FIVE ESTUARIES OFFSHORE WIND FARM

PRELIMINARY ENVIRONMENTAL INFORMATION REPORT

VOLUME 2, CHAPTER 7: MARINE MAMMAL ECOLOGY

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DEFINITION OF ACRONYMS

Term	Definition
ADD	Acoustic Deterrent Device
ASCOBANS	Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas
AoS	Area of Study
BEIS	Department of Business, Energy and Industrial Strategy
CEA	Cumulative Effects Assessment
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CIEEM	Chartered Institute of Ecology and Environmental Management
CITES	Conservation of International Trade in Endangered Species
CSIP	Cetacean Strandings Investigation Programme
DBS	Dogger Bank South
DCO	Development Consent Order
DEB	Dynamic Energy Budget
DECC	Department for Energy and Climate Change
DEPONS	Disturbance Effects on the Harbour Porpoise Population in the North Sea
dML	Deemed Marine Licence
ECC	Export Cable Corridor
EDR	Effective Deterrence Range
EEA	European Economic Area
EIA	Environmental Impact Assessment
EMF	Electromagnetic Frequency
EPP	Evidence Plan Process
EPS	European Protected Species
ES	Environmental Statement
ETG	Expert Topic Group
EU	European Union
GS	Grey Seal
HF	High Frequency
HRA	Habitats Regulation Assessment
HP	Harbour Porpoise
HS	Harbour Seal

Term	Definition
IAMMWG	Inter-Agency Marine Mammal Working Group
IPC	Infrastructure Planning Commission
JCDP	Joint Cetacean Data Protocol
JCP	Joint Cetacean Protocol
JNCC	Joint Nature Conservation Committee
LF	Low Frequency
LSE	Likely Significant Effect
MCZ	Marine Conservation Zone
MDS	Maximum Design Scenario
MERP	Marine Ecosystems Research Program
ML	Marine Licence
MMMP	Marine Mammal Mitigation Protocol
MMO	Marine Management Organisation
MMOb	Marine Mammal Observer
MPCP	Marine Pollution Contingency Plan
MU	Management Unit
NE	Natural England
N-N	North Array North edge
N-NE	North Array Northeast corner
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NSIP	Nationally Significant Infrastructure Project
NPS	National Policy Statement
O&M	Operation and Maintenance
ORJIP	Offshore Renewables Joint Industry Programme
OSP	Offshore Substation Platform
OWF	Offshore Wind Farm
PCW	Phocid Carnivores in Water
PEIR	Preliminary Environmental Information Report
PEMP	Project Environmental Management Plan
PINS	Planning Inspectorate
PTEC	Perpetuus Tidal Energy Centre

Term	Definition
PTS	Permanent Threshold Shift
RIAA	Report to Informa Appropriate Assessment
RMS	Root Mean Squared
ROV	Remotely Operated Vehicle
SAC	Special Area of Conservation
SAFESIMM	Statistical Algorithms for Estimating the Sonar Influence on Marine Megafauna
SCANS	Small Cetaceans in European Atlantic and the North Sea
SCOS	Special Committee on Seals
SEL	Sound Exposure Level
SEL_{cum}	Cumulative Sound Exposure Level
SIP	Site Integrity Plan
SMRU	Sea Mammal Research Unit
SNCB	Statutory Nature Conservation Body
SNS	Southern North Sea
SoS	Secretary of State
SOV	Service Offshore Vessel
SPL	Sound Pressure Level
SPL_{peak}	Peak Sound Pressure Level
SSC	Suspended Sediment Concentration
SSSI	Site of Special Scientific Interest
S-SW	South Array Southwest corner
TTS	Temporary Threshold Shift
UXO	Unexploded Ordnance
VE	Five Estuaries
VE OWFL	Five Estuaries Offshore Wind Farm Limited
VER	Valued Ecological Receptors
VHF	Very High Frequency
VMP	Vessel Management Plan
WCS	Worst Case Scenario
WTG	Wind Turbine Generator
ZOI	Zone of Influence

GLOSSARY OF TERMS

Term	Definition
Applied mitigation	Mitigation that has been applied throughout undertaking the assessments
Array Areas	The areas in which the wind turbines will be located.
Baseline	Refers to the existing conditions represented by the latest available survey and other data which is used to assess the benchmark for making comparisons to assess the impact of a development.
Development Consent Order	An order made under the Planning Act 2008 granting development consent for a Nationally Significant Infrastructure Project (NSIP) from the Secretary of State (SoS).
Effect	Term used to express the consequence of an impact. The significance of an effect is determined by correlating the magnitude of the impact in question with the sensitivity of the receptor in question, in accordance with defined significance criteria.
Embedded mitigation	Mitigation that is embedded in the project design.
Environmental Statement	Environmental Statement (the documents that collate the processes and results of the EIA).
Export Cable Corridor	The area(s) where the export cables will be located.
Impact	An impact to the receiving environment is defined as any change to its baseline condition, either adverse or beneficial, resulting from the activities associated with the construction, operation and maintenance, or decommissioning of the project.
Likely Significant Effect	It is a requirement of Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 to determine the likely significant effects of the proposed development on the environment which should relate to the level of an effect and the type of effect.
Magnitude	The extent of any interaction, the likelihood, duration, frequency and reversibility of any potential impact.
Maximum Design Scenario	The maximum design parameters of the combined project assets that result in the greatest potential for change in relation to each impact assessed.
Mitigation	Mitigation measures, or commitments, are commitments made by the project to reduce and/or eliminate the potential for significant effects to arise as a result of the project. Mitigation measures can be embedded (part of the project design) or secondarily added to reduce impacts in the case of potentially significant effects (applied mitigation).

Term	Definition
Peak Sound Pressure Level	Characterised as a transient sound from impulsive noise sources, it is the maximum change in positive pressure as the wave propagates.
Preliminary Environmental Information Report	Preliminary Environmental Information Report. The PEIR is written in the style of a draft Environmental Statement (ES) and forms the basis of statutory consultation. Following consultation, the PEIR documentation will be updated into the final ES that will accompany the application for the Development Consent Order (DCO).
Receptor	These are as defined in Regulation 5(2) of The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 and include population and human health, biodiversity, land, soil, water, air, climate, material assets, cultural heritage and landscape that may be at risk from exposure to pollutants which could potentially arise as a result of the Proposed Development.
Red Line Boundary	The extent of development including all works, access routes, visibility splays and discharge points. At ES the Red Line Boundary will become 'the proposed Order Limits'.
Scoping Opinion	A Scoping Opinion is adopted by the Secretary of State for a proposed development.
Scoping Report	A report that presents the findings of an initial stage in the Environmental Impact Assessment process
Sensitivity	The potential vulnerabilities of receptors to an impact from VE, their recoverability and the value/importance of the receptor.
Sound Exposure Level	Measure that considers both the received level of the sound and duration of exposure.
Sound Pressure Level	Measure of the average unweighted level of sound, usually a continuous noise source.

7 MARINE MAMMAL ECOLOGY

7.1 INTRODUCTION

7.1.1 GoBe Consultants Ltd and SMRU Consulting have prepared this chapter in order to assess the potential effects of development (construction, operation and maintenance and decommissioning) associated with Five Estuaries Offshore Wind Farm (hereafter referred to as VE) on marine mammal ecology.

