	4	N	N	Y	Y	N	N
Codling Wind Park Extension	OWF	Pre-planning Application	NO	6	N	N	Y	Y	N	N
Cooley Point	OWF	Pre-planning Application	NO	6	N	N	Y	Y	N	N
Courseulles-sur-mer	OWF	Construction	EU	2	N	N	Y	Y	N	N
Culzean	OWF	Consented	YES	3	Y	Y	Y	Y	N	N
Dieppe - Le Treport	OWF	Consented	EU	3	N	N	Y	Y	N	N
DMAP	OWF	Early Planning	NO	7	N	N	Y	Y	N	N
Dogger Bank A	OWF	Construction	YES	2	Y	Y	Y	Y	Y	Y
Dogger Bank B	OWF	Construction	YES	2	Y	Y	Y	Y	Y	Y

Project	Type	Status	IA?[29]	Tier	HP	BD	WD	MW	HS	GS
Dogger Bank C	OWF	Construction	YES	2	Y	Y	Y	Y	Y	Y
Dogger Bank D	OWF	Pre-planning Application	NO	6	Y	Y	Y	Y	Y	Y
Dogger Bank South (East)	OWF	In examination	YES	5	Y	Y	Y	Y	Y	Y
Dogger Bank South (West)	OWF	In examination	YES	5	Y	Y	Y	Y	Y	Y
Draig y Mor	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
Dublin Array[30]	OWF	Application Submitted	NO	4	N	N	Y	Y	N	N
Dublin Northeast	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
Dudgeon Ext	OWF	Consented	YES	3	Y	Y	Y	Y	Y	Y
Dunkerque	OWF	Early Planning	EU	6	Y	Y	Y	Y	N	N
E1	OWF	Licensing Area	NO	7	Y	Y	Y	Y	N	N
E2	OWF	Licensing Area	NO	7	Y	Y	Y	Y	N	N
E3	OWF	Licensing Area	NO	7	Y	Y	Y	Y	N	N
E4	OWF	Licensing Area	NO	7	Y	Y	Y	Y	N	N
E5	OWF	Licensing Area	NO	7	Y	Y	Y	Y	N	N
East Anglia One	OWF	Active	YES	1	Y	Y	Y	Y	Y	Y
East Anglia One North	OWF	Consented	YES	3	Y	Y	Y	Y	Y	Y
East Anglia Three	OWF	Consented	YES	3	Y	Y	Y	Y	Y	Y
East Anglia Two	OWF	Consented	YES	3	Y	Y	Y	Y	Y	Y
Eastern Green Link 3 (EGL3)	Cable	Early Planning	NO	6	Y	Y	Y	Y	Y	Y
Eastern Green	Cable	Early Planning	NO	6	Y	Y	Y	Y	Y	Y

[30] Application submitted to An Bord Pleanála, but Environmental Impact Assessment not yet publicly available online

Project	Type	Status	IA?[29]	Tier	HP	BD	WD	MW	HS	GS
Link 4 (EGL4)										
EIS Area 1	CCS	Licensing Round	NO	7	N	N	Y	Y	N	N
Emerald	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
EnBW He dreiht	OWF	Approved	EU	2	Y	Y	Y	Y	N	N
Endurance	CCS	Area for Lease	NO	6	Y	Y	Y	Y	Y	Y
Erebus Demo	OWF	Consented	YES	3	N	N	Y	Y	N	N
Fecamp	OWF	Construction	EU	2	Y	Y	Y	Y	N	N
Five Estuaries	OWF	In examination	YES	4	Y	Y	Y	Y	Y	Y
Forthwind Ltd	OWF	Consented	YES	3	Y	Y	Y	Y	N	N
Gas Shearwater to Bacton Seal Line	Pipeline	Active / In-Operation	NO	6	Y	Y	Y	Y	Y	Y
Gebied 1 Noord (1-n)	OWF	Option area	EU	7	Y	Y	Y	Y	N	N
Gebied 1 Zuid (1-z)	OWF	Early Planning	EU	7	Y	Y	Y	Y	N	N
Gebied 2 Noord (2-n)	OWF	Option area	EU	7	Y	Y	Y	Y	N	N
Gebied 2 Zuid (2-z)	OWF	Option area	EU	7	Y	Y	Y	Y	N	N
Gebied 5 Oost (5-o)	OWF	Option area	EU	7	Y	Y	Y	Y	N	N
Gode Wind 3	OWF	Construction	EU	2	Y	Y	Y	Y	N	N
Green Volt	OWF	Consented	YES	4	Y	Y	Y	Y	N	N
Greystones	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
Harbour Energy North	OWF	Early Planning	NO	6	Y	Y	Y	Y	N	N
Havbredey	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
Helvick Head	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
Hesselk	OWF	Concept /Early Planning	EU	6	N	N	N	N	N	N
HKN Kavel V	OWF	Approved	EU	4	Y	Y	Y	Y	N	N

Project	Type	Status	IA?[29]	Tier	HP	BD	WD	MW	HS	GS
HKW Noord - HKW-N	OWF	Early Planning	EU	6	Y	Y	Y	Y	N	N
HKZ Kavel III	OWF	Construction	EU	2	Y	Y	Y	Y	N	N
HKZ Kavel IV	OWF	Construction	EU	2	Y	Y	Y	Y	N	N
Hollandse Kust (Noord)	OWF	Construction	EU	2	Y	Y	Y	Y	N	N
Hollandse Kust (West)	OWF	Planned	EU	6	Y	Y	Y	Y	N	N
Hollandse Kust (Zuid)	OWF	Construction	EU	2	Y	Y	Y	Y	N	N
Hollandse Kust west zuidelijk deel	OWF	Early Planning	EU	6	Y	Y	Y	Y	N	N
Hollandse Kust Zuid Holland III	OWF	Construction	EU	2	Y	Y	Y	Y	N	N
Hornsea Project Four	OWF	Consented	YES	3	Y	Y	Y	Y	Y	Y
Hornsea Project Three	OWF	Consented	YES	3	Y	Y	Y	Y	Y	Y
Hornsea Project Two	OWF	Active	YES	2	Y	Y	Y	Y	Y	Y
IJmuiden Ver	OWF	Early Planning	EU	6	Y	Y	Y	Y	N	N
IJmuiden Ver Noord	OWF	Early Planning	EU	6	Y	Y	Y	Y	N	N
Ilen	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
Inch Cape Offshore Ltd	OWF	Construction	YES	2	Y	Y	Y	Y	N	N
Inis Ealga Marine Energy Park	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
Jyske Banke	OWF	Early Planning	EU	6	Y	Y	Y	Y	N	N
Kaskasi II	OWF	Active	EU	1	Y	Y	Y	Y	N	N
Kattegatt I	OWF	Concept /Early Planning	EU	6	N	N	N	N	N	N
Kattegatt Offshore	OWF	Concept /Early Planning	EU	6	N	N	N	N	N	N

Project	Type	Status	IA?[29]	Tier	HP	BD	WD	MW	HS	GS
Kattegatt Syd	OWF	Concept /Early Planning	EU	6	N	N	N	N	N	N
Kilmichael Point	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
Kincardine Phase 1	OWF	Active	YES	1	Y	Y	Y	Y	N	N
Kinsale	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
Krigers Flak Syd	OWF	Concept /Early Planning	EU	6	N	N	N	N	N	N
Latitude 52	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
Lir (Future Development Area)	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
Lir (Site A)	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
Lir (Site B)	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
Llyr 1 Cierco Ltd.,SBM Offshore N.V.	OWF	Application Submitted	YES	4	N	N	Y	Y	N	N
Llyr 2 Cierco Ltd.,SBM Offshore N.V.	OWF	Application Submitted	YES	4	N	N	Y	Y	N	N
Machair	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
Malin Sea Wind	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
Marram	OWF	Pre-planning Application	NO	6	Y	Y	Y	Y	N	N
Mona	OWF	Determination	YES	4	N	N	Y	Y	N	N
Moneypoint One	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
Mooir Vannin	OWF	Pre-planning Application	NO	6	N	N	Y	Y	N	N
Moray West	OWF	Construction	YES	2	Y	Y	Y	Y	N	N
Morecambe	OWF	In examination	YES	4	N	N	Y	Y	N	N
Morgan	OWF	Determination	YES	4	N	N	Y	Y	N	N
Morven	OWF	Pre-planning	NO	6	N	N	Y	Y	N	N

Project	Type	Status	IA?[29]	Tier	HP	BD	WD	MW	HS	GS
		Application								
Muir Mhòr	OWF	Application Submitted	YES	4	Y	Y	Y	Y	N	N
N-10.1	OWF	Development Zone	EU	7	Y	Y	Y	Y	N	N
N-10.2	OWF	Development Zone	EU	7	Y	Y	Y	Y	N	N
N-3.7	OWF	Development Zone	EU	7	Y	Y	Y	Y	N	N
N-6.6	OWF	Development Zone	EU	7	Y	Y	Y	Y	N	N
N-6.7	OWF	Development Zone	EU	7	Y	Y	Y	Y	N	N
N-9.1	OWF	Development Zone	EU	7	Y	Y	Y	Y	N	N
N-9.2	OWF	Development Zone	EU	7	Y	Y	Y	Y	N	N
N-9.3	OWF	Development Zone	EU	7	Y	Y	Y	Y	N	N
N-9.4	OWF	Development Zone	EU	7	Y	Y	Y	Y	N	N
Neart Na Gaoithe	OWF	Construction	YES	2	Y	Y	Y	Y	N	N
CS013	CCS	Licensing Round	NO	7	Y	Y	Y	Y	N	N
CS014	CCS	Licensing Round	NO	7	Y	Y	Y	Y	N	N
CS015	CCS	Licensing Round	NO	7	Y	Y	Y	Y	N	N
CS016	CCS	Licensing Round	NO	7	Y	Y	Y	Y	N	N
Nordlicht I	OWF	Early Planning	EU	6	Y	Y	Y	Y	N	N
Nordsee Cluster A - N-3.8	OWF	Early Planning	EU	6	Y	Y	Y	Y	N	N
Nordsee Cluster B - N-3.5	OWF	Planned	EU	6	Y	Y	Y	Y	N	N
Nordsee Cluster B - N-3.6	OWF	Planned	EU	6	Y	Y	Y	Y	N	N
Nordsren I	OWF	Early Planning	EU	6	Y	Y	Y	Y	N	N
Nordsren II	OWF	Pre-planning Application	EU	6	Y	Y	Y	Y	N	N

Project	Type	Status	IA?[29]	Tier	HP	BD	WD	MW	HS	GS
Nordsren II vest	OWF	Early Planning	EU	6	Y	Y	Y	Y	N	N
Nordsren III	OWF	Early Planning	EU	6	Y	Y	Y	Y	N	N
Nordsren III vest	OWF	Planned	EU	6	Y	Y	Y	Y	N	N
Norfolk Boreas	OWF	Consented	YES	3	Y	Y	Y	Y	Y	Y
Norfolk Vanguard East	OWF	Consented	YES	3	Y	Y	Y	Y	Y	Y
Norfolk Vanguard West	OWF	Consented	YES	3	Y	Y	Y	Y	Y	Y
North Channel Wind 1	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
North Channel Wind 2	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
North Falls	OWF	In examination	YES	4	Y	Y	Y	Y	Y	Y
North Irish Sea Array	OWF	Application Submitted	YES	4	N	N	Y	Y	N	N
Norther	OWF	Active	EU	1	Y	Y	Y	Y	N	N
Northwester 2	OWF	Active	EU	1	Y	Y	Y	Y	N	N
Oriel	OWF	Pre-planning Application	NO	6	N	N	Y	Y	N	N
Paludan Flak	OWF	Concept /Early Planning	EU	6	N	N	N	N	N	N
Pentland OWF	OWF	Consented	YES	3	Y	N	Y	Y	N	N
Perpetuus Tidal Energy	Tidal	Construction	YES	2	N	N	Y	Y	N	N
Peterhead to South Humber	Cable	Proposed	NO	6	Y	Y	Y	Y	N	N
Poseidon	OWF	Concept /Early Planning	NO	6	Y	Y	Y	Y	N	N
Rampion Ext	OWF	In determination	YES	4	Y	N	Y	Y	Y	Y
Round 5 PDA1	OWF	Leasing Round	NO	7	N	N	Y	Y	N	N
Round 5 PDA2	OWF	Leasing Round	NO	7	N	N	Y	Y	N	N
Round 5 PDA3	OWF	Leasing Round	NO	7	N	N	Y	Y	N	N
Saint-Brieuc	OWF	Construction	EU	2	N	N	Y	Y	N	N

Project	Type	Status	IA?[29]	Tier	HP	BD	WD	MW	HS	GS
Saint-Nazaire	OWF	Construction	EU	2	N	N	Y	Y	N	N
Salamander	OWF	Application Submitted	YES	4	Y	Y	Y	Y	N	N
Scarabeen	OWF	Early Planning	NO	6	Y	Y	Y	Y	N	N
Sceirde Rocks	OWF	Application Submitted	NO	4	N	N	Y	Y	N	N
Scroby Sands	OWF	Active	NO	1	Y	Y	Y	Y	Y	Y
Sea Stacks	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
Seagreen Alpha	OWF	Active	YES	1	Y	Y	Y	Y	N	N
Sealtainn	OWF	Early Planning	NO	6	Y	Y	Y	Y	N	N
Seastar	OWF	Active	EU	1	Y	Y	Y	Y	N	N
Setanta Wind Park	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
Shearwater One	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
Shelmalere	OWF	Pre-planning Application	NO	6	N	N	Y	Y	N	N
Sheringham Shoal Ext	OWF	Consented	YES	2	Y	Y	Y	Y	Y	Y
Sinclair	OWF	Early Planning	NO	6	Y	Y	Y	Y	N	N
CS020	CCS	Licensing Area	NO	7	Y	Y	Y	Y	Y	Y
CS025	CCS	Licensing Area	NO	7	Y	Y	Y	Y	Y	Y
CS026	CCS	Licensing Area	NO	7	Y	Y	Y	Y	N	N
CS027	CCS	Licensing Area	NO	7	N	N	Y	Y	N	N
CS028	CCS	Licensing Area	NO	7	Y	Y	Y	Y	Y	Y
CS008	CCS	Licensing Area	NO	7	Y	Y	Y	Y	Y	Y
CS009	CCS	Licensing Area	NO	7	Y	Y	Y	Y	Y	Y
CS019	CCS	Licensing Area	NO	7	Y	Y	Y	Y	Y	Y
Sofia	OWF	Construction	YES	2	Y	Y	Y	Y	Y	Y
South East Scotland to South Humber	Cable	Proposed	NO	6	Y	Y	Y	Y	N	N

Project	Type	Status	IA?[29]	Tier	HP	BD	WD	MW	HS	GS
South East Wind	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
South Irish Sea	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
Spiorad na Mara	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
Stoura	OWF	Concept /Early Planning	NO	6	Y	Y	Y	Y	N	N
Stromar	OWF	Early Planning	NO	6	Y	Y	Y	Y	N	N
Sud Atlantique	OWF	Early Planning	NO	6	N	N	N	N	N	N
Sud de la Bretagne	OWF	Early Planning	NO	6	N	N	N	N	N	N
Sud de la Bretagne Extension	OWF	Early Planning	NO	6	N	N	N	N	N	N
Sunrise	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
Talisk	OWF	Early Planning	NO	6	N	N	Y	Y	N	N
Thor	OWF	Construction	EU	2	Y	Y	Y	Y	N	N
Trem Mkllebugt	OWF	Early Planning	EU	6	N	N	N	N	N	N
Triton Knoll	OWF	Active	YES	2	Y	Y	Y	Y	N	N
TwinHub	OWF	Consented	YES	3	N	N	Y	Y	N	N
Vesterhav Nord	OWF	Construction	EU	2	Y	Y	Y	Y	N	N
Vesterhav Syd	OWF	Construction	EU	2	Y	Y	Y	Y	N	N
Viking Link	Cable	Complete/In Operation	YES	2	Y	Y	Y	Y	N	N
West Anglesey Demonstration Zone	Tidal	Construction	YES	2	N	N	Y	Y	N	N
West of Orkney	OWF	S36 under consideration	YES	4	N	N	Y	Y	N	N
White Cross	OWF	In planning	YES	4	N	N	Y	Y	N	N
Wicklow	OWF	Early Planning	NO	5	N	N	Y	Y	N	N
Windenergiegebied Borssele noordzij	OWF	Early Planning	EU	6	Y	Y	Y	Y	N	N

Project	Type	Status	IA?[29]	Tier	HP	BD	WD	MW	HS	GS
de/Borsele 1										
Windenergiegebied Borssele noordzijde/Borsele 2	OWF	Early Planning	EU	6	Y	Y	Y	Y	N	N
Seismic survey 1	Seismic	N/A	NO	7	Y	Y	Y	Y	Y	Y
Seismic survey 2	Seismic	N/A	NO	7	Y	Y	Y	Y	Y	Y
Seismic survey 3	Seismic	N/A	NO	7	Y	Y	Y	Y	N	N
Seismic survey 4	Seismic	N/A	NO	7	Y	Y	Y	Y	N	N

Table 11-82: Offshore construction programme for each project in the marine mammal CEA short list. U = years in which UXO clearance is expected; P = years in which piling activities are expected, C = years in which tidal/cable/CCS projects are expected to be constructing, S = years in which seismic surveys are expected, D = years in which decommissioning activities are expected. The indicative project construction period (UXO clearance in 2026, piling between 2027 and 2029) is indicated by the red box.

Project	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
The Project						U	P	P	P			
ANIAR Offshore Array - Phase 1						P	P	P	P			
ANIAR Offshore Array - Phase 2						P	P	P	P			
Arklow Bank Phase 1	P	P										
Arklow Bank 2							P					
Arven						P	P	P	P			
Aspen						P	P	P	P			
Atlantic Marine Energy Test Site	P	P	P									
Awel y Môr						P	P	P	P	P		
Ayre						P	P	P	P			
Baltic Eagle		P	P	P								
Banba						P	P	P	P			
Beech						P	P	P	P			
Berwick Bank							P					
Blackwater						P	P					
Blyth Demonstration Phases 2&3				P								
Borkum Riffgrund 1				P								

Project	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Borkum Riffgrund 2				P								
Borkum Riffgrund 3	P	P	P	P								
Borkum Riffgrund West 1				P								
Borkum Riffgrund West 2				P								
Borkum Riffgrund West II				P								
Borssele Kavel I	P											
Borssele Kavel II	P											
Borssele Kavel III	P											
Borssele Kavel IV	P											
Borssele Kavel V	P	P										
Bowdun									P	P	P	
BP (AKA Flora)						P	P	P	P			
Broadshore		P	P	P	P	P						
Buchan									P	P	P	P
Cailleach						P	P	P	P			
Caledonia							P	P	P	P		
CampionWind				P	P	P	P	P				
Cedar								P				
Celtic One						P	P	P	P			
Cenos											P	P
Centre-Manche 1											P	P
Centre-Manche 2						P	P	P	P			
Clarus						P	P	P	P			
Clogher Head						P	P	P	P			
Cluaran Deas Ear				P	P	P	P	P				
CS006				C	C	C						
CS007				C	C	C						
Codling Wind Park							P	P	P			
Codling Wind Park Extension						P	P	P	P			
Cooley Point	P	P	P	P	P	P						
Courseulles-sur-mer		P	P									
Culzean						P	P	P	P			
Dieppe - Le Treport					P							
DMAP						P	P	P	P			
Dogger Bank A		P										
Dogger Bank B		P	P	P	P							
Dogger Bank C				P	P	P	P					
Dogger Bank D							P	P	P			
Dogger Bank South (East)						P	P	P	P			
Dogger Bank South (West)						P	P	P	P			

Project	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Draig y Mor						P	P	P	P			
Dublin Array						P	P					
Dublin Northeast							P	P				
Dudgeon Ext						P	P	P				
Dunkerque					P	P	P	P				
E1									P			
E2									P			
E3									P			
E4									P			
E5									P			
East Anglia One	P											
East Anglia One North			P	P	P	P						
East Anglia Three		P	P	P								
East Anglia Two			P	P	P	P						
Eastern Green Link 3 (EGL3)								C	C			
Eastern Green Link 4 (EGL4)								C	C			
EIS Area 1				C	C	C						
Emerald						P	P	P	P			
EnBW He dreiht			P	P								
Endurance			P	P	P							
Erebus Demo			P	P	P	P						
Fecamp	P	P	P									
Five Estuaries							P	P	P	P	P	P
Forthwind Ltd				P	P	P	P	P				
Gas Shearwater to Bacton Seal Line					C	C	C	C	C	C	C	C
Gebied 1 Noord (1-n)						P	P	P	P			
Gebied 1 Zuid (1-z)						P	P	P	P			
Gebied 2 Noord (2-n)						P	P	P	P			
Gebied 2 Zuid (2-z)						P	P	P	P			
Gebied 5 Oost (5-o)						P	P	P	P			
Gode Wind 3			P									
Green Volt							P					
Greystones								P	P			
Harbour Energy North						P	P	P	P			
Havbredey						P	P	P	P			
Helvick Head						P	P	P	P			
Hesselk							P	P				
HKN Kavel V	P	P										
HKW Noord - HKW-N												
HKZ Kavel III	P	P	P	P								

Project	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
HKZ Kavel IV	P	P										
Hollandse Kust (Noord)	P	P										
Hollandse Kust (West)				P	P							
Hollandse Kust (Zuid)	P	P										
Hollandse Kust west zuidelijk deel	P	P	P									
Hollandse Kust Zuid Holland III	P	P										
Hornsea Project Four					P	P	P	P	P	P		
Hornsea Project Three					P	P	P	P	P	P	P	P
Hornsea Project Two	P	P										
IJmuiden Ver						P						
IJmuiden Ver Noord				P	P	P	P					
Ilen						P	P	P	P			
Inch Cape Offshore Ltd	P	P	P									
Inis Ealga Marine Energy Park						P	P	P	P			
Jyske Banke						P	P	P	P			
Kaskasi II	P	P										
Kattegatt I								P	P			
Kattegatt Offshore								P	P	P		
Kattegatt Syd												
Kilmichael Point						P	P	P	P			
Kincardine Phase 1	P											
Kinsale						P	P	P	P			
Krigers Flak Syd						P	P	P	P			
Latitude 52						P	P	P	P			
Lir (Future Development Area)						P	P	P	P			
Lir (Site A)						P	P	P	P			
Lir (Site B)						P	P	P	P			
Llyr 1 Cierco Ltd.,SBM Offshore N.V.						P						
Llyr 2 Cierco Ltd.,SBM Offshore N.V.						P						
Machair						P	P	P	P			
Malin Sea Wind						P	P	P	P			
Marram										P		
Mona						P	P					
Moneypoint One						P	P	P	P			
Mooir Vannin						P	P	P	P			
Moray West		P	P	P								
Morecambe						P	P	P				
Morgan						P	P					
Morven				P	P	P	P	P				
Muir Mhòr									P	P		

Project	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
N-10.1						P	P	P	P			
N-10.2						P	P	P	P			
N-3.7						P	P	P	P			
N-6.6						P	P	P	P			
N-6.7						P	P	P	P			
N-9.1						P	P	P	P			
N-9.2						P	P	P	P			
N-9.3						P	P	P	P			
N-9.4						P	P	P	P			
Neart Na Gaoithe	P	P	P									
CS013				C	C	C						
CS014				C	C	C						
CS015				C	C	C						
CS016				C	C	C						
Nordlicht I						P						
Nordsee Cluster A - N-3.8							P					
Nordsee Cluster B - N-3.5								P				
Nordsee Cluster B - N-3.6							P					
Nordsren I				P								
Nordsren II				P								
Nordsren II vest				P								
Nordsren III				P								
Nordsren III vest				P								
Norfolk Boreas			P	P	P	P						
Norfolk Vanguard East			P	P	P							
Norfolk Vanguard West			P	P	P							
North Channel Wind 1									P	P		
North Channel Wind 2										P	P	
North Falls						P	P	P	P			
North Irish Sea Array						P	P	P				
Norther	P											
Northwester 2	P											
Oriel						P	P	P	P			
Paludan Flak					P	P	P	P				
Pentland OWF					P	P						
Perpetuus Tidal Energy		C	C	C	C							
Peterhead to South Humber		C	C	C	C	C	C	C	C	C		
Poseidon							P	P	P	P	P	
Rampion Ext					P	P						
Round 5 PDA1						P	P	P	P			

Project	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Round 5 PDA2						P	P	P	P			
Round 5 PDA3						P	P	P	P			
Saint-Brieuc	P	P	P									
Saint-Nazaire	P	P										
Salamander								P				
Scaraben						P	P	P	P			
Sceirde Rocks						P	P	P	P			
Scroby Sands											D	D
Sea Stacks						P	P	P	P			
Seagreen Alpha	P	P	P									
Sealtainn						P	P	P	P			
Seastar	P											
Setanta Wind Park							P	P	P			
Shearwater One						P	P	P	P			
Shelmalere	P	P	P	P	P	P	P					
Sheringham Shoal Ext					P	P	P	P				
Sinclair												
CS020				C	C	C						
CS025				C	C	C						
CS026				C	C	C						
CS027				C	C	C						
CS028				C	C	C						
CS008				C	C	C						
CS009				C	C	C						
CS019				C	C	C						
Sofia			P	P	P							
South East Scotland to South Humber				C	C	C	C	C				
South East Wind							P	P	P	P		
South irish Sea						P	P	P	P			
Spiorad na Mara						P	P	P	P			
Stoura									P			
Stromar								P	P	P		
Sud Atlantique										P	P	
Sud de la Bretagne						P	P	P	P			
Sud de la Bretagne Extension											P	
Sunrise						P	P	P	P			
Talisk						P	P	P	P			
Thor				P	P	P						
Trem Mkllebugt					P	P	P	P	P			
Triton Knoll	P	P										

Project	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
TwinHub					P	P	P					
Vesterhav Nord		P	P									
Vesterhav Syd		P	P									
Viking Link	C	C	C									
West Anglesey Demonstration Zone				C	C	C	C	C	C	C	C	C
West of Orkney								P	P	P		
White Cross						P						
Wicklow						P	P	P	P			
Windenergiegebied Borssele noordzijde/Borselle 1						P	P	P	P			
Windenergiegebied Borssele noordzijde/Borselle 2						P	P	P	P			
Seismic survey 1						S	S	S	S			
Seismic survey 2						S	S	S	S			
Seismic survey 3						S	S	S	S			
Seismic survey 4						S	S	S	S			

11.7.2 Screening Impacts

618. Certain impacts assessed for the Project alone are not considered in the marine mammal CEA due to:

- the highly localised nature of the impacts;
- management and mitigation measures in place at the Project and on other projects will reduce the risk occurring; and
- where the potential significance of the impact from the Project alone has been assessed as negligible.

619. 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 (as a requirement of European Protected Species legislation);
- 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;
- Changes in water quality: highly localised and negligible significance;
- Changes in prey availability: highly localised and negligible significance; and
- Barrier effects/operational noise: highly localised and negligible significance.

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

- The potential for disturbance from underwater noise during construction and decommissioning of offshore energy developments; and
- The potential for disturbance from vessel activity during construction, operation and decommissioning of offshore energy developments.

11.7.3 Disturbance from underwater noise

11.7.3.1 Method

Piling for OWF

621. The numbers of animals disturbed as a result of piling at the Project were based on the highest value across the array area assuming a single monopile installation. For all offshore projects that had a quantitative impact assessment for pile driving available (PEIR or ES chapter), the maximum number of animals predicted to be disturbed was obtained from the project-specific assessment and used in this CEA for that specific project.

622. For all projects that have no quantitative impact assessment available (PEIR or ES chapter), a 26km EDR was assumed for disturbance for monopiles, 15km EDR for pin-piles and 15km for mitigated piling for EU projects, based on the guidance in JNCC (2020). The density of cetaceans used to calculate the number of animals impacted was the relevant SCANS IV block wide density estimate for each project. To estimate the number of harbour and grey seals predicted to be disturbed, the average densities across the respective MUs were calculated. For harbour seal that included the abundance in Southeast England MU (4,868 individuals) divided by the area of MU (131,453.7km^2) equating to a density of 0.037 harbour seals per km^2. Similarly, grey seal density calculations considered the abundance in Southeast and Northeast England MUs (65,505 individuals) divided by the area of MUs (194,290.6km^2) equating to a density of 0.337 grey seals per km^2.

UXO clearance

623. Given that most projects have unknown UXO clearance timeframes, and that the expectation is that projects will use low-order methods, the numbers of animals potentially disturbed during UXO clearance were not estimated in the cumulative assessment for other projects. However, number of animals to be disturbed as a result of UXO clearance at the Project in 2026 was considered quantitatively.

Tidal, Cables and Carbon Capture Storage Projects

624. For tidal, cables and carbon capture storage projects it is assumed there will be no pile driving. Therefore, construction-related impacts are limited to a 5km EDR, as per the project alone assessment for other construction related noise. The density of cetaceans used to calculate the number of animals impacted was the relevant SCANS IV block wide density estimate for each project. To estimate the number of harbour and grey seals predicted to be disturbed, the average densities across the respective MUs were calculated (see paragraph 622 for more details, the densities of 0.037 and 0.337 individuals per km^2 were used for harbour and grey seal, respectively).

Seismic surveys

625. The potential number of seismic surveys that could be undertaken is unknown[31]. Therefore, it has been assumed that four seismic surveys could be conducted within the North Sea at any one time (to account for concurrent surveys in the northern and southern North Sea in both UK waters and those of neighbouring North Sea nations). It has been assumed that the area of disturbance for seismic surveys is 1,759km^2 as per the advice provided in JNCC (2023). This footprint assumes that the seismic lines are undertaken sequentially from one line to the adjacent line (<500 m away).

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

- For porpoise: abundance in North Sea MU (346,601)/area of MU (680,487km^2) = 0.51 porpoise/km^2.
- For bottlenose dolphins: abundance in Greater North Sea MU (2,022)/area of MU (639,886km^2) = 0.0032 dolphins/km^2
- For white-beaked dolphins: abundance in Celtic & Greater North Sea MU (43,951)/area of MU (1,568,078km^2) = 0.028 dolphins/km^2
- For minke whales: abundance in Celtic & Greater North Sea MU (20,118)/area of MU (1,568,078km^2) = 0.013 whales/km^2

627. To estimate the number of harbour and grey seals predicted to be disturbed, the average densities across the respective MUs were calculated (see paragraph 622 for more details, the densities of 0.037 and 0.337 individuals per km^2 were used for harbour and grey seal, respectively). Given that the MUs for seals are smaller than that for cetaceans, it was assumed that the CEA for both harbour and grey seals would incorporate only two seismic survey operations within their respective MUs at any one time.

[31] Maps from the Marine Noise Registry were examined but it was not possible to extract information on the number of seismic surveys occurring concurrently in the North Sea on any one day.

Decommissioning

628. The effects of decommissioning activities on marine mammals are considered to be similar to, or less than those occurring during construction. Therefore, decommissioning-related impacts are considered as a worst case scenario of 26 km EDR, as per EDR associated with disturbance during monopile installation. The density of cetaceans used to calculate the number of animals impacted was the relevant SCANS IV block wide density estimate for each project. To estimate the number of harbour and grey seals predicted to be disturbed, the average densities across the respective MUs were calculated (see paragraph 622 for more details, the densities of 0.037 and 0.337 individuals per km^2 were used for harbour and grey seal, respectively).

11.7.3.2 Precaution in the CEA

629. A combination of uncertainties in project timelines and the need to apply precautionary assumptions leads to numerous levels of precaution within this CEA which results in highly precautionary and unrealistic estimates of effects. The main areas of precaution in the assessment include:

- The number of developments active at the same time (clearing UXOs, piling or surveying). For example, the maximum level of disturbance to porpoise across Tier 1-7 projects would require that 49 offshore windfarm developments, two cables, two carbon capture and storage, and four seismic surveys are all active at the same time. This is considered to be extremely unrealistic.
- The inclusion of lower tier developments. In reality, the best information in terms of construction timeline is available for Tier 1-3 projects which have consent. By including projects that have no consent (Tiers 4-7), no ES chapter or no submitted information at all then worst-case scenarios have to be assumed in the absence of other information.
- The assumption that pile driving can occur at any point throughout the construction window for each development. This results in most projects having piling activities occurring over multiple consecutive years. For example, the piling window for the Project is listed as 2027-2029 (which results in three years of potential impact in the CEA); however, piling would only occur within a one-year period within this window. Since the exact timing of the piling activities within the respective development construction windows is unknown, it had to be assumed that it could occur at any point, thus resulting in piling schedules and subsequent disturbance levels that are far greater than would ever occur in reality.
- The assumption that all OWF developments will install pile-driven monopile foundations. The project envelope for most of these developments includes options for pin-piles or monopiles. As a worst case, monopiles have been assumed; however, it is likely that a portion of these projects will use jacket foundations with pin-piles, which have a much lower recommended effective deterrence range (15km instead of 26km) (JNCC, 2020), and are therefore considered to disturb far fewer animals.

11.7.3.3 Harbour porpoise – Disturbance from underwater noise

630. The potential number of harbour porpoise disturbed per day by each project (with and without PEIR/ES chapter available) is provided in Table 11-83.

631. A summary of the total disturbance impact to harbour porpoise per day by Tier (all projects with and without the PEIR/ES chapter), is provided in Table 11-83

632. A summary of the total disturbance impact to harbour porpoise per day across all projects in Tier 1-3 is provided in Table 11-84.

633. Across all years considered in the CEA (2021 to 2032 inclusive) and all Tiers (1-7), the period with highest level of predicted disturbance to harbour porpoise is in 2027, during the first year of piling at the Project.

634. When considering the potential impact from the Project in addition to all Tier 1-3 projects (those consented and thus with higher levels of data confidence) across all years considered in the CEA (2021 to 2032), the highest level of predicted disturbance to harbour porpoise across the North Sea MU is in 2025, preceding the UXO clearance and piling window for the Project. At this time, a maximum of 53,783 porpoises (15.52% MU) may be disturbed per day (assuming all Tier 1-3 projects are constructing at the same time, and that disturbance is additive across projects i.e. no overlapping disturbance footprints). As a result of construction activities at the Project and Tier 1-3 projects between 2026 and 2029 (UXO clearance and piling window), on average, approximately 38,347 harbour porpoises (11.06% MU) could be potentially disturbed.

Table 11-83: Number of harbour porpoise potentially disturbed by underwater noise by project (with and without PEIR/ES chapter available). Cells highlighted in colours indicate UXO clearance, piling, construction, seismic survey. The project construction period (UXO clearance, piling, construction, seismic survey. The project construction period (UXO clearance in 2026, piling between 2027 and 2029) is indicated by the red box.

Project	Tier	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
The Project	N/A						3462	1903	1903	1903			
Projects with PEIR/ES chapter													
Berwick Bank	4							2822					
Blyth Demonstration Phases 2&3	3				0								
Dogger Bank A	3		4302										
Dogger Bank B	2		3931	3931	3931	3931							
Dogger Bank C	2				4302	4302	4302	4302					
Dogger Bank South (East)	4						4630	4630	4630	4630			
Dogger Bank South (West)	4						5953	5953	5953	5953			
Dudgeon Ext	3						5161	5161	5161				
East Anglia One	1	2974											
East Anglia One North	3			1289	1289	1289	1289						

Project	Tier	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
East Anglia Three	3		3825	3825	3825								
East Anglia Two	3			3358	3358	3358	3358						
Five Estuaries	4							9498	9498	9498	9498	9498	9498
Forthwind Ltd	3				0	0	0	0	0				
Green Volt	3							5208					
Hornsea Project Four	3					6417	6417	6417	6417	6417	6417		
Hornsea Project Three	3					19396	19396	19396	19396	19396	19396	19396	19396
Hornsea Project Two	2	7855	7855										
Inch Cape	2	556	556	556									
Kincardine Phase 1	2	0											
Muir Mhor	4									14630	14630	14630	
Moray West	2		1609	1609	1609								
Neart Na Gaoithe	2	1880	1880	1880									
Norfolk Boreas	3			2251	2251	2251	2251						
Norfolk Vanguard East	3			4354	4354	4354							
Norfolk Vanguard West	3			4354	4354	4354							
North Falls	4						1072	1072	1072	1072			
Pentland OWF	3					323	323						
Rampion Ext	4					630	630						
Seagreen Alpha	1	1103	1103	1103									
Sheringham Shoal Ext	2					1338	1338	1338	1338				
Sofia	2			2035	2035	2035							
Triton Knoll	1	948	948										
Viking Link	1	0	0	0									
Caledonia	4							8942	8942	8942	8942		
Culzean	3					0							
Rampion 2	4							752	752	752			
Salamander	4								12366				

Project	Tier	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Cenos	4											9529	9529
Projects without PEIR/ES chapter													
Arven	6						364	364	364	364			
Aspen	6						423	423	423	423			
Ayre	6						199	199	199	199			
Beech	6						423	423	423	423			
Borkum Riffgrund 1	1				568								
Borkum Riffgrund 2	1				568								
Borkum Riffgrund 3	2	568	568	568	568								
Borkum Riffgrund West 1	1				568								
Borkum Riffgrund West 2	2				568								
Borkum Riffgrund West II	1				568								
Borssele Kavel I	1	219											
Borssele Kavel II	1	219											
Borssele Kavel III	1	219											
Borssele Kavel IV	1	219											
Borssele Kavel V	1	219	219										
Bowdun	6									423	423	423	
BP (AKA Flora)	6						426	426	426	426			
Broadshore	6		364	364	364	364	364						
Buchan	6									364	364	364	364
CampionWind	6				423	423	423	423	423				
Cedar	6								423				
Cluaran Deas Ear	6				1271	1271	1271	1271	1271				

Project	Tier	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Dunkerque	6					74	74	74	74				
Dogger bank D	6							1280	1280	1280			
E1	7									423			
E2	7									423			
E3	7									423			
E4	7									423			
E5	7									423			
Eastern Green Link 3 (EGL3) Scoping Route	6								47	47	47	47	47
Eastern Green Link 4 (EGL4) Scoping Route	6								47	47	47	47	47
EnBW He dreiht	2			435	435								
Fecamp	2	74	74	74									
Gebied 1 Noord (1-n)	7						568	568	568	568			
Gebied 1 Zuid (1-z)	7						568	568	568	568			
Gebied 2 Noord (2-n)	7						568	568	568	568			
Gebied 2 Zuid (2-z)	7						568	568	568	568			
Gebied 5 Oost (5-o)	7						568	568	568	568			
Gode Wind 3	2			435									
Harbour Energy North	6						423	423	423	423			
HKN Kavel V	4	568	568										
HKW Noord - HKW-N	6												
HKZ Kavel III	2	568	568	568	568								
HKZ Kavel IV	2	568	568										
Hollandse Kust (Noord)	2	568	568										

Project	Tier	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Hollandse Kust (West)	6				568	568							
Hollandse Kust (Zuid)	2	568	568										
Hollandse Kust west zuidelijk deel (HK-w-z)	6	568	568	568									
Hollandse Kust Zuid Holland III	2	568	568										
IJmuiden Ver	6						568						
IJmuiden Ver Noord (IJ-Ver-n)	6				568	568	568	568					
Jyske Banke	6						334	334	334	334			
Kaskasi II	1	435	435										
Marram	6										423		
N-10.1	7						435	435	435	435			
N-10.2	7						435	435	435	435			
N-3.7	7						435	435	435	435			
N-6.6	7						435	435	435	435			
N-6.7	7						435	435	435	435			
N-9.1	7						435	435	435	435			
N-9.2	7						435	435	435	435			
N-9.3	7						435	435	435	435			
N-9.4	7						435	435	435	435			
Nordlicht I	6						435						
Nordsee Cluster A - N-3.8	6							435					
Nordsee Cluster B - N-3.5	6								435				
Nordsee Cluster B - N-3.6	6							435					

Project	Tier	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Nordsren I	6				435								
Nordsren II	6				435								
Nordsren II vest	6				435								
Nordsren III	6				435								
Nordsren III vest	6				435								
Norther	1	219											
Northwester 2	1	219											
Peterhead to South Humber	6		47	47	47	47	47	47	47	47	47		
Scaraben	6						364	364	364	364			
Scroby Sands	1											658	658
Sealtainn	5						364	364	364	364			
Seastar	1	219											
Sinclair	6						364	364	364	364			
South East Scotland to South Humber	6				47	47	47	47	47				
Stoura	6								199	199	199		
Stromar	6								199	199	199		
Thor	2				435	435	435						
Vesterhav Nord	2		435	435									
Vesterhav Syd	2		435	435									
Windenergiegebied Borssele noordzijde/Borselle 1	6						219	219	219	219			
Windenergiegebied Borssele zuidzijde/Borselle 2	6						219	219	219	219			
CS006	7				47	47	47						

Project	Tier	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
CS007	7				47	47	47						
Endurance	6			47	47	47							
Gas Shearwater to Bacton Seal Line	6					47	47	47	47	47	47	47	47
CS013	7				40	40	40						
CS014	7				40	40	40						
CS020	7				47	47	47						
CS025	7				47	47	47						
CS026	7				40	40	40						
CS027	7				47	47	47						
CS028	7				47	47	47						
CS008	7				47	47	47						
CS009	7				47	47	47						
CS019	7				47	47	47						
4 seismic surveys	7						3596	3596	3596	3596			

Table 11-84: Total number of harbour porpoise disturbed by underwater noise across the Tiers (all projects with and without the PEIR/ES chapter). Results including lower Tier projects with lower data confidence are denoted by grey text.

Years	The Project Alone		The Project + Tiers 1 to 3		The Project + Tiers 1 to 4		The Project + Tiers 1 to 5		The Project + Tiers 1 to 7	
	#	% MU	#	% MU	#	% MU	#	% MU	#	% MU
2021	0	0.00%	20,985	6.05%	21,553	6.22%	21,553	6.22%	22,121	6.38%
2022	0	0.00%	31,015	8.95%	31,583	9.11%	31,583	9.11%	32,562	9.39%
2023	0	0.00%	33,495	9.66%	33,495	9.66%	33,060	9.54%	34,521	9.96%
2024	0	0.00%	36,154	10.43%	36,154	10.43%	36,154	10.43%	42,207	12.18%
2025	0	0.00%	53,783	15.52%	54,413	15.70%	54,413	15.70%	58,412	16.85%
2026	3,462	1.00%	47,732	13.77%	60,017	17.32%	60,381	17.42%	78,439	22.63%
2027	1,903	0.55%	43,725	12.62%	77,394	22.33%	77,758	22.43%	96,056	27.71%

Years		The Project Alone		The Project + Tiers 1 to 3		The Project + Tiers 1 to 4		The Project + Tiers 1 to 5		The Project + Tiers 1 to 7	
		#	% MU	#	% MU	#	% MU	#	% MU	#	% MU
2028		1,903	0.55%	34,215	9.87%	77,428	22.34%	77,792	22.44%	95,804	27.64%
2029		1,903	0.55%	27,716	8.00%	73,193	21.12%	73,557	21.22%	92,162	26.59%
2030		0	0.00%	25,813	7.45%	58,883	16.99%	58,883	16.99%	60,845	17.55%
2031		0	0.00%	20,054	5.79%	53,711	15.50%	53,711	15.50%	55,004	15.87%
2032		0	0.00%	20,054	5.79%	39,081	11.28%	39,081	11.28%	39,587	11.42%
2021 to 2032	Minimum	0	0.00%	20,054	5.79%	21,553	6.22%	21,553	6.22%	22,121	6.38%
	Average	764	0.22%	32,895	9.49%	51,409	14.83%	51,494	14.86%	58,965	17.01%
	Maximum	3,462	1.00%	53,783	15.52%	77,428	22.34%	77,792	22.44%	96,056	27.71%
2026 to 2029	Minimum	1,903	0.55%	27,716	8.00%	60,017	17.32%	60,381	17.42%	78,392	22.62%
	Average	2,293	0.66%	38,347	11.06%	72,008	20.78%	72,372	20.88%	90,603	26.14%
	Maximum	3,462	1.00%	47,732	13.77%	77,428	22.34%	77,792	22.44%	96,056	27.71%

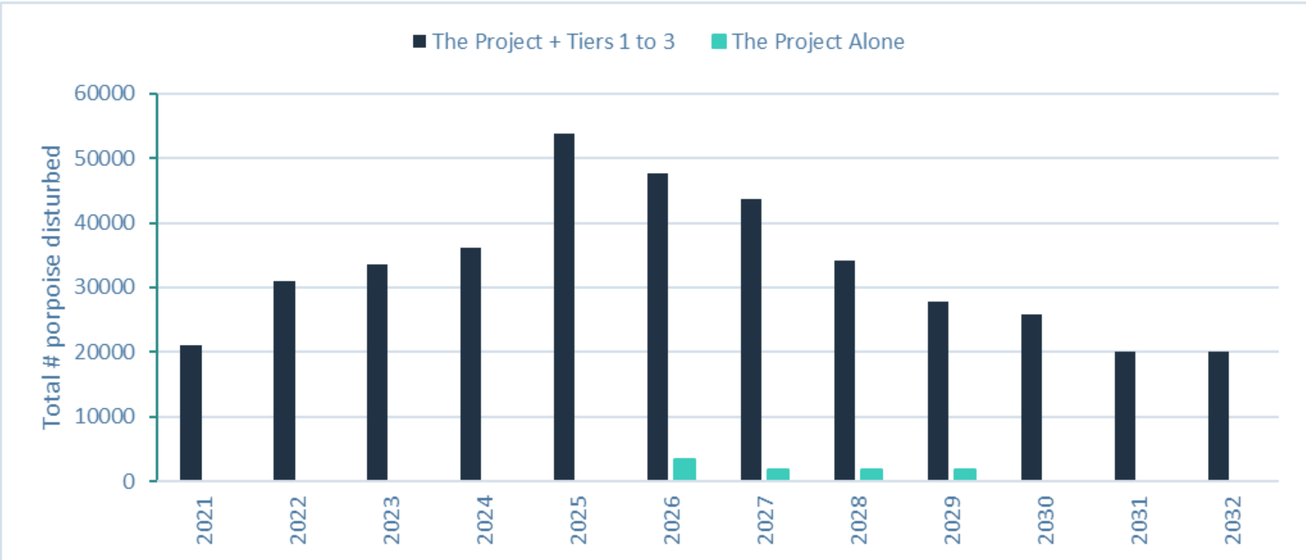

Plate 11.36: Cumulative underwater noise disturbance estimates to harbour porpoise for the Project alone and the Project in addition to Tier 1-3 projects.