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

- Volume 2, Chapter 1: Offshore Project Description;
- Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes;
- Volume 2, Chapter 3: Marine Water and Sediment Quality;
- Volume 2, Chapter 6: Fish and Shellfish Ecology;
- Volume 4, Annex 7.1: Marine Mammal Baseline Characterisation;
- Volume 7, Report 8: Outline Marine Mammal Mitigation Protocol for Piling Activities;
- Volume 4, Annex 6.2: Subsea Noise Technical Report;
- Report to Inform Appropriate Assessment (RIAA);
- HiDef Aerial Surveying Ltd. (2020). Digital video aerial surveys of seabirds and marine mammals at Five Estuaries: Annual report for March 2019 to February 2020; and
- HiDef Aerial Surveying Ltd. (2021). Digital video aerial surveys of seabirds and marine mammals at Five Estuaries: Two-year report for March 2019 to February 2021.

7.2 STATUTORY AND POLICY CONTEXT

7.2.1 This section identifies legislation and national and local policy of relevance to marine mammal ecology. The Marine Works (Environmental Impact Assessment) Regulations 2007 and the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (together referred to as 'the EIA Regulations') are considered along with the legislation relevant to marine mammal ecology.

7.2.2 The following section provides information regarding the legislative context surrounding the assessment of potential effects in relation to fish and shellfish ecology. Full details of all policy and legislation relevant to the VE application are provided within Volume 1, Chapter 2: Policy and Legislation. A summary of the current policy and legislation specifically relevant to marine mammal receptors is provided below. Five Estuaries Offshore Wind Farm Limited (VE OWFL) has ensured that the assessment adheres to the relevant legislation.

7.2.3 In undertaking the assessment, the following policy and legislation has been considered:

- The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017;
- The Marine Works (Environmental Impact Assessment) Regulations 2007;
- The Convention on the Conservation of European Wildlife and Natural Habitats (the Bern Convention; 1979);

- The Conservation of Offshore Marine Habitats and Species Regulations 2017 ;
- Marine and Coastal Access Act 2009;
- The Wildlife and Countryside Act 1981;
- OSPAR Convention 1992;
- The Convention on the Conservation of Migratory Species of Wild Animals 1979 (the Bonn Convention);
- The UK Biodiversity Action Plan and UK Post-2010 Biodiversity Framework (2012);
- 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; and
- The Conservation of Seals Act 1970.

7.2.4 Relevant legislation and policy to this assessment are outlined in Table 7.1.

7.2.1 Guidance on the issues to be assessed for offshore renewable energy developments has been obtained through reference to:

- The Overarching National Policy Statement (NPS) for Energy (NPS EN-1; Department for Energy and Climate Change (DECC 2011a);
- The National Policy Statement for Renewable Energy Infrastructure (NPS EN-3; DECC 2011b); and
- The UK Marine Policy Statement (HM Government 2011).

Table 7.1: Legislation and policy context.

Legislation/Policy	Key Provisions	Section Where Comment Addressed
Overarching National Policy Statement for Energy (NPS EN-1) (DECC, 2011a)	Paragraph 5.3.3 of NPS EN-1 states: *"Where the development is subject to EIA the applicant should ensure that the Environmental Statement (ES) clearly sets out any effects on internationally, nationally and locally designated sites of ecological or geological conservation importance, on protected species and on habitats and other species identified as being of principal importance for the conservation of biodiversity. The applicant should provide environmental information proportionate to the infrastructure where EIA is not required to help the IPC consider thoroughly the potential effects of a proposed project."*	The potential effects of VE have been assessed with regard to international, national and local sites designated for ecological or geological features of conservation importance (see sections 7.11, 7.12 and 7.13). Direct or indirect effects on features of relevant Special Area of Conservation (SAC) sites are also considered in the Habitats Regulations Assessment Screening Report and where relevant has been included in the Report to Inform Appropriate Assessment (RIAA). Important protected areas for marine mammals within their respective Management Units (MUs) are detailed in Volume 4, Annex 7.1: Marine Mammal Baseline Characterisation.
	Paragraph 5.3.15 of NPS EN-1 states: *"Development proposals provide many opportunities for building-in beneficial biodiversity or geological features as*	Embedded mitigation measures inherent to VE are presented in section 7.10.

Legislation/Policy	Key Provisions	Section Where Comment Addressed
	part of good design. When considering proposals, the IPC should maximise such opportunities in and around developments, using requirements or planning obligations where appropriate."	
	Paragraph 5.3.16 of NPS EN-1 states: *"Many individual wildlife species receive statutory protection under a range of legislative provisions"*	Relevant marine mammal policy and legislation listed in section 7.2.
	Paragraph 5.3.17 of NPS EN-1 states: *"Other species and habitats have been identified as being of principal importance for the conservation of biodiversity in England and Wales and thereby requiring conservation action. The Secretary of State should ensure that these species and habitats are protected from the adverse effects of development by using requirements or planning obligations."*	All species receptors, including those of principal importance for the conservation of biodiversity in England are summarised in section 7.8. Full details are provided in Volume 4, Annex 7.1: Marine Mammal Baseline Characterisation.
	Paragraph 5.3.18 of NPS EN-1 states: *"The applicant should include appropriate mitigation measures as an integral part of the proposed development. In particular, the applicant should demonstrate that:*	Embedded mitigation relevant for marine mammals to be adopted as part of the VE project are detailed in section 7.10.

Legislation/Policy	Key Provisions	Section Where Comment Addressed
	> *During construction, they will seek to ensure that activities will be confined to the minimum areas required for the works;* > *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."*	
National Policy Statement for Renewable Energy infrastructure (NPS EN-3) (DECC, 2011b)	Paragraph 2.6.64 of NPS EN-3 states: *"Assessment of offshore ecology and biodiversity should be undertaken by the applicant for all stages of the lifespan of the proposed Offshore Wind Farm (OWF) and in accordance with the appropriate policy for OWF EIAs."*	Construction, operation, maintenance and decommissioning phases of VE have been assessed in sections 7.11, 7.12, and 7.13.
	Paragraph 2.6.65 of NPS EN-3 states:	Consultations with relevant statutory and

Legislation/Policy	Key Provisions	Section Where Comment Addressed
	"Consultation on the assessment methodologies should be undertaken at early stages with the statutory consultees as appropriate."	non-statutory stakeholders have been conducted throughout VE (see Table 7.2 for a summary of consultation with regards to marine mammals).
	Paragraph 2.6.66 of NPS EN-3 states: *"Any relevant data that has been collected as part of post-construction ecological monitoring from existing, operational OWFs should be referred to where appropriate."*	Relevant data collected during post construction monitoring from other OWF projects, along with results from existing literature has informed the assessment of VE in sections 7.11, 7.12, and 7.13 and been included in Volume 4, Annex 7.1: Marine Mammal Baseline Characterisation.
	Paragraph 2.6.67 of NPS EN-3 states: *"The assessment should include the potential of the scheme to have both positive and negative effects on marine ecology and biodiversity."*	The assessment methodology for marine mammals includes the provision for assessment of both positive and negative effects presented within section 7.6
	Paragraph 2.6.68 of NPS EN-3 states: *"The Secretary of State should consider the effects of a proposal on marine ecology and biodiversity taking into account all relevant information made available to it."*	The potential effects on marine mammal ecology are presented within this chapter, with the assessment of effects presented within sections 7.11, 7.12 and 7.13.