635. There are numerous levels of precaution built into this CEA which makes the resulting estimates highly precautionary and unrealistic. The main areas of precaution in the assessment include those listed previously (Paragraph 629), plus those specific to harbour porpoise:

- The number of developments active at the same time (clearing UXOs, piling or surveying). In order for 96,103 porpoise to be disturbed across all Tier 1-7 projects in 2027, this would require that 49 offshore windfarm developments, two cables, two carbon capture and storage, and four seismic surveys are all active at the same time. This is considered to be extremely unrealistic.

- The assumption that all porpoise within a 26km range are disturbed. Pile driving activities at other offshore windfarms have shown that this assumption of total displacement within 26km of pile driving is a considerable over-estimate. At Beatrice, there was only a 50% probability of response at 7.4km and a 28% response within 26km for the first location piled, with decreasing response levels over the construction period to 50% probability of response at only 1.3km by the final location (Plate 11.37) (Graham *et al*., 2019). Likewise, pile driving at the first seven large-scale offshore windfarms in the German Bight (including unmitigated piling) found declines in porpoise activity out to only 17km, with unmitigated piling in isolation also illustrating only weak declines beyond approximately 17km (Brandt *et al*., 2018). Benhemma-Le Gall et al. (2021) examined the broad-scale responses of harbour porpoise to pile-driving and vessel activities during offshore windfarm construction and showed a reduction in harbour porpoise foraging activity close to piling activity (2 – 10 km) and an increase further way (16 – 30 km). This suggests that the disturbance caused the animals to temporarily move away and continue foraging.

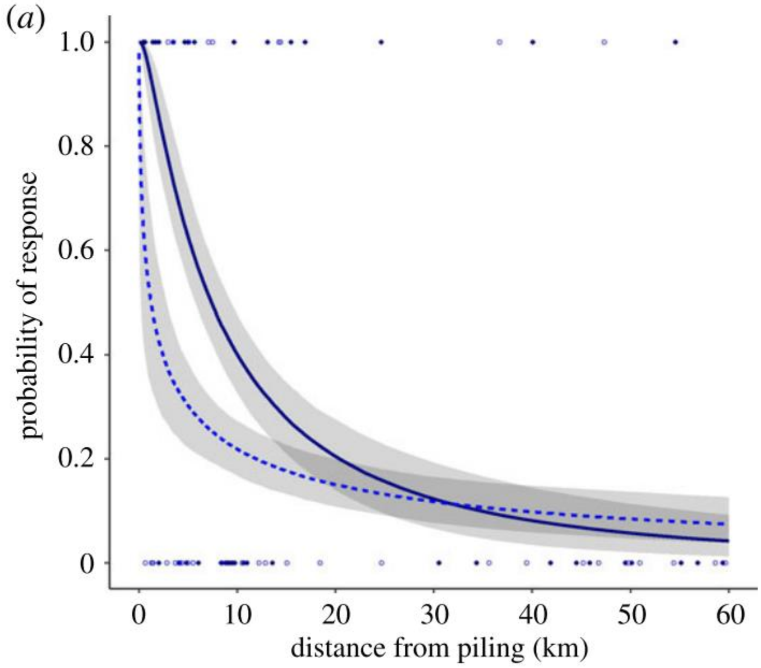

Plate 11.37: The probability of harbour porpoise response (in the 24 h following the end of piling) in relation to the partial contribution of distance from piling for the first location piled (solid navy line) and the final location piled (dashed blue line) (Graham *et al.,* 2019)

636. Although the estimate of cumulative impact of disturbance from underwater noise is considered to be highly precautionary (for the reasons listed above), there remains the potential for the cumulative increase in disturbance from construction activities across these developments to result in individuals experiencing multiple successive days of disturbance. Assuming that disturbance results in a period of zero energy intake, there is the potential for high levels of repeated disturbance to lead to a reduction in calf survival and potentially an effect on adult fertility (see Booth *et al*., 2019 for further details).

637. The number of animals predicted to be impacted in this CEA (though acknowledging that this is a highly precautionary estimate) and duration of impact arising from cumulative projects could potentially result in temporary changes in behaviour and/or distribution of individuals at a scale that could lead to potential reductions to lifetime reproductive success to some individuals , although likely not enough to affect the population trajectory over a generational scale. While cumulative population modelling has not been specifically conducted here for the CEA, results from previous large scale cumulative population modelling studies can be used to draw conclusions as to the potential for population-level impacts. For example, previous population modelling (using iPCoD) of offshore windfarms in eastern English waters has demonstrated low probabilities of population-level impacts, even when 16 piling operations were modelled over a 12-year period (disturbing up to a total of 34,396 porpoise per day) (Booth *et al*., 2017). The number of porpoise assumed to be disturbed by construction across the Tier 1-3 projects in this CEA is lower than was modelled in Booth *et al*., (2017) (average disturbed per day between 2021 and 2032 is 30,725 porpoise over an eight year period, or an average of 32,895 porpoise per day over the four years ODOW is constructing. Therefore, with fewer porpoise predicted to be disturbed per day, across fewer years than the previous modelling, the likelihood of population level effects is expected to be very low.

638. More recently, the iPCoD model was used to explore noise management in the Southern North Sea SAC for harbour porpoise (Brown *et al*., 2023). This study provided a wide range of iPCoD simulations including disturbance to harbour porpoise over a 10-year period at the scale of the North Sea MU. One of the most extreme disturbance scenarios assumed a seasonally variable base-level daily disturbance of c. 3,500 - 7,000 porpoise throughout the MU, in addition to disturbance at up to twice the Southern North Sea SAC seasonal disturbance thresholds (up to c. 16,000 porpoise disturbed per day in summer, averaging c. 8,000 disturbed across the season). Even at these persistently high disturbance levels, the predicted declines were low, generally ≤5% after 10 years of disturbance and, in each case, the population remained at a stable size once piling disturbance ended, indicating no long-term effect on the population trajectory (it is important to note here that iPCoD does not allow for density dependence and as such the population cannot increase back to baseline levels after disturbance has ceased).

639. Similarly, the DEPONS model has been used to predict the potential population level effects of cumulative OWF construction in the North Sea. Nabe-Nielsen *et al*., (2018) showed that the North Sea porpoise population was unlikely to be significantly impacted by the construction of 60 windfarms each with 65 turbines resulting in 3,900 disturbance days between 2011-2020, unless impact ranges were assumed to be much larger (exceeding 50 km) than that indicated by existing studies. Even at these extreme disturbance scenarios, the modelled North Sea population showed a quick recovery to baseline size (within 6-7 years) despite up to a 20% decline in population size.

640. It should be also noted that the presence of the Southern North Sea SAC and consideration of its conservation objectives (specifically relating to disturbance thresholds) means that disturbance impacts in the Southern North Sea population will be highly regulated and controlled (though a SIP) such that extreme scenarios (such as those including Tiers 6 and 7 in the CEA here) will not be permitted to occur.

641. Therefore, given that impacts are likely not enough to affect the population trajectory over a generational scale, the magnitude of the cumulative disturbance from underwater noise is Medium.

642. The sensitivity of harbour porpoise to disturbance from both piling and UXO clearance has been assessed as Low. The same has been assumed here for disturbance from seismic surveys.

643. Therefore, the effect significance of disturbance to harbour porpoise from the cumulative impact of underwater noise is **Minor (not significant)** in EIA terms.

11.7.3.4 Bottlenose dolphin – Disturbance from underwater noise

644. Of the 142 projects screened into the CEA for bottlenose dolphins, 64 projects were in a location where the SCANS IV block-wide density estimate is 0.00 dolphins/km^2 (blocks NS-E, NS-D, CS-K, NS-B, NS-I, NS-J); therefore, these projects were not included further in this CEA. In addition, 25 projects within the bottlenose dolphin MU scoped bottlenose dolphins out of their project-specific EIAs (Blyth Demonstration Phase A&B, Cenos, Dogger Bank A, Dogger Bank B, Dogger Bank C, Dogger Bank South, Dudgeon Ext, Five Estuaries, Forthwind, Sofia, East Anglia projects, Norfolk Vanguard, Norfolk Boreas, Hornsea Project Three, Hornsea Project Two, Kincardine, North Falls, Sheringham Shoal Ext, Triton Knoll, Viking Link) and therefore these projects were not included further in this CEA. This left a total of 37 OWF, four cable projects, eight CCS projects plus four seismic surveys included in the bottlenose dolphin CEA (Table 11-85)

645. The potential number of bottlenose dolphins disturbed per day by projects (with and without PEIR/ES chapters) is provided in Table 11-85.

646. A summary of the total disturbance impact to bottlenose dolphins per day by Tier (all projects with and without the PEIR/ES chapter), is provided in Table 11-85.

647. A summary of the total disturbance impact to bottlenose dolphins per day across all projects in Tier 1-3 is provided in Table 11-85

648. Across all years considered in the CEA (2021 to 2032 inclusive), and all Tiers (1-7), the period with the highest level of predicted disturbance to bottlenose dolphins is in 2027, which is the first year when the piling will commence at the Project.

649. When considering the potential impact from the Project in addition to all Tier 1-3 projects (those consented and thus with higher levels of data confidence), the highest level of predicted disturbance to bottlenose dolphins across the MU is in 2027. At this time, a maximum of 284 dolphins (14.05% MU) may be disturbed per day, of which 22.53% is disturbance from the Project (assuming all Tier 1-3 projects are constructing at the same time, and that disturbance is additive across projects i.e. no overlapping disturbance footprints).

650. On average, as a result of construction activities at the Project and Tier 1-3 projects between 2026 and 2029 (UXO clearance and piling window), approximately 60 bottlenose dolphins (2.96% MU) could be potentially disturbed. The average value is driven by piling at the Project and Hornsea Four based on precautionary bottlenose dolphin densities (SCANS IV and uniform density through the Greater North Sea MU for the Project and Hornsea Four, respectively). It should, however, be acknowledged that no bottlenose dolphins were sighted during the 31 site-specific baseline surveys, geophysical surveys of the Project or site-specific surveys at nearby Hornsea Four (see Volume 2, Appendix 11.1: Marine Mammal Technical Baseline). Furthermore, the relevant SCANS-IV block-wide density estimate for bottlenose dolphin was driven by a cluster of sightings of bottlenose dolphins off the North Yorkshire and Durham coasts, many tens of kilometres north of the Project. These results suggest that the waters in the vicinity of the Project and Hornsea Four are not of particular importance to bottlenose dolphins, and that the density values used in this CEA are highly precautionary.

651. It is important to highlight that there are numerous other levels of precaution built into this CEA which makes the resulting estimates highly precautionary. A key source of precaution in this assessment is that the harbour porpoise dose-response function and harbour porpoise EDRs have been used for bottlenose dolphins, as there is no bottlenose dolphin-specific equivalent. Harbour porpoise have a lower auditory injury threshold (i.e. higher hearing sensitivity) than bottlenose dolphins (Southall *et al*., 2019) and 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, Sarnocinska *et al*., 2019, Thompson *et al*., 2020, Benhemma-Le Gall *et al*., 2021).

652. Studies have shown that dolphin species show comparatively less of a disturbance response from underwater noise compared to 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). In the Moray Firth, bottlenose dolphins have been shown to remain in the impacted area during both seismic activities and pile installation activities (Fernandez-Betelu *et al*., 2021) which highlights a lack of complete displacement response.

653. Likewise, other 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 to harbour porpoise (e.g. Kastelein *et al*., 2006, Culloch *et al*., 2016). Noise modelling in support of UXO clearance impact assessments consistently estimate that, based on differences in hearing sensitivity alone, the anticipated range to the onset of temporary hearing loss (TTS, sometimes used as a proxy for behavioural responses to a single impulse) for harbour porpoise is c. 10-20 times greater than that for dolphins (e.g. Mason and Barnham, 2018, Neart na Gaoithe Offshore Windfarm, 2019). Considering the above, it can be concluded that using porpoise response data as a proxy for bottlenose dolphins is likely to result in an over-estimate of the response for bottlenose dolphins.

654. The number of animals predicted to be impacted in this CEA (though acknowledging that this is a highly precautionary estimate) and duration of impact arising from cumulative projects could potentially result in temporary changes in behaviour and/or distribution of individuals at a scale that could lead to potential reductions to lifetime reproductive success to some individuals (especially when considering dependent calves, see Booth and Heinis (2018) and Booth *et al.* (2019)). However, given that waters in the vicinity of the Project are not considered of particular relevance to bottlenose dolphins, although individuals may be displaced from the disturbance zones during piling/construction activities at respective projects, it is anticipated that animals would be able to use alternative habitat within the Greater North Sea MU. Considering the above, the cumulative disturbance is likely to be not enough to affect the MU population trajectory over a generational scale and the magnitude of the cumulative disturbance from underwater noise is Medium.

655. The sensitivity of bottlenose dolphins to disturbance from both piling and UXO clearance has been assessed as Low. The same has been assumed here for disturbance from seismic surveys.

656. Therefore, the effect significance of disturbance to bottlenose dolphins from the cumulative impact of underwater noise is **Minor (not significant)** in EIA terms.

Table 11-85: Number of bottlenose dolphins potentially disturbed by underwater noise by projects (with and without PEIR/ES chapter). Cells highlighted in colours indicate UXO clearance, piling, construction, seismic survey and decommissioning. The project construction period (UXO clearance in 2026, piling between 2027 and 2029) is indicated by the red box.

Project	Tier	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
The Project	N/A						89	64	64	64			
Projects with PEIR/ES chapter													
Berwick Bank	4							107					
Green Volt	3							204					
Hornsea Project Four	3					14	14	14	14	14	14		
Inch Cape	2	19	19	19									

Project	Tier	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Muir Mhor	4									74	74	74	
Moray West	2		15	15	15								
Neart Na Gaoithe	2	2	2	2									
Seagreen Alpha	1	3	3	3									
Caledonia	4							37	37	37	37		
Culzean	3					0							
Rampion 2	4							129	129	129			
Salamander	4								84				
Projects without PEIR/ES chapter													
Borkum Riffgrund 1	1				1								
Borkum Riffgrund 2	1				1								
Borkum Riffgrund 3	2	1	1	1	1								
Borkum Riffgrund West 1	1				1								
Borkum Riffgrund West 2	2				1								
Borkum Riffgrund West II	1				1								
BP (AKA Flora)	6						30	30	30	30			
Dunkerque	6					2	2	2	2				
Dogger bank D	6							89	89	89			
EnBW He dreiht				0	0								
Eastern Green Link 3 (EGL3) Scoping Route	6								3	3	3	3	3
Eastern Green Link 4 (EGL4) Scoping Route	6								3	3	3	3	3
Fecamp	2	2	2	2									
Gebied 1 Noord (1-n)	7						1	1	1	1			
Gebied 1 Zuid (1-z)	7						1	1	1	1			

Project	Tier	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Gebied 2 Noord (2-n)	7						1	1	1	1			
Gebied 2 Zuid (2-z)	7						1	1	1	1			
Gebied 5 Oost (5-o)	7						1	1	1	1			
HKN Kavel V	4	1	1										
HKW Noord - HKW-N	6												
HKZ Kavel III	2	1	1	1	1								
HKZ Kavel IV	2	1	1										
Hollandse Kust (Noord)	2	1	1										
Hollandse Kust (West)	6				1	1							
Hollandse Kust (Zuid)	2	1	1										
Hollandse Kust west zuidelijk deel (HK-w-z)	6	1	1	1									
Hollandse Kust Zuid Holland III	2	1	1										
IJmuiden Ver	6						1						
IJmuiden Ver Noord (IJ-Ver-n)	6				1	1	1	1					
Peterhead to South Humber	6		3	3	3	3	3	3	3	3	3		
South East Scotland to South Humber	6				3	3	3	3	3				
Endurance	6			3	3	3							
Gas Shearwater to Bacton Seal Line	6					3	3	3	3	3	3	3	3
CS006	7				3	3	3						
CS007	7				3	3	3						
CS013	7				3	3	3						
CS014	7				3	3	3						
CS020	7				3	3	3						

Project	Tier	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
CS025	7				3	3	3						
CS028	7				3	3	3						
CS008	7				3	3	3						
CS009	7				3	3	3						
CS019	7				3	3	3						
4 seismic surveys	7						22	22	22	22			

Table 11-86: Total number of bottlenose dolphins disturbed by underwater noise across the Tiers (all projects with and without the PEIR/ES chapter). Results including lower Tier projects with lower data confidence are denoted by grey text.

Years		The Project Alone		The Project + Tiers 1 to 3		The Project + Tiers 1 to 4		The Project + Tiers 1 to 5		The Project + Tiers 1 to 7	
		#	% MU	#	% MU	#	% MU	#	% MU	#	% MU
2021		0	0.00%	30	1.48%	31	1.53%	31	1.53%	34	1.68%
2022		0	0.00%	45	2.23%	46	2.27%	46	2.27%	52	2.57%
2023		0	0.00%	41	2.03%	41	2.03%	41	2.03%	50	2.47%
2024		0	0.00%	22	1.09%	22	1.09%	22	1.09%	57	2.82%
2025		0	0.00%	16	0.79%	16	0.79%	16	0.79%	54	2.67%
2026		89	4.40%	105	5.19%	105	5.19%	105	5.19%	197	9.74%
2027		64	3.17%	284	14.05%	557	27.55%	557	27.55%	713	35.26%
2028		64	3.17%	80	3.96%	330	16.32%	330	16.32%	491	24.28%
2029		64	3.17%	81	4.01%	321	15.88%	321	15.88%	476	23.54%
2030		0	0.00%	14	0.69%	125	6.18%	125	6.18%	137	6.78%
2031		0	0.00%	0	0.00%	74	3.66%	74	3.66%	83	4.10%
2032		0	0.00%	0	0.00%	0	0.00%	0	0.00%	9	0.45%
2021 to 2032	Minimum	0	0.00%	0	0.00%	0	0.00%	0	0.00%	9	0.45%
	Average	23	1.16%	60	2.96%	139	6.87%	139	6.87%	195	9.62%
	Maximum	89	4.40%	284	14.05%	557	27.55%	557	27.55%	713	35.26%
2026 to 2029	Minimum	64	3.17%	80	3.96%	105	5.19%	105	5.19%	191	9.45%
	Average	70	3.47%	138	6.80%	328	16.23%	328	16.23%	468	23.13%
	Maximum	89	4.40%	284	14.05%	557	27.55%	557	27.55%	713	35.26%

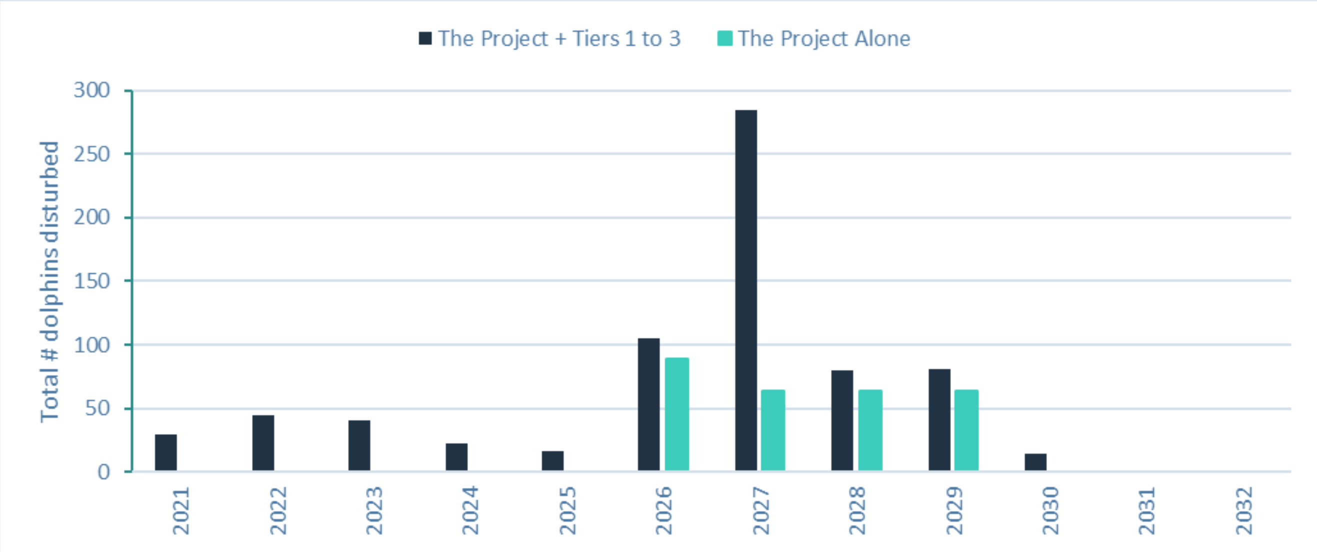

Plate 11.38: Cumulative underwater noise disturbance estimates to bottlenose dolphins for the Project alone and the Project in addition to Tier 1-3 projects.

11.7.3.5 White-beaked dolphin – Disturbance from underwater noise

657. Of the 202 projects screened into the CEA for white-beaked dolphins, 93 projects were in a location where the SCANS IV block-wide and ObSERVE density estimate is 0.00 dolphins/km^2 (SCANS IV blocks CS-D, NS-B, NS-I, CS-C, CS-F, CS-E, CS-A, CS-D, BB-B; ObSERVE blocks 4, 6, 8); therefore, these projects were not included further in this CEA. In addition, 33 projects within the white-beaked dolphin MU scoped white-beaked dolphins out of their project-specific EIAs (Awel y Mor, Atlantic Marine Energy Test site, Arklow Bank Phase 2, Blyth Demonstration Phase 2&3, Codling Wind Park, Dogger Bank South, Dudgeon Extension, East Anglia Projects, Erebus, Five Estuaries, Forthwind, Kincardine Phase 1, Llyr 1, Llyr 2, Mona, Moray West, Morecambe, Morgan, Norfolk Boreas, Norfolk Vanguard East, Norfolk Vanguard West, North Falls, North Irish Sea Array, Oriel, Perpetuus Tidal Energy, Rampion 2, Rampion Ext, Sceirde Rocks, Sheringham Shoal Extension, Triton Knoll, Twin Hub, Viking Link, West Anglesey Demonstration Zone, White Cross) and therefore these projects were not included further in this CEA. In cases where less than 0.5 animals were predicted to be disturbed, for the purpose of this CEA assessment it was assumed that zero animals would experience disturbance. For this reason, eight projects were excluded from further consideration. This left a total of 75 OWFs, four cable projects, seven CCS projects plus four seismic surveys included in the white-beaked dolphin CEA.

658. The potential number of white-beaked dolphins disturbed per day by projects (with and without PEIR/ES chapters) is provided in Table 11-88.

659. A summary of the total disturbance impact to white-beaked dolphins per day by Tier (all projects with and without the PEIR/ES chapter), is provided Table 11-87.

660. A summary of the total disturbance impact to white-beaked dolphins per day across all projects in Tier 1-3 is provided in Plate 11.38.

661. Across all years considered in the CEA (2021 to 2032 inclusive), and all Tiers (1-7), the period with highest level of predicted disturbance to white-beaked dolphins is in 2027, during the first year of piling at the Project.

662. When considering the potential impact from the Project in addition to all Tier 1-3 projects (those consented and thus with higher levels of data confidence), the highest level of predicted disturbance to white-beaked dolphins across the MU is in 2027. At this time, a maximum of 1,801 dolphins (4.10% MU) may be disturbed per day (assuming all Tier 1-3 projects are constructing at the same time, and that disturbance is additive across projects i.e. no overlapping disturbance footprints).

663. Across the UXO clearance and piling window at the Project (2026 to 2029), in 2026 a maximum of 482 white-beaked dolphins are at risk to experience disturbance as a result of construction activities at the Project and Tier 1-3 projects, of which less than 7% is disturbance from the UXO clearance at Project (32 individuals). As per the JNCC (2020) guidance, it is not expected that disturbance from a single UXO detonation would result in any widespread and prolonged displacement and therefore would not be sufficient to result in any changes to the vital rates of individuals. Additionally, the maximum value in 2026 is mostly driven by the number of white-beaked dolphins potentially disturbed by piling at Pentland Offshore WindFarm with 337 individuals being affected. It should be noted that Pentland Offshore WindFarm is located approximately 700 km north from the Project. As such, although the cumulative impacts are quantified on the relevant marine mammal MU scale, it is highly unlikely that a project located at this distance and piling for a maximum of 63 days would contribute to a cumulative effect in terms of additive days of disturbance to specific individuals.

664. Additionally, the total impact to the Celtic and Greater North Seas MU population is expected to be lower as the Project construction progresses. For example, although in 2026 a maximum of 482 white-beaked dolphins (1.10% MU) may be disturbed per day, and this number increases in 2027 (1,801 individuals impacted, 4.10% MU), the number of animals potentially disturbed reduces to 115 dolphins (0.26% MU) in 2028 and 2029. The average cumulative number of individuals potentially disturbed across the UXO clearance and piling window at the Project (2026 to 2029) was estimated as 558 white-beaked dolphins (1.27% MU). There are numerous levels of precaution built into this CEA which makes the resulting estimates highly precautionary. For precaution specific to dolphin species, please see paragraph 649 et seq. The same precautions inherent in the bottlenose dolphin assessment are also relevant here for white-beaked dolphins.

665. The number of animals predicted to be impacted in this CEA (though acknowledging that this is a highly precautionary estimate) and duration of impact arising from cumulative projects could potentially result in temporary changes in behaviour and/or distribution of individuals at a scale that could lead to potential reductions to lifetime reproductive success to some individuals . However, considering the average number of individuals potentially disturbed across the UXO clearance and piling window at the Project cumulatively with other Tier 1-3 projects and small proportion of the MU population affected (1.27% of the MU), the cumulative disturbance is likely not enough to affect the population trajectory over a generational scale. Given that impacts are likely not enough to affect the population trajectory over a generational scale, the magnitude of the cumulative disturbance from underwater noise is Medium.

666. The sensitivity of white-beaked dolphins to disturbance from both piling and UXO clearance has been assessed as Low. The same has been assumed here for disturbance from seismic surveys.

667. Therefore, the effect significance of disturbance to white-beaked from the cumulative impact of underwater noise is **Minor (not significant)** in EIA terms.

Table 11-87: Number of white-beaked dolphins potentially disturbed by underwater noise by projects (with and without PEIR/ES chapter). Cells highlighted in colours indicate UXO clearance, piling, construction, seismic survey and decommissioning. The project construction period (UXO clearance in 2026, piling between 2027 and 2029) is indicated by the red box.

Project	Tier	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
The Project	N/A						32	23	23	23			
Projects with PEIR/ES chapter													
Berwick Bank	4							830					
Dogger Bank A	3		21										
Dogger Bank B	2			21	21	21							
Dogger Bank C	2				21	21	21	21					
Green Volt	3							1665					
Hornsea Project Four (HOW04)	3					85	85	85	85	85	85		
Hornsea Project Three (HOW03)	3					7	7	7	7	7	7	7	7
Hornsea Project Two (HOW02)	2	3	3										

Project	Tier	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Inch Cape Offshore Ltd	2	51	51	51									
Muir Mhor	4									6750	6750	6750	
Neart Na Gaoithe Offshore Wind	2	763	763	763									
Pentland OWF	3						337						
Seagreen Alpha	1	448	448	448									
Sofia	2			5	5	5							
West of Orkney	4								1709	1709	1709		
Caledonia	4							3114	3114	3114	3114		
Cenos	4											963	963
Projects without PEIR/ES chapter													
Morven BP E1	6				170	170	170	170	170				
Arven	6						125	125	125	125			
Aspen	6						56	56	56	56			
Ayre	6						96	96	96	96			
Beech	6						56	56	56	56			
Borkum Riffgrund 1	1				2								
Borkum Riffgrund 2	1				2								
Borkum Riffgrund 3	2	2	2	2	2								
Borkum Riffgrund West 1	1				2								
Borkum Riffgrund West 2	2				2								
Borkum Riffgrund West II	1				2								
Bowdun	6									56	56	56	
BP (AKA Flora)	6						2	2	2	2			
Broadshore	6		125	125	125	125	125						
Buchan	6									125	125	125	125
Campion Wind	6				56	56	56	56	56				
Cedar	6								56				

Project	Tier	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Centre-Manche 1	6											2	2
Centre-Manche 2	6						2	2	2	2			
Clarus	6						83	83	83	83			
Cluaran Deas Ear	6				170	170	170	170	170				
Courseulles-sur-mer	2		2	2									
Dieppe - Le Treport	3					2							
Dogger Bank D	6							6	6	6			
Dunkerque	6					2	2	2	2				
E1	7									56			
E2	7									56			
E3	7									56			
E4	7									56			
E5	7									56			
Eastern Green Link 3 (EGL3) Scoping Route	6								6	6	6	6	6
Eastern Green Link 4 (EGL4) Scoping Route	6								6	6	6	6	6
Fecamp	2	2	2	2									
Gebied 1 Noord (1-n)	7						2	2	2	2			
Gebied 1 Zuid (1-z)	7						2	2	2	2			
Gebied 2 Noord (2-n)	7						2	2	2	2			
Gebied 2 Zuid (2-z)	7						2	2	2	2			
Gebied 5 Oost (5-o)	7						2	2	2	2			
Harbour Energy North	6						56	56	56	56			
Havbredey	6						181	181	181	181			
HKN Kavel V	4	2	2										
HKW Noord - HKW-N	6												

Project	Tier	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
HKZ Kavel III	2	2	2	2	2								
HKZ Kavel IV	2	2	2										
Hollandse Kust (Noord)	2	2	2										
Hollandse Kust (West)	6				2	2							
Hollandse Kust (Zuid)	2	2	2										
Hollandse Kust west zuidelijk deel (HK-w-z)	6	2	2	2									
Hollandse Kust Zuid Holland III	2	2	2										
IJmuiden Ver	6						2						
IJmuiden Ver Noord (IJ-Ver-n)	6				2	2	2	2					
Ilen	6						251	251	251	251			
Jyske Banke	6						44	44	44	44			
Marram	6										56		
Moneypoint One	6						251	251	251	251			
Peterhead to South Humber	6		6	6	6	6	6	6	6	6	6		
Scaraben	6						125	125	125	125			
Sealtainn	6						125	125	125	125			
Sinclair	6						125	125	125	125			
South East Scotland to South Humber	6				6	6	6	6	6				
Spiorad na Mara	6						545	545	545	545			
Stoura	6									125			
Stromar	6								96	96	96		
Talisk	6						181	181	181	181			
CS006	7				6	6	6						
CS007	7				6	6	6						
CS013	7				14	14	14						
CS014	7				14	14	14						
CS026	7				14	14	14						

Project	Tier	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
4 seismic surveys	7						198	198	198	198			

Table 11-88: Total number of white-beaked dolphins disturbed by underwater noise across the Tiers (all projects with and without the PEIR/ES chapter). Results including lower Tier projects with lower data confidence are denoted by grey text.

Years		The Project Alone		The Project + Tiers 1 to 3		The Project + Tiers 1 to 4		The Project + Tiers 1 to 5		The Project + Tiers 1 to 7	
		#	% MU	#	% MU	#	% MU	#	% MU	#	% MU
2021		0	0.00%	1,279	2.91%	1,281	2.91%	1,281	2.91%	1,283	2.92%
2022		0	0.00%	1,302	2.96%	1,302	2.96%	1,304	2.97%	1,437	3.27%
2023		0	0.00%	1,296	2.95%	1,294	2.94%	1,296	2.95%	1,429	3.25%
2024		0	0.00%	61	0.14%	61	0.14%	61	0.14%	652	1.48%
2025		0	0.00%	141	0.32%	141	0.32%	141	0.32%	734	1.67%
2026		32	0.07%	482	1.10%	482	1.10%	482	1.10%	3,587	8.16%
2027		23	0.05%	1,801	4.10%	5,745	13.07%	5,745	13.07%	8,675	19.74%
2028		23	0.05%	115	0.26%	10,635	24.20%	10,635	24.20%	13,727	31.23%
2029		23	0.05%	115	0.26%	11,688	26.59%	11,688	26.59%	14,906	33.92%
2030		0	0.00%	92	0.21%	11,665	26.54%	11,665	26.54%	12,016	27.34%
2031		0	0.00%	7	0.02%	7,720	17.57%	7,720	17.57%	7,915	18.01%
2032		0	0.00%	7	0.02%	970	2.21%	970	2.21%	1,109	2.52%
2021 to 2032	Minimum	0	0.00%	7	0.02%	61	0.14%	61	0.14%	652	1.48%
	Average	8	0.02%	558	1.27%	4,415	10.05%	4,416	10.05%	5,623	12.79%
	Maximum	32	0.07%	1,801	4.10%	11,688	26.59%	11,688	26.59%	14,906	33.92%
2026 to 2029	Minimum	23	0.05%	115	0.26%	482	1.10%	482	1.10%	3,587	8.16%
	Average	25	0.06%	628	1.43%	7,138	16.24%	7,138	16.24%	10,224	23.26%
	Maximum	32	0.07%	1,801	4.10%	11,688	26.59%	11,688	26.59%	14,906	33.92%

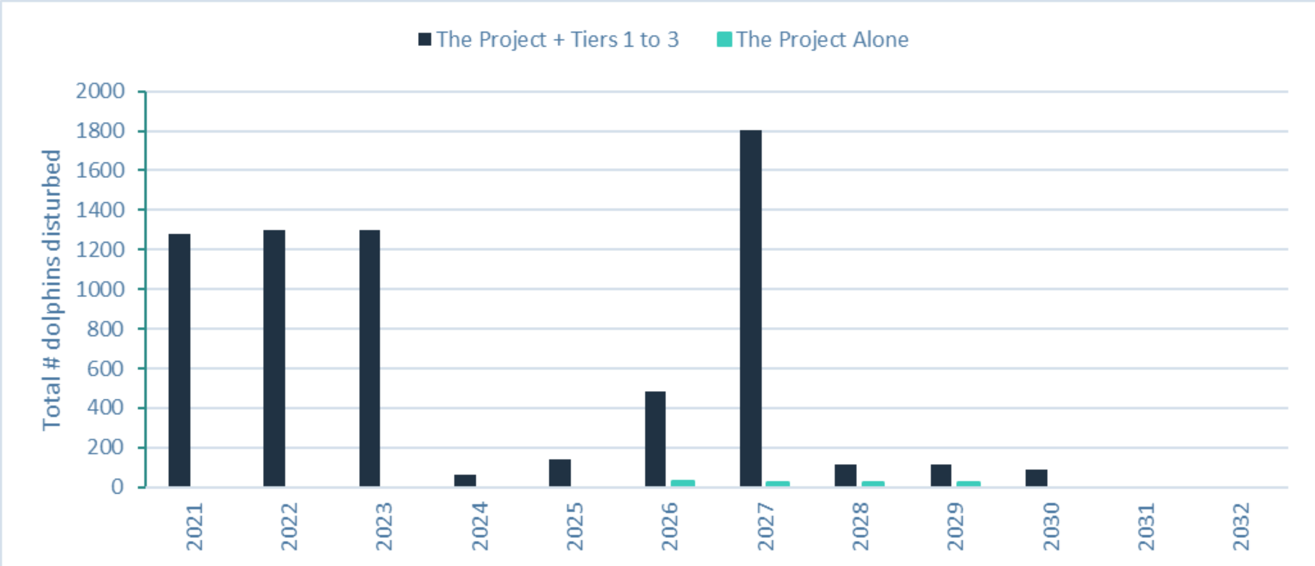

Plate 11.39: Cumulative underwater noise disturbance estimates to white-beaked dolphins for the Project alone and the Project in addition to Tier 1-3 projects.

11.7.3.6 Minke whale – Disturbance from underwater noise

668. Of the 202 projects screened into the CEA for minke whales, 44 projects were in a location where the SCANS IV block-wide and ObSERVE density estimate is 0.00 whales/km^2 (SCANS IV blocks NS-A, NS-B, NS-I, BB-B; ObSERVE block 6); therefore, these projects were not included further in this CEA. In addition, 24 projects within the MU scoped minke whales out of their project specific EIAs (Atlantic Marine Energy Test Site, Blyth Demonstration 2&3, Dudgeon Extension, Five Estuaries, Forthwind, Morecambe, East Anglia projects, Norfolk Vanguard, Norfolk Boreas, North Falls, Viking Link, West Anglesey Demonstration Zone, White Cross, Kincardine Phase 1, Oriel, Perpetuus Tidal Energy, Triton Knoll, Twin Hub, Sheringham Shoal Extension, Sceirde Rocks) and therefore these projects were not included further in this CEA. This left a total of 117 OWFs, two cable projects, 18 CCS projects plus four seismic surveys included in the minke whale CEA.

669. The potential number of minke whales disturbed per day by projects (with and without PEIR/ES chapters) is provided in Table 11-89.

670. A summary of the total disturbance impact to minke whales per day by Tier (all projects with and without the PEIR/ES chapter), is provided in Table 11-90.

671. A summary of the total disturbance impact to minke whales per day across all projects in Tier 1-3 is provided in Plate 11.40Plate 11.40: Cumulative underwater noise disturbance estimates to minke whales for the Project alone and the Project in addition to Tier 1-3 projects..

672. Across all years considered in the CEA (2021 to 2032 inclusive) and all Tiers (1-7), the period with highest level of predicted disturbance to minke whales is in 2027, during the first year of piling at the Project.

673. When considering the potential impact from the Project in addition to all Tier 1-3 projects (those consented and thus with higher levels of data confidence), the highest level of predicted disturbance to minke whales across the MU is in 2022, preceding the UXO clearance and piling window for the Project. At this time, a maximum of 1,046 whales (5.20% MU) may be disturbed per day (assuming all Tier 1-3 projects are constructing at the same time, and that disturbance is additive across projects i.e. no overlapping disturbance footprints).

674. Across the UXO clearance and piling window at the Project (2026 to 2029), in 2027 a maximum of 474 minke whales are at risk to experience disturbance as a result of construction activities at the Project and Tier 1-3 projects, of which less than 5% is disturbance from piling at Project (14 individuals). The maximum value in 2027 is driven by the number of minke whales potentially disturbed by piling at various projects, including Green Volt, Berwick Bank, Caledonia, Codling Wind Park and the North Irish Sea Array. However, it should be noted that some of the projects are located at large distances from the Project, e.g., Codling Wind Park and North Irish Sea Array are in the Irish and Celtic Seas, on the opposite side of the British mainland. Therefore, although the cumulative impacts are quantified on the relevant marine mammal MU scale, it is highly unlikely that a project located at this distance would contribute to a cumulative effect in terms of additive days of disturbance to specific individuals.

675. Additionally, the total impact to the Celtic and Greater North Seas MU population is expected to be lower as the Project construction progresses. For example, although in 2026 a maximum of 304 of minke whales (1.51% MU) may be disturbed per day which increases in 2027 (474 individuals impacted, 2.36% MU), the number of animals potentially disturbed reduces to 147 whales (0.73% MU) in 2028 and 2029. The average cumulative number of individuals potentially disturbed across the UXO clearance and piling window at the Project (2026 to 2029) was estimated as 405 minke whales (2.02% MU). There are numerous levels of precaution built into this CEA which makes the resulting estimates highly precautionary, e.g., this assessment assumes that all activities occur in the summer months when minke whales are present and their density estimates are highest. Considering the average number of individuals potentially disturbed across the UXO clearance and piling window at the Project cumulatively with other Tier 1-3 projects and small proportion of the MU population affected (2.02% of the MU), the cumulative disturbance is likely not enough to affect the population trajectory over a generational scale. As such, the magnitude of the cumulative disturbance from underwater noise is Medium.

676. The sensitivity of minke whales to disturbance from both piling and UXO clearance has been assessed as Low. The same has been assumed here for disturbance from seismic surveys.

677. Therefore, the effect significance of disturbance to minke whales from the cumulative impact of underwater noise is **Minor (not significant)** in EIA terms.

Table 11-89: Number of minke whales potentially disturbed by underwater noise by projects (with and without PEIR/ES chapter). Cells highlighted in colours indicate UXO clearance, piling, construction, seismic survey and decommissioning. The project construction period (UXO clearance in 2026, piling between 2027 and 2029) is indicated by the red box.

Project	Tier	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
The Project	N/A						14	14	14	14			
Projects with PEIR/ES chapter													
Awel y Môr	3						36	36	36	36	36		
Berwick Bank	4							132					
Dogger Bank A	3		69										
Dogger Bank B	2		62	62	62	62							
Dogger Bank C	2				62	62	62	62					
Dogger Bank South (East)	4						68	68	68	68			
Dogger Bank South (West)	4						100	100	100	100			
Erebus	3			55	55	55	55						
Green Volt	3							265					
Hornsea Project Four	3					46	46	46	46	46	46		
Hornsea Project Three	3					51	51	51	51	51	51	51	51
Hornsea Project Two	2	49	49										
Inch Cape	2	543	543	543									
Mona	4						105	105					
Moray West	2		30	30	30								
Morgan	4						96	96					
Neart Na Gaoithe	2	123	123	123									
Pentland	3					40	40						
Rampion Ext	4					6	6						
Seagreen Alpha	1	71	71	71									
Sofia	2			39	39	39							
West of Orkney	4								90	90	90		
Arklow Bank Phase 2	4								96				
Caledonia	4							543	543	543	543		
Codling Wind Park	4							130	130	130			
North Irish Sea Array	4						222	222	222				
Rampion 2	4							8	8	8			
Salamander	4								1535				
Cenos	4											384	384
Llyr 1 Cierco Ltd.,SBM Offshore N.V.	4						97						

Project	Tier	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Llyr 2 Cierco Ltd.,SBM Offshore N.V.	4						97						
Projects without PEIR/ES chapter													
Morven	6				89	89	89	89	89	89	89	89	89
Arklow Bank Phase 1	1	29	29										
Arven	6						9	9	9	9			
Aspen	6						30	30	30	30			
Ayre	6						8	8	8	8			
Banba	6						29	29	29	29			
Beech	6						30	30	30	30			
Blackwater	6						9	9					
Borkum Riffgrund 1	1				11								
Borkum Riffgrund 2	1				11								
Borkum Riffgrund 3	2	11	11	11	11								
Borkum Riffgrund West 1	1				11								
Borkum Riffgrund West 2	2				11								
Borkum Riffgrund West II	1				11								
Bowdun	6									30	30	30	
BP (AKA Flora)	6						5	5	5	5			
Broadshore	6		9	9	9	9	9						
Buchan	6									9	9	9	9
Cailleach	6						29	29	29	29			
Caledonia	6						89	89	89	89	89		
CampionWind	6				30	30	30	30	30				
Cedar	6								30				
Celtic One	6						28	28	28	28			
Clarus	6						72	72	72	72			
Clogher Head	6						29	29	29	29			
Cluaran Deas Ear	6				89	89	89	89	89				
Codling Wind Park Ext	6						29	29	29	29			
Cooley Point	6	29	29	29	29	29	29						
Culzean	6						30	30	30	30			
DMAP	7						0	0	0	0			
Dogger Bank D	6							14	14	14			
Draig y Mor	6						10	10	10	10			
Dublin Array	6						29	29					
Dublin Northeast	6							29	29				
EIS Area 1	7				1	1	1						
E1	7									30			
E2	7									30			

Project	Tier	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
E3	7									30			
E4	7									30			
E5	7									30			
Eastern Green Link 3 (EGL3) Scoping Route	6								3	3	3	3	3
Eastern Green Link 4 (EGL4) Scoping Route	6								3	3	3	3	3
Emerald	6						30	30	30	30			
Gebied 1 Noord (1-n)	7						11	11	11	11			
Gebied 1 Zuid (1-z)	7						11	11	11	11			
Gebied 2 Noord (2-n)	7						11	11	11	11			
Gebied 2 Zuid (2-z)	7						11	11	11	11			
Gebied 5 Oost (5-o)	7						11	11	11	11			
Greystones	6								29	29			
Harbour Energy North	6						30	30	30	30			
Havbredey	6						16	16	16	16			
Helvick Head	6						501	501	501	501			
HKN Kavel V	4	11	11										
HKZ Kavel III	2	11	11	11	11								
HKZ Kavel IV	2	11	11										
Hollandse Kust (Noord)	2	11	11										
Hollandse Kust (West)	6				11	11							
Hollandse Kust (Zuid)	2	11	11										
Hollandse Kust west zuidelijk deel (HK-w-z)	6	11	11	11									
Hollandse Kust Zuid Holland III	2	11	11										
IJmuiden Ver	6						11						
IJmuiden Ver Noord (IJ-Ver-n)	6				11	11	11	11					
Ilen	6						217	217	217	217			
Inis Ealga Marine Energy Park	6						28	28	28	28			
Jyske Banke	6						7	7	7	7			
Kilmichael Point	6						29	29	29	29			
Kinsale	6						28	28	28	28			
Latitude 52	6						29	29	29	29			
Lir (Future Development Area)	6						29	29	29	29			
Lir (Site A)	6						29	29	29	29			
Lir (Site B)	6						29	29	29	29			
Machair	6						29	29	29	29			
Malin Sea Wind	6						10	10	10	10			
Marram	6										30		
Moneypoint One	6						217	217	217	217			

Project	Tier	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Mooir Vannin	6						19	19	19	19			
Muir Mhòr	6									89	89		
North Channel Wind 1	6									29	29		
North Channel Wind 2	6										29	29	
North Irish Sea Array	6						29	29					
Oriel	6						29	29	29	29			
Peterhead to South Humber	6		3	3	3	3	3	3	3	3	3		
Saint-Brieuc	2	2	2	2									
Saint-Nazaire	2	2	2										
Salamander	6						30	30	30	30	30		
Scaraben	6						9	9	9	9			
Sea Stacks	6						29	29	29	29			
Sealtainn	6						9	9	9	9			
Setanta Wind Park	6							29	29	29			
Shearwater One	6						10	10	10	10			
Shelmalere	6	29	29	29	29	29	29	29					
Sinclair	6						9	9	9	9			
South East Scotland to South Humber	6				3	3	3	3	3				
South East Wind	6							29	29	29	29		
South irish Sea	6						29	29	29	29			
Spiorad na Mara	6						47	47	47	47			
Stoura	6									9			
Stromar	6								8	8	8		
Sunrise	6						29	29	29	29			
Talisk	6						16	16	16	16			
Wicklow	6						29	29	29	29			
CS006	7				3	3	3						
CS007	7				3	3	3						
Endurance	6			1	1	1							
Gas Shearwater to Bacton Seal Line	6					1	1	1	1	1	1	1	1
CS013	7				1	1	1						
CS014	7				1	1	1						
Round 5 PDA1	7						1	1	1	1			
Round 5 PDA2	7						1	1	1	1			
Round 5 PDA3	7						1	1	1	1			
CS020	7				1	1	1						
CS025	7				1	1	1						
CS026	7				1	1	1						
CS027	7				1	1	1						

Project	Tier	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
CS028	7				1	1	1						
CS008	7				1	1	1						
CS009	7				1	1	1						
CS019	7				1	1	1						
4 seismic surveys	7						91	91	91	91			

Table 11-90: Total number of minke whales disturbed by underwater noise across the Tiers (all projects with and without the PEIR/ES chapter). Results including lower Tier projects with lower data confidence are denoted by grey text.