Legislation/Policy	Key Provisions	Section Where Comment Addressed
	Paragraph 2.6.70 of NPS EN-3 states: *"Mitigation may be possible in the form of careful design of the development itself and the construction techniques employed"*	Embedded mitigation relevant for marine mammals is detailed in section 7.10.
	Paragraph 2.6.71 of NPS EN-3 states: *"Ecological monitoring is likely to be appropriate during the construction and operational phases to identify the actual impact so that, where appropriate, adverse effects can then be mitigated and to enable further useful information to be published relevant to future projects."*	The potential need for monitoring is considered within the assessment conclusions in sections 7.11, 7.12, and 7.13.
	Paragraph 2.6.92 of NPS EN-3 states: *"Where necessary, assessment of the effects on marine mammals should include details of:* > *likely feeding areas;* > *known birthing areas/haul out sites;* > *nursery grounds;* > *known migration or commuting routes;* > *duration of the potentially disturbing activity*	The effects on marine mammals have been assessed in sections 7.11, 7.12, and 7.13.

Legislation/Policy	Key Provisions	Section Where Comment Addressed
	including cumulative/in-combination > *effects with other plans or projects;* > *baseline noise levels;* > *predicted noise levels in relation to mortality, permanent threshold shift (PTS) and temporary threshold shift (TTS);* > *soft-start noise levels according to proposed hammer and pile design; and* > *operational noise."*	
	Paragraph 2.6.93 of NPS EN-3 states: *"The applicant should discuss any proposed piling activities with the relevant body. Where assessment shows that noise from offshore piling may reach noise levels likely to lead to an offence as described in 2.6.91 above, the applicant should look at possible alternatives or appropriate mitigation before applying for a licence."*	The proposed piling activity is discussed in section 7.4. Appropriate embedded mitigation measures to avoid significant effects, along with those specific to construction, operation and maintenance and decommissioning, are discussed in sections 7.11, 7.12 and 7.13.
	Paragraph 2.6.94 of NPS EN-3 states:	The maximum potential impact associated with

Legislation/Policy	Key Provisions	Section Where Comment Addressed
	"The Infrastructure Planning Commission (IPC) 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 so as to reasonably minimise significant disturbance effects on marine mammals. Unless suitable noise mitigation measures can be imposed by requirements to any development consent the IPC may refuse the application."	construction, operating, decommissioning and cumulative at VE are assessed in sections 7.11, 7.12, 7.13 and 7.14. Mitigation measures to minimise this potential disturbance are discussed in sections 7.10.
	Paragraph 2.6.97 of NPS EN-3 states: *"Monitoring of the surrounding area before and during the piling procedure can be undertaken."*	Monitoring conducted prior to development is discussed in section 7.8 and in further detail in Volume 4, Annex 7.1: Marine Mammal Baseline Characterisation. Monitoring to be conducted during piling procedures is described in section 7.10 with further detail provided in Volume 7, Report 8: Outline Marine Mammal Mitigation Protocol (MMMP) for Piling Activities.
	Paragraph 2.6.98 of NPS EN-3 states:	VE can confirm that 24 hour working

Legislation/Policy	Key Provisions	Section Where Comment Addressed
	"During construction, 24-hour working practices may be employed so that the overall construction programme and the potential for impacts to marine mammal communities is reduced in time."	practices will be employed for offshore construction works, see Volume 2, Chapter 1: Offshore Project Description. The predicted project time frame is discussed in section 7.4.
	Paragraph 2.6.99 of NPS EN-3 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 significant adverse impacts are caused."*	Soft start procedures for monopiles and multi-leg pin pile jackets are detailed in section 7.10
Marine Policy Statement (HM Government, 2011)	The Marine Policy Statement is the framework for preparing Marine Plans and taking decisions affecting the marine environment. The high-level objective "*Living within environmental limits" includes the following requirements relevant to marine mammals:* > *Biodiversity is protected, conserved and, where appropriate, recovered, and loss has been halted;* > *Healthy marine and coastal*	The potential effects of the construction, operation, and decommissioning phases and cumulative effects of VE on marine mammals have been assessed in the impact assessment in sections 7.11, 7.12,7.13 and 7.14.

Legislation/Policy	Key Provisions	Section Where Comment Addressed
	habitats occur across their natural range and are able to support strong, biodiverse biological communities and the functioning of healthy, resilient and adaptable marine ecosystems; and > *Our oceans support viable populations of representative, rare, vulnerable, and valued species*"	
Draft Overarching National Policy Statement for Energy NPS EN-1 (BEIS, 2021a)	Paragraph 5.4.3 of Draft NPS EN-1 states: *"Where the development is subject to EIA the applicant should ensure that the ES clearly sets out any effects on internationally, nationally and locally designated sites of ecological or geological conservation importance, on protected species and on habitats and other species identified as being of principal importance for the conservation of biodiversity. The applicant should provide environmental information proportionate to the infrastructure where EIA is not required to help the Infrastructure*	Direct or indirect effects on features of relevant Special Area of Conservation (SAC) and Special Protection Area (SPA) sites are also considered in the Habitats Regulations Assessment Screening Report (RIAA) and where relevant will be included in the RIAA.

Legislation/Policy	Key Provisions	Section Where Comment Addressed
	Planning Commission (IPC) consider thoroughly the potential effects of a proposed project."	
	Paragraph 5.4.8 of Draft NPS EN-1 state: *"Important sites for biodiversity are those identified through international conventions and the Habitats Regulations. The Habitats Regulations set out sites for which an HRA will assess the implications of a plan or project, including Special Areas of Conservation and Special Protection Areas. As a matter of policy, the following should be given the same protection as sites covered by the Habitat's Regulations: (a) potential Special Protection Areas and possible Special Areas of Conservation; (b) listed or proposed Ramsar sites; and (c) sites identified, or required, as compensatory measures for adverse effects on other HRA sites."*	Direct or indirect effects on features of relevant Special Area of Conservation (SAC) and Special Protection Area (SPA) sites are also considered in the Habitats Regulations Assessment Screening Report (RIAA) and where relevant will be included in the RIAA.
	Paragraph 5.4.9 and 5.4.10 of Draft NPS EN-1 state: *"Many Sites of Special Scientific Interest (SSSI) are also designated as sites of international importance; those that are not, should be given a*	There are no SSSIs which are considered to be at risk of effect from the construction, operation and decommissioning of VE, and as such no further consideration

Legislation/Policy	Key Provisions	Section Where Comment Addressed
	high degree of protection. Most National Nature Reserves are notified as SSSIs. *Development on land within or outside a SSSI, and which is likely to have an adverse effect on it (either individually or in combination with other developments), should not normally be permitted. The only exception is where the benefits (including need) of the development in the location proposed clearly outweigh both its likely impact on the features of the site that make it of special scientific interest, and any broader impacts on the national network of SSSIs. The Secretary of State should use requirements and/or planning obligations to mitigate the harmful aspects of the development and, where possible, to ensure the conservation and enhancement of the site's biodiversity or geological interest."*	of SSSIs has been given.
	Paragraph 5.4.16 of Draft NPS EN-1 state: *"Other species and habitats have been identified as being of principal importance for the conservation of biodiversity in England and Wales and thereby requiring conservation*	All species receptors, including those of conservation importance are summarised in Section 7.4.3.