Years		The Project Alone		The Project + Tiers 1 to 3		The Project + Tiers 1 to 4		The Project + Tiers 1 to 5		The Project + Tiers 1 to 7	
		#	% MU	#	% MU	#	% MU	#	% MU	#	% MU
2021		0	0.00%	885	4.40%	896	4.45%	896	4.45%	965	4.80%
2022		0	0.00%	1,046	5.20%	1,057	5.25%	1,057	5.25%	1,138	5.66%
2023		0	0.00%	947	4.71%	947	4.71%	947	4.71%	1,029	5.11%
2024		0	0.00%	325	1.62%	325	1.62%	325	1.62%	646	3.21%
2025		0	0.00%	355	1.76%	361	1.79%	361	1.79%	683	3.39%
2026		14	0.07%	304	1.51%	1,124	5.59%	1,124	5.59%	3,374	16.77%
2027		14	0.07%	474	2.36%	2,003	9.96%	2,003	9.96%	4,288	21.31%
2028		14	0.07%	147	0.73%	2,843	14.13%	2,843	14.13%	5,152	25.61%
2029		14	0.07%	147	0.73%	1,821	9.05%	1,821	9.05%	4,176	20.76%
2030		0	0.00%	133	0.66%	1,501	7.46%	1,501	7.46%	1,803	8.96%
2031		0	0.00%	51	0.25%	1,170	5.82%	1,170	5.82%	1,373	6.82%
2032		0	0.00%	51	0.25%	435	2.16%	435	2.16%	540	2.68%
2021 to 2032	Min	0	0.00%	51	0.25%	325	1.62%	325	1.62%	540	2.68%
	Av	5	0.02%	405	2.02%	1,207	6.00%	1,207	6.00%	2,097	10.42%
	Max	14	0.07%	1,046	5.20%	2,843	14.13%	2,843	14.13%	5,152	25.61%
2026 to 2029	Min	14	0.07%	147	0.73%	1,124	5.59%	1,124	5.59%	3,374	16.77%
	Av	14	0.07%	268	1.33%	1,948	9.68%	1,948	9.68%	4,248	21.11%
	Max	14	0.07%	474	2.36%	2,843	14.13%	2,843	14.13%	5,152	25.61%

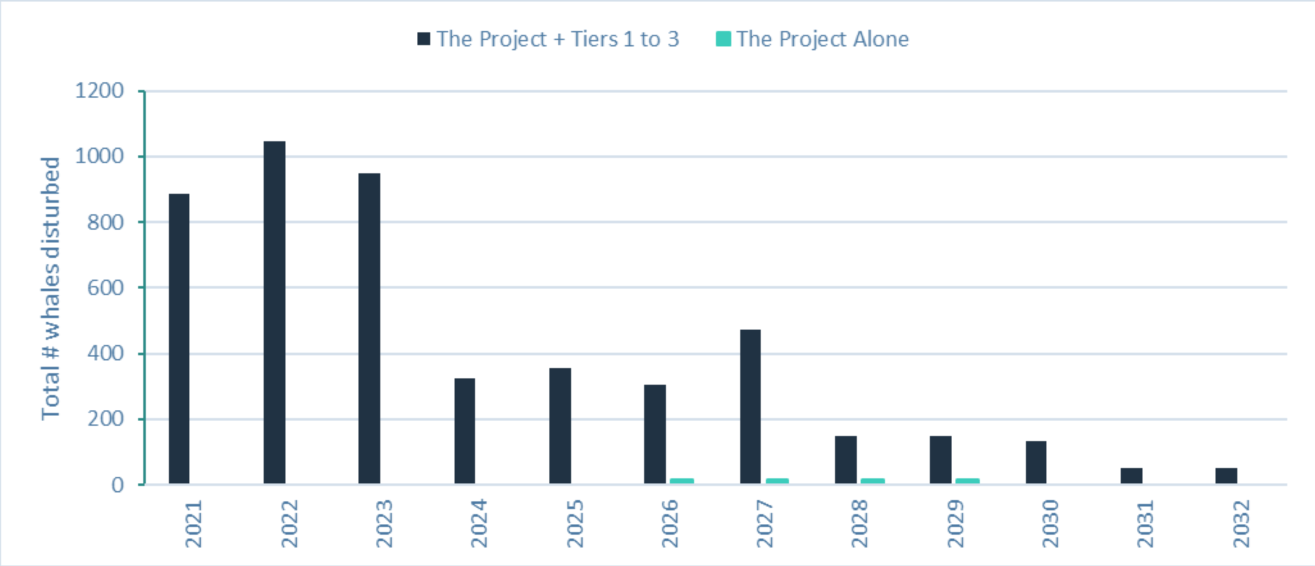

Plate 11.40: Cumulative underwater noise disturbance estimates to minke whales for the Project alone and the Project in addition to Tier 1-3 projects.

11.7.3.7 Harbour seal – Disturbance from underwater noise

678. Of the 31 projects screened into the CEA for harbour seal, six projects within the MU scoped harbour seals out of their project-specific EIAs (Dogger Bank projects, Norfolk Boreas, Rampion Extension and Hornsea Project Two) and therefore these projects were not included further in this CEA. This left a total of 18 OWF projects plus two cable projects, ten CCS, and two seismic surveys included in the harbour seal CEA.

679. The potential number of harbour seals disturbed per day by projects (with and without PEIR/ES chapters) is provided in Table 11-91.

680. A summary of the total disturbance impact to harbour seals per day by Tier (all projects with and without the PEIR/ES chapter) is provided in Table 11-92.

681. A summary of the total disturbance impact to harbour seals per day across all projects in Tier 1-3 is provided in Plate 11.41.

682. Across all years considered in the CEA (2021 to 2032 inclusive) and all Tiers (1-7), the period with highest level of predicted disturbance to harbour seals is in 2026, when pre-construction UXO clearance is occurring at the Project.

683. When considering the potential impact from the Project in addition to all Tier 1-3 projects (those consented and thus with higher levels of data confidence), the highest level of predicted disturbance to harbour seals across the MU is in 2026. At this time, a maximum of 344 harbour seals (7.07% MU) may be disturbed per day, of which, 80.2% is disturbance from the Project (assuming all Tier 1-3 projects are constructing at the same time, and that disturbance is additive across projects i.e. no overlapping disturbance footprints). It should be noted that this maximum value in 2026 is largely attributed to the number of harbour seals potentially disturbed by the UXO clearance at the Project assuming a 26km EDR (276 individuals). As per the JNCC (2020) guidance, it is not expected that disturbance from a single UXO detonation would result in any widespread and prolonged displacement and therefore would not be sufficient to result in any changes to the vital rates of individuals. Additionally, the total impact to the Southeast England MU population is expected to be lower as the Project construction progresses (Table 11-92). For example, although in 2026 a maximum of 344 harbour seals (7.07% MU) may be disturbed per day, the number of animals potentially disturbed reduces to 77 seals (1.58% MU) in 2027 to 2029. The average cumulative number of individuals potentially disturbed across the UXO clearance and piling window at the Project (2026 to 2029) was estimated as 130 harbour seals (2.67% MU).

684. There are numerous levels of precaution built into this CEA which makes the resulting estimates highly precautionary, e.g., the assumption of an EDR of 26km for piling and UXO clearance. The EDR of 26km was recommended for harbour porpoise, which is considerably more sensitive to underwater noise and disturbance than harbour seals (Booth *et al*., 2019), and therefore over-estimates the number of harbour seals that may be disturbed. Therefore, taking into account the over-precaution in the results, impacts are likely not enough to affect the population trajectory over a generational scale, and thus the magnitude of the cumulative increase in disturbance from underwater noise is Medium.

685. The sensitivity of harbour seals to disturbance from both piling and UXO clearance has been assessed as Medium. The same has been assumed here for disturbance from seismic surveys.

686. Therefore, the effect significance of disturbance to harbour seals from the cumulative impact of underwater noise is **Minor (not significant)** in EIA terms.

Table 11-91: Number of harbour seals potentially disturbed by underwater noise by projects (with and without PEIR/ES chapter). Cells highlighted in colours indicate UXO clearance, piling, construction, seismic survey and decommissioning. The project construction period (UXO clearance in 2026, piling between 2027 and 2029) is indicated by the red box.

Project	Tier	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
The Project	N/A						276	11	11	11			
Projects with PEIR/ES chapter													
Dogger Bank South (East)	4						2	2	2	2			
Dogger Bank South (West)	4						1	1	1	1			
Dudgeon Extension	3						18	18	18				
East Anglia One	1	1											
East Anglia One North	3			1	1	1							
East Anglia Three	3		36	36	36								
East Anglia Two	3			2	2	2	2						
Five Estuaries	4							3	3	3	3	3	3
Hornsea Project Four	3					5	5	5	5	5	5		
Hornsea Project Three	3					5	5	5	5	5	5	5	5
Norfolk Vanguard East	3			2	2	2							
Norfolk Vanguard West	3			2	2	2							
North Falls	4						8	8	8	8			
Sheringham Shoal Ext	2					38	38	38	38				
Sofia	2			35	35	35							
Projects without PEIR/ES chapter													
BP (AKA Flora)	6						26	26	26	26			
Dogger Bank D	6							79	79	79			
Eastern Green Link 3 (EGL3)	6								3	3	3	3	3
Eastern Green Link 4 (EGL4)	6								3	3	3	3	3
Scroby Sands	1											73	73
Endurance	6			3	3	3							
Gas Shearwater to Bacton Seal Line	6					3	3	3	3	3	3	3	3
CS006	7				3	3	3						
CS007	7				3	3	3						
CS020	7				3	3	3						
CS025	7				3	3	3						
CS028	7				3	3	3						

Project	Tier	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
CS008	7				3	3	3						
CS009	7				3	3	3						
CS019	7				3	3	3						
2 seismic surveys	7						130	130	130	130			

Table 11-92: Total number of harbour seals disturbed by underwater noise across the Tiers. Results including lower Tier projects with lower data confidence are denoted by grey text.

	the Project alone		the Project + T1-3		the Project + T1-4		the Project + T1-7	
	Disturbed	% MU	Disturbed	% MU	Disturbed	% MU	Disturbed	% MU
2021	0	0.00%	1	0.02%	1	0.02%	1	0.02%
2022	0	0.00%	36	0.74%	36	0.74%	36	0.74%
2023	0	0.00%	78	1.60%	78	1.60%	81	1.66%
2024	0	0.00%	78	1.60%	78	1.60%	105	2.16%
2025	0	0.00%	90	1.85%	90	1.85%	120	2.47%
2026	276	5.67%	344	7.07%	355	7.29%	538	11.05%
2027	11	0.23%	77	1.58%	91	1.87%	329	6.76%
2028	11	0.23%	77	1.58%	91	1.87%	335	6.88%
2029	11	0.23%	21	0.43%	35	0.72%	279	5.73%
2030	0	0.00%	10	0.21%	13	0.27%	22	0.45%
2031	0	0.00%	78	1.60%	81	1.66%	90	1.85%
2032	0	0.00%	78	1.60%	81	1.66%	90	1.85%
Min 2026-29	11	0.23%	21	0.43%	35	0.72%	279	5.73%
Max 2026-29	276	5.67%	344	7.07%	355	7.29%	370	7.61%
Max 2021-32	26	0.53%	81	1.66%	86	1.76%	538	11.05%

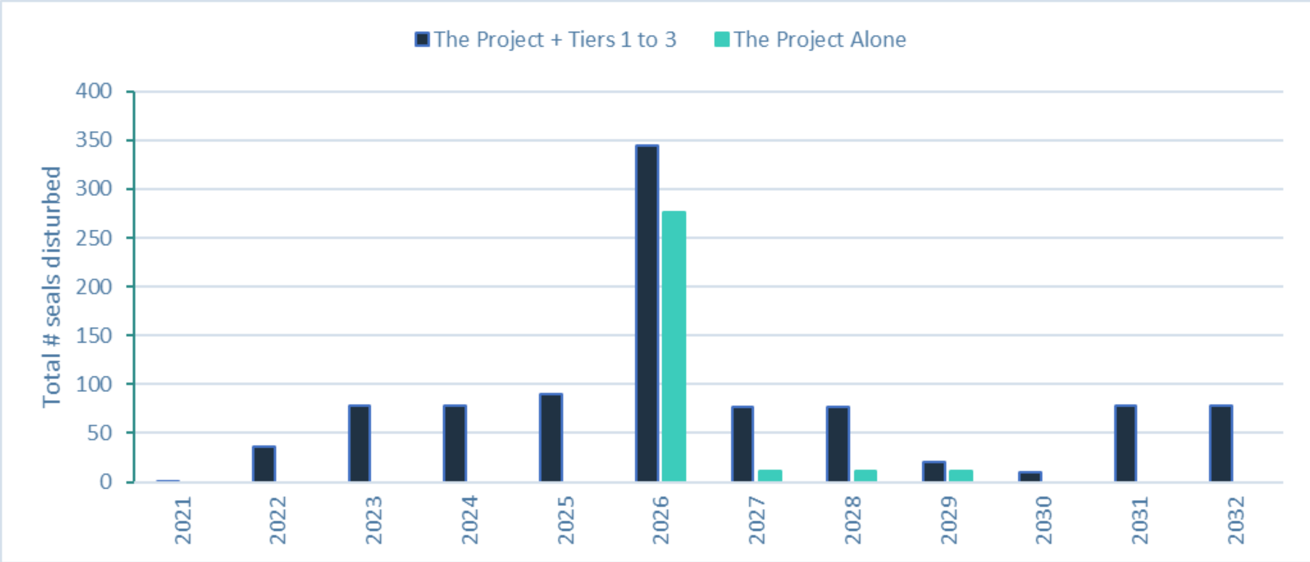

Plate 11.41: Cumulative underwater noise disturbance estimates to harbour seals for the Project alone and the Project in addition to Tier 1-3 projects.

11.7.3.8 Grey seal – Disturbance from underwater noise

687. All 24 OWF projects in the grey seal MU (including the Project) plus two cable projects, ten CCS, and two seismic surveys were included in the grey seal CEA.

688. The potential number of grey seals disturbed per day by projects (with and without PEIR/ES chapters) is provided in Table 11-93.

689. A summary of the total disturbance impact to grey seals per day by Tier (all projects with and without the PEIR/ES chapter), is provided in Table 11-94.

690. A summary of the total disturbance impact to grey seals per day across all projects in Tier 1-3 is provided in Plate 11.42.

691. Across all years considered in the CEA (2021 to 2032 inclusive) and all Tiers (1-7), the period with highest level of predicted disturbance to grey seals is in 2026, when pre-construction UXO clearance is occurring at the Project.

692. When considering the potential impact from the Project in addition to all Tier 1-3 projects (those consented and thus with higher levels of data confidence), the highest level of predicted disturbance to grey seals across the MU is also in 2026. In this year, a maximum of 3,600 grey seals (5.50% MU) may be disturbed per day, of which, 50.1% is disturbance from the Project (assuming all Tier 1-3 projects are constructing at the same time, and that disturbance is additive across projects i.e. no overlapping disturbance footprints). It should be noted that this maximum value in 2026 is largely driven by the number of harbour seals potentially disturbed by the UXO clearance at the Project using 26km EDR (1,805 individuals). As per the JNCC (2020) guidance, it is not expected that disturbance from a single UXO detonation would result in any widespread and prolonged displacement and therefore would not be sufficient to result in any changes to the vital rates of individuals.

693. Additionally, the total impact to the Southeast England and Northeast England MUs population is expected to be lower as the Project construction progresses (Table 11-92). For example, although in 2026 a maximum of 3,600 grey seals (5.50% MU) may be disturbed per day, the number of animals potentially disturbed reduces to 2,074 seals (3.17% MU) in 2027, to 2,072 (2.85%) seals in 2028 and 1,864 (2.85% MU) in 2029. The average cumulative number of individuals potentially disturbed across the UXO clearance and piling window at the Project (2026 to 2029) was estimated as 2,403 grey seals (3.67% MU). These numbers are mostly driven by the high numbers of grey seals potentially disturbed as a result of piling at the Hornsea Four Project with up to 1,489 individuals affected. However, it should be noted that this is the most precautionary number of individuals affected based on installation of only three High Voltage Alternating Current (HVAC) Booster Stations over a total of up to nine days over a 12-month piling period (Orsted, 2021).

694. Furthermore, there are other levels of precaution built into this CEA which makes the resulting estimates highly precautionary, e.g., the assumption of an EDR of 26km from UXO clearance and piling. The EDR of 26km was recommended for harbour porpoise, which is considerably more sensitive to underwater noise and disturbance than grey seals (Booth *et al*., 2019), and therefore over-estimates the number of grey seals that may be disturbed. If these UXO disturbance values (see paragraph 692) are removed or reduced then the total numbers would be much lower. Therefore, taking into account the over-precaution in the results, impacts are likely not enough to affect the population trajectory over a generational scale, and thus the magnitude of the cumulative increase in disturbance from underwater noise is Medium .

695. The sensitivity of grey seals to disturbance from piling and UXO clearance has been assessed as Low and Medium, respectively. A Low sensitivity to disturbance from seismic surveys is assumed here.

696. Therefore, the effect significance of disturbance to grey seals from the cumulative impact of underwater noise is **Minor (not significant)** in EIA terms.

Table 11-93: Number of grey seals potentially disturbed by underwater noise by projects (with and without PEIR/ES chapter). Cells highlighted in colours indicate UXO clearance, piling, construction, seismic survey and decommissioning. The project construction period (UXO clearance in 2026, piling between 2027 and 2029) is indicated by the red box.

Project	Tier	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
The Project	N/A						1805	326	326	326			
Projects with PEIR/ES chapter													
Dogger Bank A	3		2										
Dogger Bank B	2		6	6	6	6							
Dogger Bank C	2				2	2	2	2					
Dogger Bank South (East)	4						950	950	950	950			
Dogger Bank South (West)	4						855	855	855	855			
Dudgeon Ext	3						89	89	89				
East Anglia One	1	2											
East Anglia One North	3			2	2	2	2						
East Anglia Three	3		36	36	36								
East Anglia Two	3			43	43	43	43						
Five Estuaries	4							168	168	168	168	168	168
Hornsea Project Four	3					1489	1489	1489	1489	1489	1489		
Hornsea Project Three	3					49	49	49	49	49	49	49	49
Hornsea Project Two	2	1	1										
Norfolk Boreas	3			2	2	2	2						
Norfolk Vanguard East	3			8	8	8							
Norfolk Vanguard West	3			8	8	8							
North Falls	4						140	140	140	140			
Rampion Ext	4					2	2						
Sheringham Shoal Ext	2					119	119	119	119				
Sofia	2			2	2	2							
Projects without PEIR/ES chapter													
BP (AKA Flora)	6						238	238	238	238			
Dogger Bank D	6							716	716	716			
Eastern Green Link 3 (EGL3)	7								26	26	26	26	26
Eastern Green Link 4 (EGL4)	6								26	26	26	26	26
Scroby Sands	1											662	662
Endurance	6			26	26	26							

Project	Tier	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Gas Shearwater to Bacton Seal Line	6					26	26	26	26	26	26	26	26
CS006	7				26	26	26						
CS007	7				26	26	26						
CS020	7				26	26	26						
CS025	7				26	26	26						
CS028	7				26	26	26						
CS008	7				26	26	26						
CS009	7				26	26	26						
CS019	7				26	26	26						
2 seismic surveys	7						1186	1186	1186	1186			

Table 11-94: Total number of grey seals disturbed by underwater noise across the Tiers (all projects with and without the PEIR/ES chapter). Results including lower Tier projects with lower data confidence are denoted by grey text.

Years		The Project Alone		The Project + Tiers 1 to 3		The Project + Tiers 1 to 4		The Project + Tiers 1 to 5		The Project + Tiers 1 to 7	
		#	% MU	#	% MU	#	% MU	#	% MU	#	% MU
2021		0	0.00%	3	0.00%	3	0.00%	3	0.00%	3	0.00%
2022		0	0.00%	45	0.07%	45	0.07%	45	0.07%	45	0.07%
2023		0	0.00%	107	0.16%	107	0.16%	107	0.16%	133	0.20%
2024		0	0.00%	109	0.17%	109	0.17%	109	0.17%	343	0.52%
2025		0	0.00%	1,730	2.64%	1,732	2.64%	1,732	2.64%	1,992	3.04%
2026		1,805	2.76%	3,600	5.50%	5,547	8.47%	5,547	8.47%	7,205	11.00%
2027		326	0.50%	2,074	3.17%	4,187	6.39%	4,187	6.39%	6,353	9.70%
2028		326	0.50%	2,072	3.16%	4,185	6.39%	4,185	6.39%	6,403	9.77%
2029		326	0.50%	1,864	2.85%	3,977	6.07%	3,977	6.07%	6,195	9.46%
2030		0	0.00%	1,538	2.35%	1,706	2.60%	1,706	2.60%	1,784	2.72%
2031		0	0.00%	711	1.09%	879	1.34%	879	1.34%	957	1.46%
2032		0	0.00%	711	1.09%	879	1.34%	879	1.34%	957	1.46%
2021 to 2032	Min	0	0.00%	3	0.00%	3	0.00%	3	0.00%	3	0.00%
	Av	232	0.35%	1,214	1.85%	1,946	2.97%	1,946	2.97%	2,698	4.12%
	Max	1,805	2.76%	3,600	5.50%	5,547	8.47%	5,547	8.47%	7,205	11.00%
2026 to 2029	Min	326	0.50%	1,864	2.85%	3,977	6.07%	3,977	6.07%	6,195	9.46%
	Av	696	1.06%	2,403	3.67%	4,474	6.83%	4,474	6.83%	6,539	9.98%
	Max	1,805	2.76%	3,600	5.50%	5,547	8.47%	5,547	8.47%	7,205	11.00%

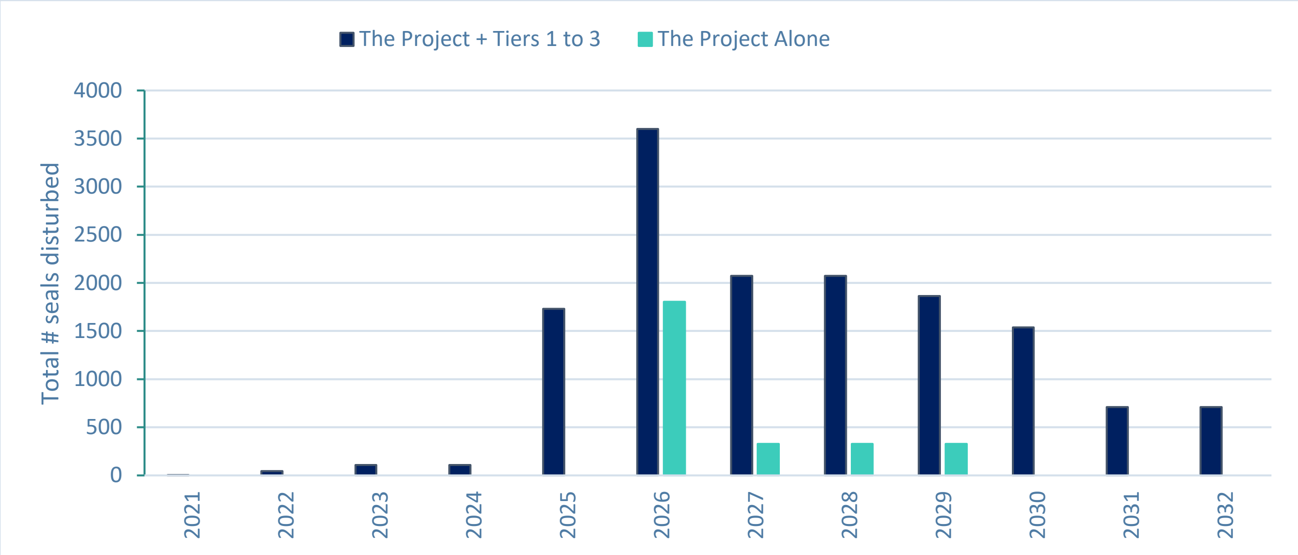

Plate 11.42: Cumulative underwater noise disturbance estimates to grey seals for the Project alone and the Project in addition to Tier 1-3 projects.

11.7.4 Disturbance from vessels

697. It is extremely difficult to reliably quantify the level of increased disturbance to marine mammals resulting from increased vessel activity on a cumulative basis given the large degree of temporal and spatial variation in vessel movements between projects and regions, coupled with the spatial and temporal variation in marine mammal movements across the region.

698. Although some OWF vessels (such as crew transport and supply vessels) may transit the windfarm at higher speeds, they often travel in repeated/predictable routes within the site. Many other vessels (e.g. jack-up vessels and pilot or attending vessels) travel more slowly within the windfarm site or spend long periods of time jacked-up, at anchor (minimizing movement and acoustic signature from engines) or using dynamic positioning systems (minimizing movement, although still generating noise). Unfortunately, there are very few species-specific studies covering these vessel types that capture vessel movement patterns as well as their acoustic signatures and the corresponding response of marine mammals.

699. Vessel routes to and from offshore windfarms and other projects will, for the majority, use existing vessel routes for pre-existing vessel traffic which marine mammals will be accustomed to. They may also have become habituated to the volume of regular vessel movements and therefore the additional risk is predominantly confined to construction sites. The vessel movements for offshore windfarms are likely to be limited and slow, resulting in less risk of disturbance to marine mammal receptors. In addition, most projects are likely to adopt VMPs (or comply with exiting Marine Wildlife Watching Codes) in order to minimise any potential effects on marine mammals.

700. Seismic surveys do not use existing vessel routes, so may risk adding vessel presence to novel areas; however, these are slow-moving and operate their own mitigation measures to protect marine mammals (for example, see JNCC et al., 2010; 2017 – while mitigating for PTS the measures outlined in these guidance documents will also reduce disturbance impacts). Therefore, increases in disturbance from vessels from offshore projects are likely to be small in relation to current and ongoing levels of shipping.

701. For all marine mammal receptors, the cumulative impact of increased disturbance from vessels is predicted to be of local spatial extent, long-term duration (vessel presence is expected throughout the lifespan of a windfarm), intermittent (vessel activity will not be constant) and reversible (disturbance effects are temporary). Therefore, the magnitude of vessel disturbance is considered to be Low , indicating that the potential is for short-term and/or intermittent behavioural effects, with survival and reproductive rates very unlikely to be impacted to the extent that the population trajectory would be altered. It is anticipated that any animals displaced from the area will return when vessel disturbance has ended.

702. It should be noted that underwater noise levels from vessels generally result in an increase in non-impulsive, continuous sound in the vicinity of the Project array, typically in the range of 10 – 100Hz (although higher frequencies may also be produced) (Sinclair et al., 2021). Harbour porpoise have a high frequency generalised hearing range (275Hz – 160kHz) and, therefore, the majority of additional vessel traffic noise will fall below their range of hearing. The generalised hearing range of high frequency cetaceans 150Hz – 160kHz (Southall et al., 2019) is above the anticipated frequency range of much of the construction vessel noise. Minke whales have a low frequency generalised hearing range of 7Hz – 35kHz which falls within the expected frequency range of construction vessel traffic and they have been shown to exhibit a decrease in foraging activity in response to whale watching vessels (Christiansen et al., 2013). However, these vessels were specifically following minke whales and, therefore, it is not known how they would respond to construction vessels that would be following a pre-determined route and not directly interacting with the animals. Jones et al., (2017) presents an analysis of the predicted co-occurrence of ships and seals at sea which demonstrates that UK wide there is a large degree of predicted co-occurrence. There is no evidence relating decreasing seal populations with high levels of co-occurrence between ships and animals. Considering the above, the sensitivity of marine mammal species to vessel disturbance has been assessed as Medium.

703. Therefore, the effect significance of vessel disturbance to marine mammals from the cumulative impact of underwater noise is **Moderate (not significant)** in EIA terms.

11.8 Inter-relationships

704. Inter-relationships are considered to be the impacts and associated effects of different aspects of the proposal on the same receptor. These are considered to be:

- Project lifetime effects: Assessment of the scope for effects that occur throughout more than one phase of the Project (construction, O&M and decommissioning); to interact to potentially create a more significant effect on a receptor than if just assessed in isolation in these three key project stages; and
- Receptor led effects: Assessment of the scope for all effects to interact, spatially and temporally, to create inter-related effects on a receptor. Effect may interact to produce different, or greater effect on this receptor than when the effects are considered in isolation. Receptor-led effects may be short-term, temporary or transient effects, or incorporate longer term effects.

705. A description of the likely inter-related effects arising from the Project on marine mammal ecology is provided below:

- Collision risk from vessel activity in the area (impact 9);
- Disturbance from vessel activity (impact 10);
- Changes to marine mammal prey species (impact 11); and
- Changes to water quality (impact 12).

The effects to marine mammals from the above impacts have been assessed as **negligible** significance to **minor** significance. 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 collision risk, vessel disturbance, changes to water quality and prey species has been assessed as **not significant**.

706. A description of the process to identify and assess these effects is presented in Chapter 5 (document reference 6.1.5), and the likely inter-related effects arising from the Project on marine mammal ecology is summarised below:

Table 11-95: Consideration of inter-related effects of relevance to marine mammals

Project phase(s)	Nature of inter-related effect	Assessment alone	Inter-related effects assessment
Project-lifetime effects			
Construction, O&M and decommissioning	Collision risk from vessel activity in the area	Impacts were assessed as being **Not Significant** in the construction, O&M and decommissioning phases.	The area surrounding the Project already experiences relatively high levels of vessel traffic. With VMP based on best practice vessel handing protocols in place, the interaction of vessel collision risk impact across construction, O&M and decommissioning phases is not expected to result in an effect of any greater

Project phase(s)	Nature of inter-related effect	Assessment alone	Inter-related effects assessment
			significance than those assessed in the individual project phases.
Construction, O&M and decommissioning	Disturbance from vessel activity	Impacts were assessed as being **Not Significant** in the construction, O&M and decommissioning phases.	As stated above, the area surrounding the Project already experiences high levels of vessel traffic. The adoption of a VMP based on best practice vessel handing protocols will ensure the interaction of vessel disturbance impacts across construction, O&M and decommissioning phases will result in an effect of no greater significance than those assessed in the individual project phases.
Construction, O&M and decommissioning	Changes to marine mammal prey species	Impacts were assessed as being **Not Significant** in the construction, O&M and decommissioning phases.	Considering the generalist/opportunist nature of marine mammal receptors (and thus low sensitivity to this impact), the interaction of impact of changes to prey across construction, O&M and decommissioning phases is not expected to result in an effect of any greater significance than those assessed in the individual project phases.
Construction and decommissioning	Changes to water quality	Impacts were assessed as being **Not Significant** in the construction and decommissioning phases.	The impacts of increased SSC and sediment deposition during the construction and decommissioning phases is expected to be short-term intermittent and of very localised extent, with any effects being reversible. The interaction of these impacts across construction and decommissioning stages of the development is not predicted to result in an effect of any

Project phase(s)	Nature of inter-related effect	Assessment alone	Inter-related effects assessment
			greater significance than those assessed in the individual project phases.
Construction, O&M and decommissioning	Disturbance at haul-outs	Impacts were assessed as being **Not Significant** in the construction, O&M and decommissioning phases.	Considering the far distances (<1km) of key haul-out sites for grey and harbour seals from the Project area, and the spatially localised, and temporarily reversible nature of haul-out disturbance impact, the interaction of the impact across all stages of the development is not predicted to result in an effect of any greater significance than those assessed in the individual project phases.
Receptor led effects			
No spatial or temporal interaction between the effects assessed above is expected during the project lifetime.			

11.9 Transboundary Effects

707. Transboundary effects are defined as those effects upon the receiving environment of other European Economic Area (EEA) states, whether occurring from the Project alone, or cumulatively with other projects in the wider area.

708. There may be behavioural disturbance or displacement of marine mammals from the Project 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 Project could extend into waters of other EEA states. The Project is located in proximity to other states (e.g., French, Dutch and Belgian waters) and therefore there is the potential for transit of certain species between areas.

709. The mobile nature of marine mammals also results in the potential for transboundary effects to occur. Whilst each species has been assessed within the relevant MU for the Project array, the MUs under which each species has been assessed varies greatly in the area covered. Furthermore, the respective MUs do not represent closed populations. This means that impacts, whilst localised, could potentially affect other MUs if mixing between the assessed populations occurs

710. Any transboundary impacts that do occur as a result of the Project are predicted to be short-term and intermittent, with the recovery of marine mammal populations to affected areas following the completion of construction activities.

711. The magnitude of the impact has been assessed as negligible to low and the sensitivity of receptors as negligible to low. Therefore, the significance of behavioural disturbance leading to transboundary effects is concluded to be of **minor (not significant)** in terms of the EIA regulations.

11.10 Conclusions

712. This chapter has assessed the potential effects on marine mammal receptors arising from the 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., by the presence of infrastructure at the seabed), as well as indirectly (e.g., SSC and impacts on prey species). Potential impacts considered in this chapter, alongside any mitigation and residual effects are listed below in Table 11-96.

713. The impacts on relevant receptors from all stages of the Project were assessed, including impacts from underwater noise (piling and UXO clearance), vessel collisions and disturbance, increased SSC and indirect impacts on prey species, and disturbance at haul-outs.

714. Throughout the construction, operation and decommissioning phases, all impacts assessed, with consideration of the relevant embedded mitigation, 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 Project and other developments and activities, including offshore windfarms, concluded that the effects of any cumulative impacts would be of minor (not significant) in EIA terms.

Table 11-96: Summary of effects on marine mammals

Description of impact	Effect	Additional mitigation measures	Residual impact
Construction			
Impact 1: UXO clearance - PTS	Minor significance of effect for minke whale Negligible significance of effect for all other species	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 2: UXO clearance – disturbance	Minor significance of effect for harbour porpoise, minke whale, harbour seals and grey seals Negligible significance of effect for bottlenose dolphin, and white-beaked dolphin		No significant adverse residual effects
Impact 3: Pile driving – PTS	Negligible significance of effect for all species	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 4: Pile driving – TTS	No assessment of significance		No significant adverse residual effects
Impact 5: Piling - disturbance	Minor significance of effect for harbour porpoise Negligible significance of effect for all other species		No significant adverse residual effects
Impact 6: PTS from other construction activities	Minor significance of effect for minke whale	Not Applicable – no additional mitigation identified	No significant adverse residual effects

Description of impact	Effect	Additional mitigation measures	Residual impact
	Negligible significance of effect for all other species		
Impact 7: TTS from other construction activities	No assessment of significance	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 8: Disturbance from other construction activities	Minor significance of effect for cetacean species Negligible significance of effect for pinniped species	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 9: Vessel collisions	Minor significance of effect for all species	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 10: Vessel disturbance	Minor significance of effect for cetacean species Negligible significance of effect for pinniped species		No significant adverse residual effects
Impact 11: Indirect impacts on prey	Negligible significance of effect for all species	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 12: Water quality impacts	Negligible significance of effect for all species	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 13: Disturbance at haul out sites	Minor significance of effect for harbour seals and grey seals	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Operation and Maintenance			
Impact 14: Operational noise – PTS and disturbance	Minor significance of effect for minke whale	Not Applicable – no additional mitigation identified	No significant adverse residual effects

Description of impact	Effect	Additional mitigation measures	Residual impact
	Negligible significance of effect for all other species		
Impact 15: Vessel collisions	Minor significance of effect for all species	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 16: Vessel disturbance	Negligible significance of effect for all species		No significant adverse residual effects
Impact 17: Indirect impacts on prey	Negligible significance of effect for all species	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 18: Disturbance at haul out sites	Minor significance of effect for harbour seals and grey seals	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Decommissioning			
Impact 19: Underwater noise from decommissioning	Minor to Negligible significance of effect for all species	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 20: Vessel collisions	Minor significance of effect for all species	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 21: Vessel disturbance	Negligible significance of effect for all species		No significant adverse residual effects
Impact 22: Indirect impacts on prey	Negligible significance of effect for all species	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 23: Water quality impacts	Negligible significance of effect for all species	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 24: Disturbance at haul out sites	Minor significance of effect for harbour seals and grey seals	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Cumulative			

Description of impact	Effect	Additional mitigation measures	Residual impact
Disturbance from underwater noise	Minor significance of effect for all species	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Disturbance from vessels	Negligible significance of effect for all species	Not Applicable – no additional mitigation identified	No significant adverse residual effects

11.11 References

Aarts, G., Brasseur, S. and Kirkwood, R. (2018). 'Behavioural response of grey seals to pile-driving', Wageningen Marine Research report C006/18.

Andersen, S. M., Teilmann, J., Dietz, R., Schmidt, N. M. and Miller, L. A. (2011). 'Behavioural responses of harbour seals to human-induced disturbances', Aquatic conservation: Marine and Freshwater Ecosystems, 22: 113-121.

Anderwald, P., Brandecker, A., Coleman, M., Collins, C., Denniston, H., Haberlin, M. D., O'Donovan, M., Pinfield, R., Visser, F. and Walshe, L. (2013). 'Displacement responses of a mysticete, an odontocete and a phocid seal to construction-related vessel traffic', Endangered Species Research, 21: 231-240.

Arons, A. (1954). 'Underwater explosion shock wave parameters at large distances from the charge', The Journal of the Acoustical Society of America, 26:343-346.

Barett, R. (1996). 'Guidelines for the safe use of explosives underwater', MTD Publication 96:101.

Beck, C. A., Bowen, W. D. and Iverson, S. J. (2003). 'Sex differences in the seasonal patterns of energy storage and expenditure in a phocid seal' Journal of Animal Ecology, 72:280-291.

BEIS (2020). 'Review of Consented Offshore Windfarms in the Southern North Sea Harbour Porpoise SAC', The Department for Business Energy and Industrial Strategy.

Benhemma-Le Gall, A., Graham, I., Merchant, N. and Thompson, P. (2021). 'Broad-scale responses of harbor porpoises to pile-driving and vessel activities during offshore windfarm construction', Frontiers in Marine Science 8/66724: 1-18.

Bishop, A., Pomeroy, P. and Twiss, S. (2015). 'Breeding male grey seals exhibit similar activity budgets across varying exposures to human activity', Marine Ecology Progress Series, 527:247-259.

Blackwell, S. B., Nations, C. S., Thode, A. M., Kauffman, M. E., Conrad, A. S., Norman, R. G. and Kim, K. H. (2017) 'Effects of tones associated with drilling activities on bowhead whale calling rates', PLOS ONE, 12/11: e0188459.

Blix, A., and Folkow, L. (1995). 'Daily energy expenditure in free living minke whale', Acta Physiologica, 153: 61-66.

Booth, C. and Heinis, F. (2018). 'Updating the Interim PCoD Model: Workshop Report - New transfer functions for the effects of permanent threshold shifts on vital rates in marine mammal species', Report Code SMRUC-UOA-2018-006, submitted to the University of Aberdeen and Department for Business, Energy and Industrial Strategy (BEIS), June 2018 (unpublished).

Booth, C. G., F. Heinis, and H. J. (2019). Updating the Interim PCoD Model: Workshop Report - New transfer functions for the effects of disturbance on vital rates in marine mammal species. Report Code SMRUC-BEI-2018-011, submitted to the Department for Business, Energy and Industrial Strategy (BEIS), February 2019 (unpublished).

Booth, C. G.,Heinis, F. (2019). 'Updating the Interim PCoD Model: Workshop Report - New transfer functions for the effects of disturbance on vital rates in marine mammal species', Report Code SMRUC-BEI-2018-011, submitted to the Department for Business, Energy and Industrial Strategy (BEIS), February 2019 (unpublished).

Borggaard, D., Lien, J. and Stevick, P. (1999). 'Assessing the effects of industrial activity on large cetaceans in Trinity Bay, Newfoundland (1992-1995)', Aquatic Mammals, 25/3: 149-161

Bossley, M. I., Steiner, A., Parra,G. J., Saltre, F. and Peters, K. J. (2022). 'Dredging activity in highly urbanised esturay did not affect the long-term occurrence of Indo-Pacific bottlenose dolphins and long-nosed fur seals', Marine Pollution Bulletin,184/1141843: 1-7.

Brandt, M. J., Diederichs, A., Betke, K. and Nehls, G. (2011). 'Responses of harbour porpoises to pile driving at the Horns Rev II offshore windfarm in the Danish North Sea', Marine Ecology Progress Series, 421:205-216.

Brandt, M. J., Diederichs, A., Betke, K. and Nehls, G. (2011). 'Responses of harbour porpoises to pile driving at the Horns Rev II offshore windfarm in the Danish North Sea', Marine Ecology Progress Series, 421:205-216.

Brandt, M. J., Dragon, A. C., Diederichs, A., Bellmann, M. A., Wahl, V., Piper, W., Nabe-Nielsen, J. and Nehls, G. (2018). 'Disturbance of harbour porpoises during construction of the first seven offshore windfarms in Germany', Marine Ecology Progress Series, 596: 213-232.

Brandt, M. J., Dragon, A., Diederichs, A., Schubert, A., Kosarev, V., Nehls, G., Wahl, V., Michalik, A., Braasch, A., Hinz, C., Katzer, C., Todeskino, D., Gauger, M., Laczny, M. and Piper, W. (2016). 'Effects of offshore pile driving on harbour porpoise abundance in the German Bight', Report prepared for Offshore Forum Windenergie.

Brandt, M. J., Hoeschle, C., Diederichs, A., Betke, K., Matuschek, R., Witte, S. and Nehls, G. (2013). 'Far-reaching effects of a seal scarer on harbour porpoises, *Phocoena phocoena*', Aquatic Conservation-Marine and Freshwater Ecosystems, 23:222-232.

Brasseur, S. and Kirkwood, R. (2015). 'Seal monitoring and evaluation for the Gemini offshore windpark: Pre-construction', T0-2014 report. IMARES.

Brasseur, S., Aarts, G., Meesters, E., van Polanen Petel, T., Dijkman, E., Cremer, J. and Reijnders, P. (2012). 'Habitat preference of harbour seals in the Dutch coastal area: analysis and estimate of effects of offshore windfarms', IMARES Wageningen UR.

Brasseur, S., de Groot, A., Aarts, G., Dijkman, E. and Kirkwood, R. (2015a). 'Pupping habitat of grey seals in the Dutch Wadden Sea', IMARES Wageningen UR.