Legislation/Policy	Key Provisions	Section Where Comment Addressed
	action. The Secretary of State should ensure that these species and habitats are protected from the adverse effects of development by using requirements, planning obligations, or licence conditions. 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 national or regional importance which it considers may result from a proposed development."	
Draft National Policy Statement for Renewable Energy Infrastructure (EN-3) (BEIS, 2021b)	Paragraph 2.28.1 of Draft NPS EN-3 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*	Injury and disturbance from UXO clearance has been assessed in section 7.11 as part of the assessment of construction impacts on marine mammals. Five Estuaries Offshore Wind Farm Limited (VE OWFL) are not seeking to licence UXO in the DCO. All appropriate licencing requirements will be met post-consent.

Legislation/Policy	Key Provisions	Section Where Comment Addressed
	Habitats Regulations. In addition, whales, dolphins and porpoises (collectively known as cetaceans) are legally protected species. Therefore, 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), an application will have to be made for a wildlife licence to allow the activity to take place."	
	Paragraph 2.28.2 of Draft NPS EN-3 states: *"The development of offshore wind farms can also impact fish species, 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 are assessed in sections 7.11, 7.12 and 7.13. There is no risk of entanglement with floating wind structures as there are no floating elements to VE, see Volume 2, Chapter 1: Offshore Project Description.
	Paragraph 2.28.3 of Draft NPS EN-3 states: *"Where necessary, assessment of the effects on marine mammals should include details of:* > *likely feeding areas and impacts*	Throughout the EIA and Habitat Regulation Assessment (HRA) all relevant impacts have been identified, discussed, analysed and mitigated for if necessary (see

Legislation/Policy	Key Provisions	Section Where Comment Addressed
	on prey species and prey habitat; > *known birthing areas / haul out sites for breeding and pupping;* > *migration routes;* > *protected areas (e.g. HRA sites and SSSIs);* > *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;* > *collision risk;* > *entanglement risk; and* > *barrier risk."*	sections 7.11, 7.12 and 7.13).
	Paragraph 2.28.4 of Draft NPS EN-3 states: *"The scope, effort and methods required for*	Communication with SNCBs has been consistent throughout VE, targeted ETGs have occurred as

Legislation/Policy	Key Provisions	Section Where Comment Addressed
	marine mammal surveys should be discussed with the relevant statutory nature conservation body."	discussed in section 7.3.
	Paragraph 2.28.5 of Draft NPS EN-3 states: *"The applicant should discuss any proposed noisy activities with the relevant body and must reference the JNCC underwater noise guidance 32 in relation to noisy activities (alone and in-combination with other plans or projects) within HRA sites. 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 2.28.1 above, the applicant should look at possible alternatives or appropriate mitigation (detailed below)"*	This has been assessed in the RIAA and EIA impacts from underwater noise assessed in sections 7.11, 7.12 and 7.13 of this document.
	Paragraph 2.28.6 of Draft NPS EN-3 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.*	Details have been provided in Volume 7, Report 8: Outline Marine Mammal Mitigation Protocol for Piling Activities for further details.

Legislation/Policy	Key Provisions	Section Where Comment Addressed
	Active displacement of marine mammals outside potential injury zones can be undertaken using equipment such as acoustic deterrent devices"	
	Paragraph 2.28.7 of Draft NPS EN-3 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 have been detailed in Volume 7, Report 8: Outline Marine Mammal Mitigation Protocol for Piling Activities see section 7.10 for more details
	Paragraph 2.28.8 of Draft NPS EN-3 states: *"Where noise impacts cannot be reduced to acceptable levels, other mitigation should be considered, including spatial/temporal restrictions on noisy activities, alternative foundation types, alternative installation methods and noise abatement technology. Review of up-to-date research should be undertaken and all potential mitigation options presented"*	Mitigation is discussed in Volume 7, Report 8: Outline Marine Mammal Mitigation Protocol for Piling Activities see section 7.10 for more details. Updates to noise abatement recommendations for other projects will be closely monitored and researched.

7.3 CONSULTATION AND SCOPING

7.3.1 As part of the EIA for VE, consultation has been undertaken with various statutory and non-statutory bodies, through the agreed Evidence Plan process. A formal Scoping Opinion was sought from the Secretary of State (SoS) following submission of the Scoping Report (VE OWFL, 2021). The Scoping Opinion (the Planning Inspectorate (the Planning Inspectorate (PINS), 2020) was issued in November 2021 by PINS. A record of key areas of consultation specific to marine mammal ecology undertaken during the Scoping Opinion and Evidence Plan phases and informal consultation is summarised in Table 7.2 and will be presented in full within the VE consultation report, to be published with the final DCO application.

Table 7.2: Summary of consultation relating to marine mammals.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
February 2020 & December 2021, Pre-/Post-scoping Evidence Plan meeting	The proposed species to be scoped in were agreed (harbour porpoise, grey seal and harbour seal). Other species will be scoped out of the EIA.	Harbour porpoise, grey seal and harbour seal have been scoped into the PEIR chapter as agreed in the Pre- and Post-scoping Evidence Plan meetings and based on site-specific surveys undertaken (see section 7.4 and Volume 4, Annex 7.1: Marine Mammal Baseline Characterisation).
February 2020 & December 2021, Pre-/Post-scoping Evidence Plan meeting	It was agreed that the 2018 SMRU overflight should be used to inform the Scoping Report/ EIA	The SMRU overflight was included in the Scoping Report.
February 2020 & December 2021, Pre-/Post-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 TTS is presented in Section 7.11, however it does not include an assessment of significance.
Scoping Opinion (Natural England, 2021)	*"Natural England is content with the proposed approach to evidence gathering and data collection to inform the marine mammal baseline. However, we have suggested additional sources for consideration by the applicant. In respect to the assessment, we require further information in order to confirm our agreement with the approach, especially regarding the underwater noise assessment, and the impact assessment methodology specifically regarding marine mammals (although we anticipate that more information and agreement will be sought during the Evidence Plan Process (EPP)). We advise that the Cumulative Impact Assessment (CIA) assesses the worst-case scenario (WCS), with some*	The CEA assesses the worst case scenario, see section 7.14. Barrier effects and TTS have been scoped in for construction, see section 7.11.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	consideration of realistic scenarios. We also advise that insufficient information has been provided to scope out barrier effects due to underwater noise, and advise that Temporary Threshold Shift (TTS) should be scoped in (whilst acknowledging the limitations of the assessment), rather than scoped out."	
Scoping Opinion (Natural England, 2021)	Natural England agrees with the proposed Management Units (MUs) as the reference populations.	MUs have been applied as agreed.
Scoping Opinion (Natural England, 2021)	Natural England are satisfied with the datasets listed to inform the marine mammal baseline. However, it is recommended that further references are added to strengthen the information provided in the baseline. We advise that the applicant check for any new relevant literature that may be published prior to submission of the ES. > A new paper on harbour porpoise density (Nielsen *et al*, 2021. Spatio-temporal patterns in harbour porpoise density: citizen science and conservation in UK seas) might be a useful reference to add. > Cucknell *et al*, 2020. Confirmation of the presence of harbour porpoise (*Phocoena phocoena*) within the tidal Thames and Thames Estuary. Mammal Communications 6: 21-28, London.	The suggested references have been included in Table 7.3 to strengthen the information provided in Volume 4: Annex 7.1 Marine Mammal Baseline Characterisation.
Scoping Opinion (Natural England, 2021)	Natural England agrees that the three key species are harbour porpoise, harbour seal and grey seal, for which a detailed assessment needs to be conducted. We note that the applicant proposes to use information from surveys undertaken for nearby	At PEIR the three species included in assessment are the harbour porpoise, grey seal and harbour seal based on VE site-specific surveys (see Section 7.8). No other species were identified in the