Brasseur, S., Kirkwood, R. and Aarts, G. (2015b). 'Seal monitoring and evaluation for the Gemini offshore windfarm: construction - 2015 report', Wageningen University & Research Report C004/18.

British Standards Institute. (2015). 'PD 6900:2015 Environmental impact assessment for offshore renewable energy projects – Guide'.

Canning, S. J., Santos, M. B., Reid, R. J., Evans, P. G., Sabin, R. C., Bailey, N. and Pierce, G. J. (2008). 'Seasonal distribution of white-beaked dolphins (*Lagenorhynchus albirostris*) in UK waters with new information on diet and habitat use', Journal of the Marine Biological Association of the UK, 88:1159-1166.

Carter, M., Boehme, L., Cronin, M., Duck, C., Grecian, W., Hastie, G., Jessopp, M., Matthiopoulos, J., McConnell, B., Miller, D., Morris, C., Moss, S., Thompson, D., Thompson, P. and Russell, D. (2022). 'Sympatric Seals, Satellite Tracking and Protected Areas: Habitat-Based Distribution Estimates for Conservation and Management', Frontiers in Marine Science, 9/875869: 1-18

Carter, M., Boehme, L., Duck, C., Grecian, W., Hastie, G., McConnell, B., Miller, D., Morris, C., Moss, S., Thompson, D., Thompson, P. and Russel, D. (2020). 'Habitat-based predictions of at-sea distribution for grey and harbour seals in the British Isles', Sea Mammal Research Unit, University of St Andrews, Report to BEIS, OESEA-16-76/OESEA-17-78.

Christiansen, F., and D. Lusseau. (2015). Linking Behavior to Vital Rates to Measure the Effects of Non-Lethal Disturbance on Wildlife. Conservation Letters 8:424-431.

Christiansen, F., C. G. Bertulli, M. H. Rasmussen, and D. Lusseau. (2015). Estimating cumulative exposure of wildlife to non-lethal disturbance using spatially explicit capture–recapture models. The Journal of Wildlife Management 79:311-324.

Christiansen, F., Rasmussen, M. and Lusseau, D. (2013). 'Whale watching disrupts feeding activities of minke whales on a feeding ground', Marine Ecology Progress Series, 478: 239.

CIEEM. (2019). 'Guidelines for ecological impact assessment in the UK and Ireland: Terrestrial, Freshwater, Coastal and Marine', September 2018 Version 1.1 - updated September 2019, Chartered Institute of Ecology and Environmental Management, Winchester.

Connor, R. C., Heithaus, M. R. and Barre, L. M. (2001). 'Complex social structure, alliance stability and mating access in a bottlenose dolphin super alliance', Proc R Soc Lond B, 268: 263-267.

Culloch, R. M., Anderwald, P., Brandecker, A., Haberlin, D., McGovern, B., Pinfield, R., Visser, F., Jessopp, M. and Cronin, M. (2016). 'Effect of construction-related activities and vessel traffic on marine mammals', Marine Ecology Progress Series, 549:231-242.

Dähne, M., Gilles, A., Lucke, K., Peschko, V., Adler, S., Krugel, K., Sundermeyer, J. and Siebert, U. (2013). 'Effects of pile-driving on harbour porpoises (*Phocoena phocoena*) at the first offshore windfarm in Germany', Environmental Research Letters, 8:025002.

Dähne, M., Tougaard, J., Carstensen, J., Rose, A. and Nabe-Nielsen, J. (2017). 'Bubble curtains attenuate noise from offshore windfarm construction and reduce temporary habitat loss for harbour porpoises', Marine Ecology Progress Series, 580:221-237.

De Jong, C. A. F. and Ainslie, M. A. (2008). 'Underwater radiated noise due to the piling for the Q7 Offshore Wind Park', Journal of the Acoustical Society of America, 123:2987.

De Pierrepont, J. F., Dubois, B., Desormonts, S., M.Santos, M. B. and Robin, J. P. (2005). 'Stomach contents of English Channel cetaceans stranded on the coast of Normandy', Journal of the Marine Biological Association of the United Kingdom, 85:1539-1546.

Department for Energy Security and Net Zero (DESNZ) (2023) Draft National Policy Statement for Renewable Energy Infrastructure (EN-3). Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1147382/NPS_EN-3.pdf [Accessed: March 2024]

Department for Environment Food & Rural Affairs, Joint Nature Conservation Committee, Natural England, Marine Management Organisation, Department of Agriculture Environment and Rural Affairs (Northern Ireland), Department for Business Energy & Industrial Strategy, and Offshore Petroleum Regulator for Environment and Decommissioning. (2021). 'Policy paper overview: Marine environment: unexploded ordnance clearance joint interim position statement'.

DEFRA. (2025). 'Policy paper: Reducing marine noise' https://www.gov.uk/government/publications/reducing-marine-noise/reducing-marine-noise [Accessed January 2025].

DESNZ (2023a) Draft Overarching National Policy Statement for Energy (EN-1). Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1147380/NPS_EN-1.pdf [Accessed: Mar 2024]

DESNZ (2023b) Draft National Policy Statement for Renewable Energy Infrastructure (EN-3) Available at:https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1147382/NPS_EN-3.pdf [Accessed: Mar 2024]

Diederichs, A., Nehls, G. and Brandt, M. J. (2010). 'Does sand extraction near Sylt affect harbour porpoises?', Wadden Sea Ecosystem No. 26 edition. Common Wadden Sea Secretariat, Wilhelmshaven, Germany.

Diederichs, A., Nehls, G., Dähne, M., Adler, S., Koschinski, S. and Verfuß, U. (2008). 'Methodologies for measuring and assessing potential changes in marine mammal behaviour, abundance or distribution arising from the construction, operation and decommissioning of offshore windfarms',

Donovan, C. R., Harris, C. M., Milazzo, L., Harwood, J., Marshall, L. and Williams, R. (2017). 'A simulation approach to assessing environmental risk of sound exposure to marine mammals', Ecology and Evolution.

Dunlop, R. A., Noad, M. J., McCauley, R. D., Scott-Hayward, L., Kniest, E., Slade, R., Paton, D. and Cato, D. H. (2017). 'Determining the behavioural dose–response relationship of marine mammals to air gun noise and source proximity', Journal of Experimental Biology, 220:2878-2886.

Dyndo, M., Wiśniewska, D. M,. Rojano-Doñate, L. and Madsen, P. T. (2015). 'Harbour porpoises react to low levels of high frequency vessel noise', Scientific Reports, 5/11083.

Edds-Walton, P. L. (2000). 'Vocalizations Of Minke Whales *Balaenoptera Acutorostrata* In The St. Lawrence Estuary', Bioacoustics, 11:31-50.

EMODnet. (2021). EMODnet Human Activities, Vessel Density Map, funded by the European Commission. Available from: https://ows.emodnet-humanactivities.eu/geonetwork/srv/api/records/0f2f3ff1-30ef-49e1-96e7-8ca78d58a07c. Accessed: 18 October 2023.

Erbe, C., Marley, S. A., Schoeman, R, P., Smith, J. N., Trigg, L, E. and Embling, C. B. (2019). 'The effects of ship noise on marine mammals – a review, Frontiers in Marine Science, 6: 1-21.

Evans, P. G. H. (1990). 'Marine Mammals in the English Channel in relation to proposed dredging scheme', Sea Watch Foundation, Oxford.

Fernandez-Betelu, O., Graham, I. M. and Thompson, P. (2022). 'Reef effect of offshore structures on the occurrence and foraging activity of harbour porpoises', Frontiers in Marine Science, 9: 980388.

Fernandez-Betelu, O., Graham, I. M., Brookes, K. L., Cheney, B. J., Barton, T. R. and Thompson, P. M. (2021). 'Far-Field Effects of Impulsive Noise on Coastal Bottlenose Dolphins', Frontiers in Marine Science, 8:664230.

Finneran, J. J. (2015). 'Noise-induced hearing loss in marine mammals: A review of temporary threshold shift studies from 1996 to 2015', The Journal of the Acoustical Society of America, 138:1702-1726.

Finneran, J. J., Carder, D. A., Schlundt, C. E. and Dear, R. L. (2010). 'Growth and recovery of temporary threshold shift at 3 kHz in bottlenose dolphins: Experimental data and mathematical models', The Journal of the Acoustical Society of America, 127:3256-3266.

Finneran, J. J., Carder, D. A., Schlundt, C. E. and Ridgway, S. H. (2005). 'Temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*) exposed to mid-frequency tones', The Journal of the Acoustical Society of America, 118:2696-2705.

functions for the effects of permanent threshold shifts on vital rates in marine mammal species. Report Code SMRUC-UOA-2018-006, submitted to the University of Aberdeen and Department for Business, Energy and Industrial Strategy (BEIS), June 2018 (unpublished).

Gedamke, J., Costa, D. P. and Dunstan, A. (2001). 'Localization and visual verification of a complex minke whale vocalization', The Journal of the Acoustical Society of America, 109:3038-3047.

Genesis. (2011). 'Review and Assessment of Underwater Sound Produced from Oil and Gas Sound Activities and Potential Reporting Requirements under the Marine Strategy Framework Directive', Report for the Department of Energy and Climate Change.

Gilles, A, Authier, M, Ramirez-Martinez, NC, Araújo, H, Blanchard, A, Carlström, J, Eira, C, Dorémus, G, FernándezMaldonado, C, Geelhoed, SCV, Kyhn, L, Laran, S, Nachtsheim, D, Panigada, S, Pigeault, R, Sequeira, M, Sveegaard, S, Taylor, NL, Owen, K, Saavedra, C, Vázquez-Bonales, JA, Unger, B, Hammond, PS (2023). Estimates of cetacean abundance in European Atlantic waters in summer 2022 from the SCANS-IV aerial and shipboard surveys. Final report published 29 September 2023. 64 pp. https://tinyurl.com/3ynt6swa

Goley, G. S., Song, W. J. and Kim, J. H. (2011). 'Kurtosis corrected sound pressure level as a noise metric for risk assessment of occupational noises', The Journal of the Acoustical Society of America, 129:1475-1481.

Graham, I. M., Farcas, A., Merchant, N. D. and Thompson, P. (2017a). 'Beatrice Offshore Windfarm: An interim estimate of the probability of porpoise displacement at different unweighted single-pulse sound exposure levels', Prepared by the University of Aberdeen for Beatrice Offshore Windfarm Ltd.

Graham, I. M., Merchant, N. D., Farcas, A., Barton, T. R. C., Cheney, B., Bono, S. and Thompson, P. M. (2019). 'Harbour porpoise responses to pile-driving diminish over time', Royal Society Open Science, 6:190335: 1-13.

Graham, I. M., Pirotta, E., Merchant, N. D., Farcas, A., Barton, T. R., Cheney, B., Hastie, G. D. and Thompson, P. M. (2017b). 'Responses of bottlenose dolphins and harbor porpoises to impact and vibration piling noise during harbor construction', Ecosphere 8.

Greene Jr, C. R. (1986). 'Underwater sounds from the semisubmersible drill rig SEDCO 708 drilling in the Aleutian Islands. Sect 1', API Publ, 4438

Hamernik, R. P., Qiu, W. and Davis, B. (2007). 'Hearing loss from interrupted, intermittent, and time varying non-Gaussian noise exposure: The applicability of the equal energy hypothesis', The Journal of the Acoustical Society of America, 122:2245-2254.

Hammond, P. S., Lacey, C., Gilles, A., Viquerat, S,. Börjesson, P., Herr, H., Macleod, K., Ridoux, V., Santos, M. B., Scheidat, M., Teilmann, J., Vingada, J. and Øien, N. (2021). 'Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard survey'.

Hanke, W., and G. Dehnhardt. (2013). Sensory biology of aquatic mammals. Journal of Comparative Physiology 199:417.

Hanke, W., M. Witte, L. Miersch, M. Brede, J. Oeffner, M. Michael, F. Hanke, A. Leder, and G. Dehnhardt. (2010). Harbor seal vibrissa morphology suppresses vortex-induced vibrations. Journal of Experimental Biology 213:2665-2672.

Hanke, W., S. Wieskotten, C. Marshall, and G. Dehnhardt. (2013). Hydrodynamic perception in true seals (Phocidae) and eared seals (Otariidae). Journal of Comparative Physiology A-Neuroethology Sensory Neural and Behavioral Physiology 199:421-440.

Harwood, J., King, S., Schick, R., Donovan, C. and Booth, C. (2014). 'A protocol for Implementing the Interim Population Consequences of Disturbance (PCoD) approach: Quantifying and assessing the effects of UK offshore renewable energy developments on marine mammal populations', Report Number SMRUL-TCE-2013-014, Scottish Marine and Freshwater Science, 5(2).

Hastie, G. D., Lepper, P., McKnight, J. C., Milne, R., Russell, D. J. F. and Thompson, D. (2021). 'Acoustic risk balancing by marine mammals: anthropogenic noise can influence the foraging decisions by seals', Journal of Applied Ecology.

Hastie, G. D., Russell, D. J. Benjamins, S. Moss, S. Wilson, B. and Thompson, D. (2016). 'Dynamic habitat corridors for marine predators; intensive use of a coastal channel by harbour seals is modulated by tidal currents', Behavioral Ecology and Sociobiology, 70: 2161-2174.

Hastie, G., Merchant, N. D., Götz, T., Russell, D. J., Thompson, P. and Janik, V. M. (2019). 'Effects of impulsive noise on marine mammals: investigating range-dependent risk', Ecological Applications, 29:e01906.

Heinänen, S. and Skov, H. (2015). 'The identification of discrete and persistent areas of relatively high harbour porpoise density in the wider UK marine area', JNCC Report No. 544, JNCC, Peterborough.

Henderson, D., Subramaniam, M., Gratton, M. A. and Saunders, S. S. (1991). 'Impact noise: the importance of level, duration, and repetition rate', The Journal of the Acoustical Society of America, 89:1350-1357.

HiDef. (2022). 'Digital video aerial surveys of seabirds and marine mammals at Outer Dowsing: Annual report for March 2021 to February 2022.'

HiDef. (2023). 'Digital video aerial surveys of seabirds and marine mammals at Outer Dowsing: 24-month report for March 2021 to February 2023.'

Hin, V., Harwood, J. and de Roos, A. M. (2019). 'Bio-energetic modeling of medium-sized cetaceans shows high sensitivity to disturbance in seasons of low resource supply', Ecological Applications: e01903.

Hoekendijk, J., Spitz, J., Read, A. J., Leopold, M. F. and Fontaine, M. C. (2018). 'Resilience of harbor porpoises to anthropogenic disturbance: Must they really feed continuously?', Marine Mammal Science, 34:258-264.

IAMMWG. (2015). 'Management Units for cetaceans in UK waters (January 2015)' JNCC Report No: 547, JNCC Peterborough

IAMMWG. (2022). 'Updated abundance estimates for cetacean Management Units in UK waters', JNCC Report No. 680 (Revised March 2022)', JNCC Report No. 680, JNCC Peterborough, ISSN 0963-8091

IAMMWG. (2023). 'Review of Management Unit boundaries for cetaceans in UK waters (2023)', JNCC Report 734, JNCC, Peterborough, ISSN 0963-8091.

Jansen, J. K., Brady, G. M., Ver Hoef, J. M. and Boveng, P. L. (2015). 'Spatially Estimating Disturbance of Harbout Seals (*Phoca vitulina*)', PLOS ONE, 10/7: e0129798.

JNCC, Natural England, and CCW. (2010). 'The protection of marine European Protected Species from injury and disturbance', Guidance for the marine area in England and Wales and the UK offshore marine area.

JNCC. (2010a). 'JNCC guidelines for minimising the risk of injury to marine mammals from using explosives.'

JNCC. (2010b). 'Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise.'

JNCC. (2017). 'JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys', August 2017.

JNCC. (2019a). European Community Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC) Fourth Report by the United Kingdom under Article 17 on the implementation of the Directive from January 2013 to December 2018 Conservation status assessment for the species: S1351 - Harbour porpoise (*Phocoena phocoena*) UNITED KINGDOM.

JNCC. (2019b). European Community Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC) Fourth Report by the United Kingdom under Article 17 on the implementation of the Directive from January 2013 to December 2018 Conservation status assessment for the species: S2032- White-beaked dolphin (*Lagenorhynchus albirostris*) UNITED KINGDOM.

JNCC. (2019c). European Community Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC) Fourth Report by the United Kingdom under Article 17 on the implementation of the Directive from January 2013 to December 2018 Conservation status assessment for the species: S1349 - Bottlenose dolphin (*Tursiops truncatus*) UNITED KINGDOM.

JNCC. (2019d). European Community Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC) Fourth Report by the United Kingdom under Article 17 on the implementation of the Directive from January 2013 to December 2018 Conservation status assessment for the species: S2618 - Minke whale (*Balaenoptera acutorostrata*) UNITED KINGDOM.

JNCC. (2019e). European Community Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC) Fourth Report by the United Kingdom under Article 17 on the implementation of the Directive from January 2013 to December 2018 Conservation status assessment for the species: S1364 - Grey seal (*Halichoerus grypus*) UNITED KINGDOM.

JNCC. (2019f). European Community Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC) Fourth Report by the United Kingdom under Article 17 on the implementation of the Directive from January 2013 to December 2018 Conservation status assessment for the species: S1365 - Common seal (*Phoca vitulina*) UNITED KINGDOM

JNCC. (2020). 'Guidance for assessing the significance of noise disturbance against Conservation Objectives of harbour porpoise SACs (England, Wales & Northern Ireland)', Report No. 654, JNCC, Peterborough.

JNCC. (2020). Guidance for assessing the significance of noise disturbance against Conservation Objectives of harbour porpoise SACs (England, Wales & Northern Ireland). Report No. 654, JNCC, Peterborough.

JNCC. (2023). 'MNR Disturbance Tool: Description and Output Generation', September 2023.

Jones, E., Hastie, G., Smout, S., Onoufriou, J., Merchant, N. D., Brookes, K. and Thompson, D. (2017). 'Seals and shipping: quantifying population risk and individual exposure to vessel noise', Journal of Applied Ecology, 54:1930-1940.

Judd, A. (2012). 'Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects', Center for Environment, Fisheries, and Aquaculture Science.

Karpovich, S., Skinner, J., Mondragon, J. and Blundell, G. (2015). 'Combined physiological and behavioral observations to assess the influence of vessel encounters on harbor seals in glacial fjords of southeast Alaska', Journal of Experimental Marine Biology and Ecology, 473:110-120.

Kastak, D., Holt, M., Kastak, C., Southall, B., Mulsow, J. and Schusterman, R. (2005). 'A voluntary mechanism of protection from airborne noise in a harbor seal', Page 148 in 16th Biennial Conference on the Biology of Marine Mammals. San Diego CA.

Kastelein, R. A., Gransier, R. and Hoek, L. (2013a). Comparative temporary threshold shifts in a harbor porpoise and harbor seal, and severe shift in a seal', Journal of the Acoustical Society of America, 134:13-16.

Kastelein, R. A., Gransier, R., Hoek, L. and de Jong, C. A. (2012a). 'The hearing threshold of a harbor porpoise (*Phocoena phocoena*) for impulsive sounds (L)', Journal of the Acoustical Society of America, 132:607-610.

Kastelein, R. A., Gransier, R., Hoek, L. and Olthuis, J. (2012c). 'Temporary threshold shifts and recovery in a harbor porpoise (*Phocoena phocoena*) after octave-band noise at 4kHz', Journal of the Acoustical Society of America, 132:3525-3537.

Kastelein, R. A., Gransier, R., Hoek, L. and Rambags, M. (2013b). 'Hearing frequency thresholds of a harbor porpoise (*Phocoena phocoena*) temporarily affected by a continuous 1.5 kHz tone', Journal of the Acoustical Society of America, 134:2286-2292.

Kastelein, R. A., Gransier, R., Hoek, L., Macleod, A. and Terhune, J. M. (2012b). 'Hearing threshold shifts and recovery in harbor seals (*Phoca vitulina*) after octave-band noise exposure at 4 kHz', Journal of the Acoustical Society of America, 132:2745-2761.

Kastelein, R. A., Gransier, R., Schop, J. and Hoek, L. (2015). 'Effects of exposure to intermittent and continuous 6–7 kHz sonar sweeps on harbor porpoise (*Phocoena phocoena*) hearing', The Journal of the Acoustical Society of America, 137:1623-1633.

Kastelein, R. A., Helder-Hoek, L., Covi, J. and Gransier, R. (2016). 'Pile driving playback sounds and temporary threshold shift in harbor porpoises (*Phocoena phocoena*): Effect of exposure duration', The Journal of the Acoustical Society of America, 139:2842-2851.

Kastelein, R. A., Helder-Hoek, L., Van de Voorde, S., von Benda-Beckmann, A. M., Lam, F- P. A., Jansen, E., de Jong, C. A. and Ainslie, M. A. (2017). 'Temporary hearing threshold shift in a harbor porpoise (*Phocoena phocoena*) after exposure to multiple airgun sound', The Journal of the Acoustical Society of America, 142:2430-2442.

Kastelein, R. A., Hoek, L., Gransier, R., Rambags, M. and Claeys, N. (2014). 'Effect of level, duration, and inter-pulse interval of 1-2 kHz sonar signal exposures on harbor porpoise hearing', The Journal of the Acoustical Society of America, 136:412-422.

Kastelein, R., Jennings, N., Verboom, W., De Haan, D. and Schooneman, N. (2006). 'Differences in the response of a striped dolphin (*Stenella coeruleoalba*) and a harbour porpoise (*Phocoena phocoena*) to an acoustic alarm', Marine Environmental Research, 61:363-378.

Lacey, C., Gilles, A., Börjesson, P., Herr, H., Macleod, K., Ridoux, V., Santos, M., Scheidat, M., Teilmann, J., Sveegaard, S., Vingada, J., Viquerat, S., Øien, N. and Hammond, P. (2022). 'Modelled density surfaces of cetaceans in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys.'

Laist, D. W., Knowlton, A. R., Mead, J. G., Collet, A. S. and Podesta, M. (2001). 'Collisions between ships and whales', Marine Mammal Science, 17:35-75.

Lindeboom, H. J., Kouwenhoven, H. J., Bergman, M. J. N., Bouma, S., Brasseur, S., Daan, R., Fijn, R. C., de Haan, D., Dirksen, S., van Hal, R., Hille Ris Lambers, R., ter Hofstede, R., Krijgsveld, K. L., Leopold, M. and Scheidat, M. (2011). 'Short-term ecological effects of an offshore windfarm in the Dutch coastal zone; a compilation', Environmental Research Letters, 6:1-13.