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	offshore wind farms. Should any other marine mammal species have been observed in these surveys, we request that a rationale is provided to confirm the appropriateness of scoping them out.	two years of site specific surveys at VE, see Volume 4, Annex 7.1: Marine Mammal Baseline Characterisation.
Scoping Opinion (Natural England, 2021)	Table 11.2 Natural England agrees that all relevant marine mammal protected areas have been identified. We advise that there is an area of the Southern North Sea SAC where the winter and the summer areas overlap; this is not captured in Figure 11.5., which should be updated.	Updates to Figure 11.5 of the Scoping Report reflects the area of the Southern North Sea SAC where there is overlap of the winter and summer area.
Scoping Opinion (Natural England, 2021)	The applicant should include details of the location of the nearest breeding colony/region for harbour seals in relation to the proposed development site, as they have done for grey seal.	The closest breeding region in relation to VE is in Essex and Kent (SCOS, 2022). Information on harbour seal breeding regions have been included in Section 7.8.
Scoping Opinion (Natural England, 2021)	Natural England are satisfied with the list of impact pathways proposed to be scoped into the assessment, with the exception of barrier effects from underwater noise as detailed in the below comments.	Barrier effects from underwater noise have been scoped in, see section 7.11.
Scoping Opinion (Natural England, 2021)	Natural England is not aware of any other data currently available on operational noise of wind turbines of a similar size to those proposed. We therefore query the likelihood of having this data at the time of submission, and request further information on how else the applicant may undertake the assessment if this data does not become available.	The impact of operational noise has been assessed fully in Volume 4, Appendix 6.2: Subsea Noise Technical Report and presented in section 7.12. The turbine size at VE is larger than those used in the calculation in Tougaard *et al.,* (2020) so caution must be used when interpreting the extrapolation used for the calculations.
Scoping Opinion (Natural England, 2021)	Natural England considers that TTS should be scoped in albeit only for context, as opposed to being scoped out. We agree with the justification	TTS impact ranges have been presented in 7.11 and Table 7.23 there is no assessment of magnitude, sensitivity or

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	provided as to not undertaking a meaningful assessment of impact significance.	significance as previously agreed with Natural England.
Scoping Opinion (Natural England, 2021)	Natural England agrees that the impact pathways to be scoped out are suitable, other than the impact of barrier effects – see below. Impact number 11.14 – Natural England agrees that the barrier effects due to the physical presence of the OWF should be scoped out. However, we consider that insufficient information has been presented to scope out barrier effects due to underwater noise. Barrier effects do not have to be permanent to require assessment; temporary barrier effects from underwater noise could also arise and affect marine mammals that would normally transit through the area. For this specific project location this is of relevance to grey and harbour seals, which are present in significant numbers in the Thames Estuary and may transit through the AoS and array area on foraging trips. Further information is required to justify the scoping out of barrier effects from underwater noise.	Barrier effects from underwater noise during construction have been scoped into the assessment, see section 7.11.
Scoping Opinion (Natural England, 2021)	The applicant has included the statement that, in reference to the mitigation measures listed in paragraph 11.5.6, that *"these measures are inherently part of the design of VE and hence have been considered in the judgments as to which impacts can be scoped in/out presented in Table 11.3 and Table 11.4."* This statement in itself is of concern as there are many mitigation measures listed here which we do not considered embedded mitigation and	No action required as this is an observation only