Lonergan, M., Duck, C., Moss, S., Morris, C. and Thompson, D. (2013).' Rescaling of aerial survey data with information from small numbers of telemetry tags to estimate the size of a declining harbour seal population', Aquatic Conservation-Marine and Freshwater Ecosystems 23: 135-144.

Lusseau, D. (2003). 'Male and female bottlenose dolphins Tursiops spp. have different strategies to avoid interactions with tour boats in Doubtful Sound, New Zealand', Marine Ecology Progress Series, 257: 267-274.

Lusseau, D. (2006). 'The short-term behavioral reactions of bottlenose dolphins to interactions with boats in Doubtful Sound, New Zealand', Marine Mammal Science, 22: 802-818.

Lusseau, D., New, L., Donovan, C., Cheney, B., Thompson, P., Hastie, G. and Harwood, J. (2011). 'The development of a framework to understand and predict the population consequences of disturbances for the Moray Firth bottlenose dolphin population', Scottish Natural Heritage Commissioned Report (98pp).

Macleod, K., Du Fresne, S., Mackey, B., Faustino, C. and Boyd, I. (2010). 'Approaches to marine mammal monitoring at marine renewable energy developments', Final Report.

Madsen, P. T., Wahlberg, M., Tougaard, J., Lucke, K. and Tyack, P. (2006). 'Wind turbine underwater noise and marine mammals: implications of current knowledge and data needs', Marine ecology progress series, 309: 279-295.

Malme, C. I., Miles, P. R., Clark, C. W., Tyack, P. and Bird, J. E. (1984). 'Investigations on the potential effects of underwater noise from petroleum-industry activities on migrating gray-whale behavior. Phase 2: January 1984 migration', United States: N. p., 1984. Web.

Marley, S. A., Salgado Kent, C. P. and Erbe, C. (2017). 'Occupancy of bottlenose dolphins (*Turisops aduncus*) in relation to vessel traffic, dredging, and environmental variables within a highly urbanised estuary', Hydrobiologia, 792: 243-263.

Martin, S. B., Lucke, K. and Barclay, D. R. (2020). 'Techniques for distinguishing between impulsive and non-impulsive sound in the context of regulating sound exposure for marine mammals', J Acoust Soc Am, 147:2159.

Marubini, F. Gimona, A. Evans, P. G. Wright, P. J. and Pierce, G. J. (2009). 'Habitat preferences and interannual variability in occurrence of the harbour porpoise *Phocoena phocoena* off northwest Scotland', Marine Ecology Progress Series, 381:297-310.

Mason, T. and Barnham, R. (2018). 'Estimated ranges of impact for various UXO detonations, Norfolk Vanguard', Subacoustech Environmental Ltd. Report number E603R0401.

McGarry, T., Boisseau, O., Stephenson, S. and Compton, R. (2017). 'Understanding the Effectiveness of Acoustic Deterrent Devices (ADDs) on Minke Whale (*Balaenoptera acutorostrata*), a Low Frequency Cetacean', Report for the Offshore Renewables Joint Industry Programme (ORJIP) Project 4, Phase 2. Prepared on behalf of the Carbon Trust.

McQueen, A. D., Suedel, B. C. de Jong, C. and Thomsen, F. (2020). 'Ecological risk assessment of underwater sounds from dredging operations', Integrated environmental assessment and management, 16:481-493.

Mellinger, D. K., Carson, C. D. and Clark, C. W. (2000). 'Characteristics of minke whale (*Balaenoptera acutorostrata*) pulse trains recorded near Puerto Rico', Marine Mammal Science, 16:739-756.

MMO. (2015). 'Modelled Mapping of Continuous Underwater Noise Generated by Activities.'

Mooney, T. A., Nachtigall, P. E., Breese, M., Vlachos, S. and Au, W. W. (2009). 'Predicting temporary threshold shifts in a bottlenose dolphin (*Tursiops truncatus*): The effects of noise level and duration', The Journal of the Acoustical Society of America, 125:1816-1826.

Nabe-Nielsen, J., R. M. Sibly, J. Tougaard, J. Teilmann, and S. Sveegaard. (2014). Effects of noise and by-catch on a Danish harbour porpoise population. Ecological Modelling 272:242-251.

Nabe-Nielsen, J., van Beest, F., Grimm, V., Sibly, R., Teilmann, J. and Thompson, P. M. (2018). 'Predicting the impacts of anthropogenic disturbances on marine populations', Conservation Letters, e12563.

Nachtigall, P. E., Mooney, T. A., Taylor, K. A., Miller, L. A., Rasmussen, M. H., Akamatsu, T., Teilmann, J., Linnenschmidt, M. and Vikingson, G. A. (2008). 'Shipboard measurements of the hearing of the white-beaked dolphin *Lagenorynchus albirostris*', Journal of Experimental Biology, 211: 642-647.

National Academies of Sciences Engineering and Medicine. (2016). 'Approaches to Understanding the Cumulative Effects of Stressors on Marine Mammals', Washington, DC: The National Academies Press.

Natural England. (2021). 'Offshore Wind Marine Environmental Assessments: Best Practice Advice for Evidence and Data Standards. Phase I: Expectations for pre-application baseline data for designated nature conservation and landscape receptors to support offshore wind applications'.

Natural England. (2022). 'Offshore Wind Marine Environmental Assessments: Best Practice Advice for Evidence and Data Standards. Phase III: Expectations for data analysis and presentation at examination for offshore wind applications'.

Natural England. (2022). Offshore Wind Marine Environmental Assessments: Best Practice Advice for Evidence and Data Standards. Phase III: Expectations for data analysis and presentation at examination for offshore wind applications.

Neart na Gaoithe Offshore Windfarm. (2019). 'UXO Clearance – European Protected Species Risk Assessment and Marine Mammal Mitigation Plan', Revision 2.0.

Nedwell, J., Langworthy, J. and Howell, D. (2003). 'Assessment of sub-sea acoustic noise and vibration from offshore wind turbines and its impact on marine wildlife; initial measurements of underwater noise during construction of offshore windfarms, and comparison with background noise', Subacoustech Report ref: 544R0423, published by COWRIE.

New, L. F., Harwood, J., Thomas, L., Donovan, C., Clark, J. S., Hastie, G., Thompson, P. M., Cheney, B., Scott-Hayward, L. and Lusseau, D. (2013). 'Modelling the biological significance of behavioural change in coastal bottlenose dolphins in response to disturbance', Functional Ecology, 27:314-322.

NMFS. (2016). 'Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts, Page 189. U.S. Department of Commerce, Silver Spring.

NMFS. (2018). 'Revisions to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts', Page 167. U.S. Department of Commerce, NOAA, Silver Spring.

Nowacek, S. M., Wells, R. S. and Solow, A. R. (2001). 'Short-term effects of boat traffic on bottlenose dolphins, *Tursiops truncatus*, in Sarasota Bay, Florida', Marine Mammal Science, 17:673-688.

Outer Dowsing (2023a) Preliminary Environmental Information Report Available at: https://www.outerdowsing.com/outer-dowsing-offshore-wind-consultations/ [Accessed February 2024]

Outer Dowsing (2023b) Autumn Consultation Available at: https://www.outerdowsing.com/outer-dowsing-offshore-wind-consultations/ [Accessed February 2024]

Orsted. (2021). Hornsea Project Four: Environmental Statement (ES). Volume A2, Chapter 4: Marine Mammals.

OSPAR. (2008). 'OSPAR Guidance on Environmental Considerations for Offshore Wind-Farm Development'.

OSPAR. (2009). 'Overview of the impacts of anthropogenic underwater sound in the marine environment', Report 441:2009.

Otani, S., Naito, Y., Kato, A. and Kawamura, A. (2000). 'Diving behavior and swimming speed of a free-ranging harbor porpoise, *Phocoena phocoena'*, Marine Mammal Science, 16:811-814.

Paterson, W. D., Russel, D. J. F., Wu, M., McConnell, B. J. and Thompson, D. (2015). 'Harbour seal haul-out monitoring, Sound of Islay', Scottish Natural Heritage Commissioned Report No. 894.

Paxton, C., Scott-Hayward, L., Mackenzie, M., Rexstad, E. and Thomas, L. (2016). 'Revised Phase III Data Analysis of Joint Cetacean Protocol Data Resources', JNCC, Peterborough 2016.

Pierce, G. J., Santos, M. B. and Cervino, S. (2007). 'Assessing sources of variation underlying estimates of cetacean diet composition: a simulation study on analysis of harbour porpoise diet in Scottish (UK) waters', Journal of the Marine Biological Association of the United Kingdom, 87: 213-221.

Pierce, G. J., Santos, M. B., Reid, R., Patterson, I. and Ross, H. (2004). 'Diet of minke whales *Balaenoptera acutorostrata* in Scottish (UK) waters with notes on strandings of this species in Scotland 1992–2002', Journal of the Marine Biological Association of the UK, 84:1241-1244.

Pierpoint, C. (2008). 'Harbour porpoise (*Phocoena phocoena*) foraging strategy at a high energy, near-shore site in south-west Wales, UK', Journal of the Marine Biological Association of the UK, 88:1167-1173.

Pirotta, E., Laesser, B. E., Hardaker, A., Riddoch, N., Marcoux, M. and Lusseau, D. (2013). 'Dredging displaces bottlenose dolphins from an urbanised foraging patch', Marine Pollution Bulletin, 74:396-402.

Pirotta, E., Merchant, N. D., Thompson, P. M., Barton, T. R. and Lusseau, D. (2015). 'Quantifying the effect of boat disturbance on bottlenose dolphin foraging activity', Biological Conservation, 181:82-89.

Richardson, W. J., Wursig, B. and Greene, C. R. (1990). 'Reactions of bowhead whales, *Baleana mysticetus*, to drilling and dredging noise in the Canadian Beaufort Sea', Marine Environmental Research, 29/1: 135-160.

Risch, D., Clark, C. W., Dugan, P. J. Popescu, M., Siebert, U. and Van Parijs, S. M. (2013). 'Minke whale acoustic behavior and multi-year seasonal and diel vocalization patterns in Massachusetts Bay, USA', Marine Ecology Progress Series, 489:279-295.

Risch, D., Siebert, U. and Van Parijs, S. M. (2014). 'Individual calling behaviour and movements of North Atlantic minke whales (*Balaenoptera acutorostrata*)', Behaviour, 151:1335-1360.

Robinson, S. P., Wang, L., Cheong, S. H., Lepper, P. A., Hartley, J. B., Thompson, P. M., Edwards, E. and Bellman, F. (2022). 'Acoustic characterisation of unexploded ordnance disposal in the North Sea using high order detonations', Marine Pollution Bulletin, 184.

Robinson, S. P., Wang, L., Cheong, S. H., Lepper, P. A., Marubini, F. and Hartley, J. B. (2020). 'Underwater acoustic characterisation of unexploded ordnance disposal using deflagration', Marine Pollution Bulletin, 160:111646.

Rojano-Doñate, L., McDonald, B. I., Wisniewska, D. M., Johnson, M., Teilmann, J., Wahlberg, M., Højer-Kristensen, J. and Madsen, P. T. (2018). 'High field metabolic rates of wild harbour porpoises', Journal of Experimental Biology 221: jeb185827.

Royal Haskoning DHV. (2021). Dudgeon and Sheringham Shoal Offshore Windfarm Extensions, Preliminary Environmental Information Report, Appendix 12.1 Marine Mammal Information and Survey Data.

Russell, D. J. F., Hastie, G. D., Thompson, D., Janik, V. M., Hammond, P. S., Scott-Hayward, L. A. S., Matthiopoulos, J., Jones, E. L. and McConnell., B. J. (2016b).' Avoidance of windfarms by harbour seals is limited to pile driving activities', Journal of Applied Ecology, 1642-1652.

Russell, D. J. F., McConnell, B., Thompson, D., Duck, C., Morris, C., Harwood, J. and Matthiopoulos, J. (2013). 'Uncovering the links between foraging and breeding regions in a highly mobile mammal', Journal of Applied Ecology, 50:499-509.Russell, D. J., Brasseur, S. M., Thompson, D., Hastie, G. D., Janik, V. M., Aarts, G., McClintock, B. T., Matthiopoulos, J., Moss, S. E. and McConnell, B. (2014). 'Marine mammals trace anthropogenic structures at sea', Current Biology, 24: R638-R639.

Russell, D. J., Hastie, G. D. Thompson, D., Janik, V. M., Hammond, P. S., Scott-Hayward, L. A., Matthiopoulos, J., Jones, E. L. and McConnell, B. J. (2016a). 'Avoidance of windfarms by harbour seals is limited to pile driving activities', Journal of Applied Ecology, 53:1642-1652.

Russell, D., and Hastie, G. (2017). 'Associating predictions of change in distribution with predicted received levels during piling', Report produced for SMRU Consulting.

Russell, D., Jones, E. and Morris, C. (2017). 'Updated Seal Usage Maps: The Estimated at-sea Distribution of Grey and Harbour Seals', Scottish Marine and Freshwater Science, 8/25: 1-18

Santos, M., Pierce, G., Reid, R., Patterson, I., Ross, H. and Mente, E. (2001). 'Stomach contents of bottlenose dolphins (*Tursiops truncatus*) in Scottish waters', Journal of the Marine Biological Association of the United Kingdom, 81:873-878.

Sarnocinska, J., Teilmann, J., Dalgaard, J. B., v. Beest, F., Delefosse, M. and Tougaard, J. (2019). 'Harbour porpoise (*Phocoena phocoena*) reaction to a 3D seismic airgun survey in the North Sea', Frontiers in Marine Science, 6:824.

Scheidat, M., Tougaard, J., Brasseur, S., Carstensen, J., van Polanen Petel, T., Teilmann, J. and Reijnders, P. (2011). 'Harbour porpoises (*Phocoena phocoena*) and windfarms: a case study in the Dutch North Sea', Environmental Research Letters, 6:1-10.

SCOS. (2021). 'Scientific Advice on Matters Related to the Management of Seal Populations: 2020.'

SCOS. (2022). 'Scientific Advice on Matters Related to the Management of Seal Populations: 2021.'

SCOS. (2023). 'Scientific Advice on Matters Related to the Management of Seal Populations: 2022.'

Seiche. (2022a). MMO and PAM Weekly Reports: April – July 2022.

Seiche. (2022b). MMO and PAM Weekly Reports: August 2021 – January 2022.

Sinclair, R. Kazer, S. Ryder, M. New, P. and Verfuss, U. (2021). 'Review and recommendations on assessment of noise disturbance for marine mammal', NRW Evidence Report No. 529.

Sini, M., Canning, S. J., Stockin, K. and Pierce, G. J. (2005). 'Bottlenose dolphins around Aberdeen harbour, north-east Scotland: a short study of habitat utilization and the potential effects of boat traffic', Marine Biological Association of the United Kingdom, Journal of the Marine Biological Association of the United Kingdom, 85: 1547.

Sivle, L. D., Kvadsheim, P. H., Curé, C., Isojunno, S., Wensveen, P. J., Lam, F.-P. A., Visser, F., Kleivane, L., Tyack, P. L. and Harris, C. M. (2015). 'Severity of expert-identified behavioural responses of humpback whale, minke whale, and northern bottlenose whale to naval sonar', Aquatic Mammals,41:469.

Soloway, A. G. and Dahl, P, H. (2014). 'Peak sound pressure and sound exposure level from underwater explosions in shallow water', JASA, 136/3: 1-6.

Southall, B. L., Berkson, J., Bowen, D., Brake, R., Eckman, J., Field, J., Gisiner, R., Gregerson, S., Lang, W., Lewandoski, J., Wilson, J. and Winokur, R. (2009). 'Addressing the Effects of Human-Generated Sound on Marine Life: An Integrated Research Plan for U.S. federal agencies'.

Southall, B. L., Bowles, A. E., Ellison, W. T., Finneran, J. J., Gentry, R. L., Greene Jr, C. R. J., Kastak, D., Ketten, D. R., Miller, J. H., Nachtigall, P. E., Richardson, W. J., Thomas, J. A. and Tyack, P. L. (2007). 'Marine mammal noise exposure criteria: initial scientific recommendations', Aquatic Mammals, 33:411-414.

Southall, B. L., Finneran, J. J., Reichmuth, C., Nachtigall, P. E., Ketten, D. R., Bowles, A. E., Ellison, W.T., Nowacek, D. P. and Tyack, P. L. (2019). 'Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects', Aquatic Mammals, 45/2: 125-232.

Southall, B. L., Nowacek, D. P., Bowles, A. E., Senigaglia, V., Bejder, L. and Tyack, P. L. (2021). 'Marine Mammal Noise Exposure Criteria: Assessing the severity of marine mammal behavioral responses to human noise', Aquatic Mammals, 47:421-464.

Sparling, C. E., Speakman, J. R. and Fedak, M. A. (2006). 'Seasonal variation in the metabolic rate and body composition of female grey seals: fat conservation prior to high-cost reproduction in a capital breeder?', Journal of Comparative Physiology B, 176:505-512.

Stone, C., Hall, K., Mendes, S. and Tasker, M. (2017). 'The effects of seismic operations in UK waters: analysis of Marine Mammal Observer data', Journal of Cetacean Research and Management, 16/1.

The Planning Inspectorate. (2020). 'EIA: Process, Preliminary Environmental Information, and Environmental Statements', Advice Note Seven: Environmental Impact Assessment: Process, Preliminary Environmental Information and Environmental Statements.

The Planning Inspectorate. (2022). 'Scoping Opinion: Proposed Outer Dowsing Offshore Wind', Case reference: EN010130, 09 September 2022.

Thompson, F., McCully, S. R., Wood, D., Pace, F. and White, P. (2009). 'A generic investigation into noise profiles of marine dredging in relation to the acoustic sensitivity of the marine fauna in UK waters with particular emphasis on aggregate dredging: PHASE 1 Scoping and review of key issues., MALSF'.

Thompson, P. M., Brookes, K. L., Graham, I. M., Barton, T. R., Needham, K., Bradbury, G. and Merchant, N. D. (2013). 'Short-term disturbance by a commercial two-dimmensional seismic survey does not lead to long-term displacement of harbour porpoises', Proceedings of the Royal Society B-Biological Sciences, 280:1-8.

Thompson, P. M., Graham, I. M., Cheney, B., Barton, T. R., Farcas, A. and Merchant, N. D. (2020). 'Balancing risks of injury and disturbance to marine mammals when pile driving at offshore windfarms', Ecological Solutions and Evidence, 1: e12034.

Thomsen, F., Lüdemann, K. Kafemann, R. and Piper, W. (2006). 'Effects of offshore windfarm noise on marine mammals and fish', Biola, Hamburg, Germany on behalf of COWRIE Ltd 62.

Todd, V. L., Todd, I. B., Gardiner, J. C., Morrin, E. C., MacPherson, N. A., DiMarzio, N. A. and Thomsen, F. (2015). 'A review of impacts of marine dredging activities on marine mammals', ICES Journal of Marine Science: Journal du Conseil, 72:328-340.

Tougaard, J., Buckland, S., Robinson, S. and Southall, B. (2013). 'An analysis of potential broad-scale impacts on harbour porpoise from proposed pile driving activities in the North Sea', Report of an expert group convened under the Habitats and Wild Birds Directive - Marine Evidence Group MB0138. 38pp.

Tubelli, A. A., Zosuls, A., Ketten, D. R., Yamato, M. and Mountain, D. C. (2012). 'A prediction of the minke whale (*Balaenoptera acutorostrata*) middle-ear transfer function', Journal of the Acoustical Society of America, 132:3263-3272.

Tyack, P. (2009). 'Acoustic playback experiments to study behavioral responses of free-ranging marine animals to anthropogenic sound', Marine Ecology Progress Series, 395: 187-200.

Tyack, P. L. and Thomas, L. (2019). 'Using dose–response functions to improve calculations of the impact of anthropogenic noise', Aquatic Conservation: Marine and Freshwater Ecosystems, 29:242-253.

van Beest, F. M., Nabe-Nielsen, J., Carstensen, J., Teilmann, J. and Tougaard, J. (2015). 'Disturbance Effects on the Harbour Porpoise Population in the North Sea (DEPONS): Status report on model development'.

van Beest, F. M., Teilmann, J., Hermannsen, L., Galatius, A., Mikkelsen, L., Sveegaard, S., Balle, J. D., Dietz, R. and Nabe-Nielsen, J. (2018). 'Fine-scale movement responses of free-ranging harbour porpoises to capture, tagging and short-term noise pulses from a single airgun', Royal Society Open Science, 5:170110.

Verboom, W. (2014). 'Preliminary information on dredging and harbour porpoises', JunoBioacoustics.

Vincent, C., Huon, M., Caurant, F., Dabin, W., Deniau, A., Dixneuf, S., Dupuis, L., Elder, J.-F., Fremau, M.-H. and Hassani, S. (2017). 'Grey and harbour seals in France: Distribution at sea, connectivity and trends in abundance at haulout sites', Deep Sea Research Part II: Topical Studies in Oceanography 141:294-305.

von Benda-Beckmann, A. M., Aarts, G., Sertlek, H. Ö., Lucke, K., Verboom, W. C., Kastelein, R. A., Ketten, D. R., van Bemmelen, R., Lam, F.-P. A. and Kirkwood, R. J. (2015). 'Assessing the impact of underwater clearance of unexploded ordnance on harbour porpoises (*Phocoena phocoena*) in the southern North Sea', Aquatic Mammals 41:503.

Ward, W. D. (1997). 'Effects of High-Intensity Sound', Pages 1497-1507, Encyclopaedia of Acoustics.

Whyte, K. F., Russell, D. J. F., Sparling, C. E., Binnerts, B. and Hastie, G. D. (2020). 'Estimating the effects of pile driving sounds on seals: Pitfalls and possibilities', J Acoust Soc Am, 147:3948.

Wilson, L. and Hammond, P. (2016). 'Harbour seal diet composition and diversity. Marine Mammal Scientific Support Research Programme MMSS/001/11 CSD 3.2', Report to the Scottish Government. https://data.marine.gov.scot/dataset/harbour-seal-diet-composition-and-diversity

Wisniewska, D. M., Johnson, M., Teilmann, J., Rojano-Doñate, L., Shearer, J., Sveegaard, S., Miller, L. A., Siebert, U. and Madsen, P. T. (2016). 'Ultra-high foraging rates of harbor porpoises make them vulnerable to anthropogenic disturbance', Current Biology, 26:1441-1446.

Wisniewska, D. M., Johnson, M., Teilmann, J., Siebert, U., Galatius, A., Dietz, R. and Madsen, P. T. (2018). 'High rates of vessel noise disrupt foraging in wild harbour porpoises (*Phocoena phocoena*)', Proceedings of the Royal Society B: Biological Sciences, 285/20172314.

Young, C., S. Gende, and J. Harvey. 2014. Effects of Vessels on Harbor Seals in Glacier Bay National Park. Tourism in Marine Environments 10.