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	should not be considered when determining whether an impact can be scoped out e.g. having a MMMP for piling does not mean impacts can be scoped out. However, our understanding is that none of the mitigation measures listed have led to the scoping out of any key impact pathways, which we agree with, therefore this is an observation only.	
Scoping Opinion (Natural England, 2021)	We understand that the applicant has also relied on the Project Environmental Management Plan (PEMP) as a mitigation measure to scope out the impact pathway of accidental pollution to marine mammals. We query why this measure has not been included in the bullet point list. Consider whether the PEMP should be referred to in the ES chapter.	A PEMP has been added to the embedded mitigation list in Section 7.10 for more details.
Scoping Opinion (Natural England, 2021)	We note that bullet point 6 in this list appears incomplete. Please specify the mitigation measure that was meant to be listed here.	The text in the Scoping Report has been corrected.
Scoping Opinion (Natural England, 2021)	Natural England agrees that all relevant embedded mitigation protocols are listed. 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.	No action is required at this stage.
Scoping Opinion (Natural England, 2021)	As part of the CIA, we advise that the applicant considers the worst-case scenario, alongside realistic scenarios.	For the CEA the worst-case for each project has been included, see Section 7.14 for more details.
Scoping Opinion (PINS, 2021)	Effects on marine mammals other than harbour porpoise, grey seals & harbour seals The Scoping Report seeks to scope out this matter as the site-specific surveys (covering two years) did not	The data sources identified in section 7.4.4 below have not recorded the presence of any other relevant marine mammals.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	record any marine mammal species other than the three species listed. It is noted that Table 11.1 of the Scoping Report lists various other sources of baseline data, some of which is not yet available. NE has also advised of additional data sources which could be used to inform the baseline (see Appendix 2 of this report). The Inspectorate agrees that this matter can be scoped out of further assessment unless any of the data sources listed in Table 11.1 indicate the presence of other marine mammal species in the vicinity of the Proposed Development.	
Scoping Opinion (PINS, 2021)	The Scoping Report seeks to scope this matter out on the grounds that the Proposed Development a PEMP. It states that it has been agreed with statutory nature conservation bodies (SNCBs) on previous OWF projects that major incidents which would lead to substantial mortality are unlikely and significant effects are unlikely. However, the Scoping Report does not quantify the volume of oils/chemicals that would be carried on board vessels or provide any detail on the PEMP. The Inspectorate does not consider that the Scoping Report contains sufficient information for it to agree that this matter can be scoped out of further assessment. In the absence of information such as evidence demonstrating clear agreement with relevant statutory bodies, the Inspectorate is not in a position to agree to scope these matters from the assessment. Accordingly, the ES should include an assessment of these matters or the information referred to demonstrating agreement with the relevant	Further justification has been provided in section 7.4.2 as to the scoping out of accidental pollution, this has been agreed with SNCBs.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	consultation bodies and the absence of LSE on the environment.	
Scoping Opinion (PINS, 2021)	The Scoping Report seeks to scope out TTS on the grounds that the effects of TTS would be captured through the assessment of disturbance. The effects of TTS are stated to be difficult to interpret in terms of effects on individuals and unsuitable for determining the significance of effects. However, the ES will present TTS ranges and areas based on underwater noise modelling and the number of animals in the affected areas. It will not discuss the magnitude of TTS, marine mammal sensitivity or the overall significance of impact. This is stated to be in line with stakeholder advice. It is noted that NE and the MMO agree that the approach of presenting TTS areas without a significance assessment in order to provide a context for the assessment of effects although neither body agrees that this matter should be scoped out of the ES altogether. The Inspectorate considers that since it has been agreed by the relevant stakeholders that an assessment of the significance of TTS is not required and the Applicant has undertaken to report on TTS ranges and areas, this matter can be scoped out of further assessment.	TTS impact ranges have been presented in section 7.11, there has been no assessment of magnitude, sensitivity or significance as previously agreed with Natural England.
Scoping Opinion (PINS, 2021)	The Scoping Report states that there is no evidence so far of EMF associated with marine renewables having any effect on marine mammals. Only one marine mammal, a non-native species which uses electrical stimuli when foraging, is known to respond to EMF. The Inspectorate agrees this matter can be scoped out of further assessment.	This impact has been scoped out, see section 7.4.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
Scoping Opinion (PINS, 2021)	The Scoping Report seeks to scope this matter out on the grounds that long-term monitoring at various OWF has demonstrated that marine mammals are present within the array areas during operation and may be using these areas for foraging. The Scoping Report also notes that evidence shows that individuals are displaced during construction and then return. The extent of disturbance is expected to be localised and short-term. However, it is not clear on the basis of the evidence presented in the Scoping Report exactly what 'localised' and 'short-term' mean or whether barrier effects (for instance as a result of underwater noise) during construction would be assessed. The Inspectorate does not therefore agree that this matter can be scoped out of further assessment. The Applicant's attention is also drawn to the comments from NE on this matter in Appendix 2 of this report. In the absence of information such as evidence demonstrating clear agreement with relevant statutory bodies, the Inspectorate is not in a position to agree to scope these matters from the assessment. Accordingly, the ES should include an assessment of these matters or the information referred to demonstrating agreement with the relevant consultation bodies and the absence of a LSE.	Barrier effects have been scoped into the assessment for the construction phase, see section 7.11.
Scoping Opinion (PINS, 2021)	The ES should provide details about the nearest breeding colony of harbour seal to the Proposed Development (as has been done for the grey seal).	The closest breeding colony in relation to VE is in Essex and Kent (SCOS, 2022). Information on harbour seal breeding colonies have been included in Section 7.8.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
Scoping Opinion (PINS, 2021)	The measures listed include a number of plans including a Vessel Management Plan, a Site Integrity Plan for the Southern North Sea SAC and Marine Mammal Mitigation Protocols. As advised in paragraph 3.3.11 of this report, where these plans are relied on to avoid significant environmental effects, outline or in-principle plans should be submitted as part of the dDCO application.	A Outline MMMP will be provided at PEIR. A VMP and SIP will be provided a part of the DCO application. Mitigation has been established in Volume 7, Report 8: Outline Marine Mammal Mitigation Protocol for Piling Activities
Scoping Opinion (PINS, 2021)	The Scoping Report states that the assessment will be based on a range of realistic scenarios. The ES must also provide an assessment of the worst case scenario which could arise as a result of the works that would be consented by the dDCO.	The worst case scenario for VE has been included in the CEA, see section 7.14
Scoping Opinion (MMO, 2021)	For marine mammal receptors (Section 11.5.1) the proposed assessment methodology is the Permanent Threshold Shift (PTS)-onset noise exposure criteria recommended in Southall *et al*. (2019). Guidance for assessing the significance of noise disturbance against Conservation Objectives of harbour porpoise SACs (England, Wales & Northern Ireland) JNCC Report No. 654 (JNCC, 2020); and Guidance on mitigation protocols to minimise the risk of injury to marine mammals from piling noise (JNCC, 2010). The proposed assessment methodology and guidance documents are appropriate.	The assessment methodology is detailed in Section 7.5 and aligns with the proposed methodology stated at Scoping, which has been confirmed as appropriate.
Scoping Opinion (MMO, 2021)	Operational barrier effects have been scoped out of the assessment (Table 11.4) due to previous reviews concluding that operational wind farm noise will have negligible barrier effects for marine mammal receptors (Madsen *et al*., 2006; Teilmann *et al*.,	This impact has been scoped out, see section 7.4.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	2006a; Teilmann *et al*., 2006b; Cefas, 2010; Brasseur *et al*., 2012) – we have no major concerns with this approach.	
Scoping Opinion (MMO, 2021)	TTS has been scoped out of the assessment for marine mammal receptors Table 11.4). A reduction in individual foraging capability as a result of exposure to pile driving noise will be included in the assessment and potential reductions in fitness as a result of noise exposure is proposed to be captured by the assessment of disturbance. The impact assessment will present TTS ranges and areas based on underwater noise modelling and published thresholds, as well as number of animals within these areas, but no assessment of the magnitude of TTS, marine mammal sensitivity to TTS or of the overall significance of the impact of TTS will be presented. The approach to present TTS areas without a significance assessment has been agreed (VE OWF Marine Mammals Expert Topic Group Meeting Minutes dated 20/07/21), however, we would expect that TTS be scoped into the assessment as temporary reductions in hearing sensitivity for marine mammals should still be considered in the assessment rather than being scoped out.	TTS impact ranges have been presented in section 7.11. There is only the presentation of impact ranges, areas and number of individuals impacted and no assessment of significance as agreed in the Marine Mammals ETGs dated 20/07/21 and 14/12/21.
Scoping Opinion (MMO, 2021)	Section 3.4 states that dredging (Trailing hopper suction Dredger (THSD) and backhoe dredger) may also be required for the installation of the inter-array and export cables. Underwater noise modelling is proposed to assess the risk of PTS from dredging, trenching, rock dumping for marine mammal receptors (Table 11.3) but this should also be scoped into the potential	Underwater noise from other (non-piling) construction activities is assessed in section 7.11

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	impacts for fish and shellfish receptors. Overall, the potential effects of underwater noise (including TTS) from other (non-piling) construction activities should be appropriately assessed for all relevant marine mammal and fish receptors, in keeping with similar OWF developments.	
Scoping Opinion (MMO, 2021)	Although there are many uncertainties regarding the effects of dredging noise on marine wildlife, the literature suggests that dredging noise is unlikely to cause direct mortality or instantaneous injury. However, the (predominantly) low-frequency sounds produced by dredging overlap with the hearing range of many fish and marine mammal species, which may pose a risk for temporary threshold shifts, auditory masking, and behavioural effects (McQueen *et al*., 2019), as well as increased stress-related cortisol levels in fish species (Wenger *et al*., 2017). Furthermore, it is important to note that the biological significance of such responses is largely unknown.	Underwater noise from other (non-piling) construction activities is assessed in section 7.11
Scoping Opinion (MMO, 2021)	Another source of information regarding marine mammal noise criteria is the 2018 revision to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (National Marine Fisheries Service, 2018).	NMFS (2018) has been referenced in paragraph 7.5.5 and section 7.7.
Scoping Opinion (MMO, 2021)	MMO would expect that a 'Marine Mammal Mitigation Protocol' would be included in these key plans as set out in the Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise (JNCC, 2010).	Volume 7, Report 8: Outline Marine Mammal Mitigation Protocol for Piling Activities is being submitted alongside this PEIR chapter which discusses the potential mitigation used to reduce PTS, TTS and

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
		disturbance form underwater noise.
Scoping Opinion (MMO, 2021)	For marine mammal receptors the approach to cumulative impact assessment is adequately described in Sections 11.5.8-9 and will include pile driving of OWFs together with disturbance and collision risk from vessels at OWFs, UXO detonations, seismic surveys and any other offshore construction developments where information is available within the relevant MUs for each species for the anticipated periods of construction, O&M and decommissioning of VE OWF.	This is the approach taken for Cumulative Effect Assessment (CEA), see section 7.14 for details.
Post scoping ETG (December 2021)	The potential for barrier effects will be assessed within the assessment of disturbance and displacement effected.	Barrier effects have been scoped in, see section 7.11.
Post scoping ETG (December 2021)	The EIA will include a presentation of TTS arising from piling, unexploded ordnance (UXO) detonations and other marine activities. It was agreed that the TTS assessment would present the predicted TTS effect ranges along with the number of animals at risk but would not present a full assessment of significance.	TTS impact ranges have been presented in section 7.11, there has been no assessment of magnitude, sensitivity or significance as previously agreed,. This is in agreement with the conclusions of the Marine Mammal post-scoping ETG dated 14/12/21.
Post scoping ETG (December 2021)	The potential for PTS and TTS arising from operational noise will be assessed.	Operational noise impacts have been assessed in section 7.12.
Post scoping ETG (December 2021)	If monitoring data from similar sized wind turbine generators (WTG) to those proposed for VE will be used to inform the assessment. In the absence of data, then data from existing smaller WTGS will be extrapolated to inform the assessed of larger WTGs.	The underwater noise assessment of WTGs proposed for VE has been undertaken in Volume 4, Annex 6.2: Subsea Noise Technical Report and assessed in section 7.11.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
Post scoping ETG (December 2021)	The marine mammals baseline report will include the requested literature in the Scoping responses and sightings data.	The list of literature for the marine mammal baseline is in Table 7.3 and has been referenced in Volume 4, Annex 7.1: Marine Mammal Baseline Characterisation with the requested literature included.
Post scoping ETG (December 2021)	The scope of the marine mammals EIA assessment is agreed.	The scope of the marine mammal EIA assessment is presented in section 7.4

7.4 SCOPE AND METHODOLOGY

SCOPE OF THE ASSESSMENT

IMPACTS SCOPED IN FOR ASSESSMENT

7.4.1 The following impacts have been scoped into this assessment:

- Construction:
  - Impact 1: PTS from UXO[1] detonation arising from underwater noise during clearance activities;
  - Impact 2: Disturbance from UXO[1] detonation arising from underwater noise during clearance activities;
  - Impact 3: PTS from piling activities arising from underwater noise;
  - Impact 4: TTS from piling activities arising from underwater noise;
  - Impact 5: Disturbance and barrier effects from piling due to underwater noise;
  - Impact 6: PTS and disturbance from other construction activities;
  - Impact 7: Collision risk from construction vessels;
  - Impact 8: Disturbance from construction vessels;
  - Impact 9: Change in water quality due to disturbance of sediment; and
  - Impact 10: Change in fish abundance/distribution due to disturbance impacts on fish.
- Operation and maintenance:

[1] UXO clearance activities will not be licenced in the DCO, a separate Marine Licence will be submitted once there is more information on the number and size of UXOs in the area however, an indicative assessment has been included in this chapter of the PEIR.

- Impact 7: Collision risk from operation vessels;
- Impact 8: Disturbance from operation vessels;
- Impact 10: Change in fish abundance/distribution due to disturbance impacts on fish; and
- Impact 11: Operational noise from turbines.

- Decommissioning:
  - Impact 7: Collision risk from decommissioning vessels;
  - Impact 8: Disturbance from decommissioning vessels;
  - Impact 10: Change in fish abundance/distribution due to disturbance impacts on fish; and
  - Impact 12: PTS and disturbance from decommissioning activities.

IMPACTS SCOPED OUT FOR ASSESSMENT

7.4.2 On the basis of the baseline environment, the project description outlined in Volume 2, Chapter 1: Project Description, in accordance with the Scoping Opinion (PINS, 2021) and through agreements reached under the EPP, a number of impacts have been scoped out (see Table 7.2), these include:

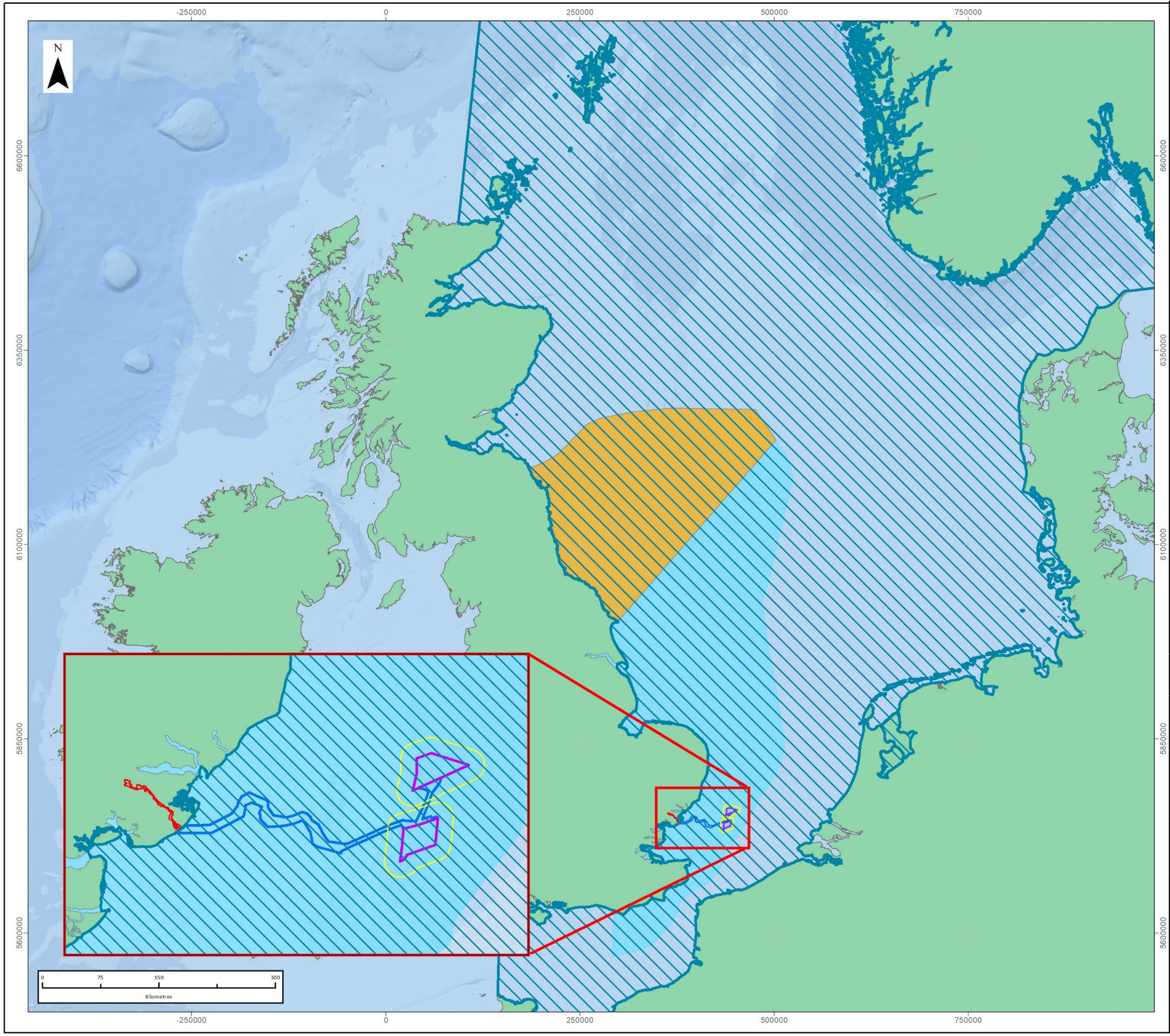
- Construction:
  - Impact 14: Accidental pollution due to the implementation of PEMP and agreement with SNCBs.
- Operation and maintenance:
  - Impact 13: Electro-magnetic fields has been scoped out as there is no likely significant effect (LSE) on the species identified in the baseline, PINS are in agreement with this conclusion (see Table 7.2); and
  - Impact 14: Accidental pollution due to the implementation of PEMP and agreement with SNCBs.

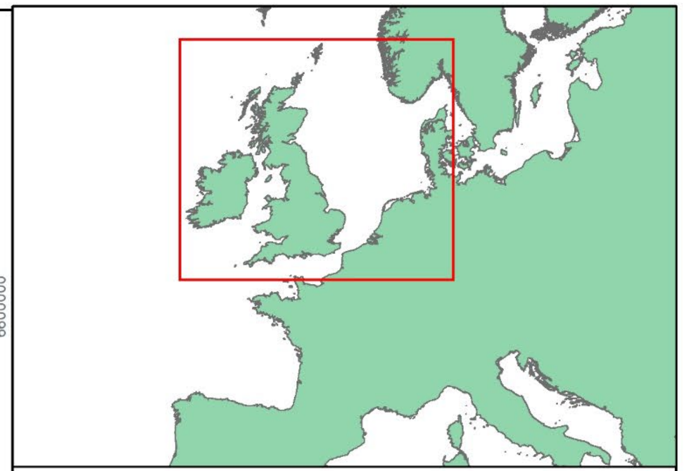
STUDY AREA

7.4.3 The VE mammal study area varies depending on the species, considering individual species ecology and behaviour. The marine mammal study area has been defined at two spatial scales (see Volume 4, Annex 7.1: Marine Mammal Baseline Characterisation for details):

- **Regional Scale 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 (Figure 7.1):
  - Harbour porpoise: North Sea Management Unit (MU);
  - Harbour seal: Southeast England MU; and
  - Grey seal: combined Southeast and Northeast England MUs.

- **The VE study area**: includes the survey area for the VE site-specific aerial surveys (carried out between March 2019 and February 2021 as part of the ornithological aerial surveys – the survey area comprised the VE array areas and a 4 km buffer as described in Volume 2, Chapter 4: Offshore Ornithology) to provide an indication of the local densities of each species within the vicinity of VE (Figure 7.1).





LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Red Line Boundary
- Study Area

Management Units, Species:

- Northeast England, Grey Seals
- Southeast England, Seals
- North Sea, Harbour Porpoise

Data Source:
Basemap: Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

Marine Mammals Study Area

VER	DATE	REMARKS	Drawn	Checked
1	20/02/2023	For Issue	SWM	KL

DRAWING NUMBER:

7.1

SCALE:	PLOT SIZE:	DATUM:	PROJECTION:
1:5,000,000	A3	WGS84	UTM31N

FIVE ESTUARIES OFFSHORE WIND FARM

Z:\GIS\GIS_Projects\0144 Five Estuaries\GIS\Figures\PEIR\Mammals\VE_Mammals_PEIR_Fig1_Study_Area.mxd

BASELINE DATA

7.4.4 Table 7.3 outlines the baseline datasets that exist for the study area and have been utilised to inform the characterisation of the baseline for this assessment (see Volume 4, Annex: 7.1: Marine Mammal Baseline Characterisation for further details on data sources and information on the survey specific limitations).

Table 7.3: Marine mammal baseline datasets.

SOURCE	DESCRIPTION
Site-specific aerial surveys for VE (HiDef Aerial Surveying Ltd 2020, 2021)	Site-specific baseline characterisation digital video aerial surveys (March 2019 – February 2021). The survey area consists of the VE array areas with a 4 km buffer. High confidence as site-specific dedicated marine mammal and ornithology surveys
Additional OWF surveys (where available)	> Galloper OWF baseline and post-construction surveys (vessel based); > Greater Gabbard OWF baseline, construction and post-construction surveys (vessel based); and > North Falls OWF baseline surveys (aerial March 2019-February 2021). Medium confidence for Galloper and Greater Gabbard surveys as data collection dated, high confidence for North Falls surveys as collected more recently.
SCANS III (Hammond *et al*. 2021)	Combination of vessel and aerial surveys of the North Sea and European Atlantic continental shelf waters conducted in July 2016. High confidence as updated assessments in 2021 and 2022.
JCP Phase III (Paxton *et al*. 2016)	38 data sources between 1994-2010. 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. Medium confidence for more recent data (2000s) and low confidence for data collected in 1990s
JCP Data Analysis Tool	The JCP Phase III Data Analysis Product has been used to extract abundance estimates for cetaceans averaged for summer 2007-2010 and scaled to the SCANS III estimates for user specified areas.

SOURCE	DESCRIPTION
	Medium confidence as from 2007-2010 scaled to SCANS III estimates
MERP (Waggitt *et al.*, 2020)	Species distribution maps available at monthly and 10 km^2 density scale. Medium confidence as at 10 km^2 scale so does not show local abundances
SCOS reports (SCOS 2021, SCOS 2022)	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. High confidence as report and assessments are updated yearly based on the yearly assessments
Seal haul-out data (provided by SMRU)	August haul-out surveys of harbour and grey seals. High confidence as surveys conducted yearly
Seal haul-out data in the Greater Thames Estuary (Cox *et al*. 2020)	Seal population data for the Greater Thames Estuary between 2003 to 2019. Medium confidence as whilst it is a long-term data set there has been no continued data collection since 2019
Porpoise presence in the Thames Estuary (Cuknell *et al.*, 2020)	Visual and acoustic vessel surveys conducted in March 2015, augmented by opportunistic sightings records and strandings data. Medium confidence as data collection from 2015
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. High confidence as surveys occur annually and results are updated
Telemetry data (provided by SMRU)	A total of 86 harbour seals have been tagged in the Southeast England MU since 2003. A total of 33 grey seals have been tagged in the Southeast England MU since 1988 and a further 31 have been tagged in the Northeast England MU. High confidence
Seal habitat preference maps (Carter et al. 2020, Carter *et al.*, 2022)	Habitat modelling was used, matching seal telemetry data to habitat variables, to understand the species-environment relationships that drive seal distribution. Haul-out count data were then

SOURCE	DESCRIPTION
	used to generate predictions of seal distribution at sea from all known haul-out sites. This resulted in predicted distribution maps on a 5x5 km grid. The estimated density surface gives the percentage of the British Isles at sea population (excluding hauled-out animals) estimated to be present in each grid cell at any one time during the main foraging season. High confidence as there has been recent update (2022) to the assessment
EU 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 the Netherlands, France and the Wadden Sea to assess connectivity with European sites. Medium confidence as papers from 1025-2017 and not specific to the UK or VE study area
Seawatch Foundation Sightings	Sightings recorded from the Eastern England region. Medium confidence
Harbour porpoise citizen science data UK (Nielsen *et al*. 2021)	Harbour porpoise density data collected by citizen science and assessment of spatio-temporal patterns. Medium confidence as citizen science data
Thames Estuary Harbour Porpoise Survey Report (ZSL and MCR., 2022)	Sightings of harbour porpoise recorded in the Thames Estuary in April 2022 High confidence as sightings collected in same region as VE

7.5 ASSESSMENT METHODOLOGY

7.5.1 The following assessment approaches have used in the marine mammal impact assessment for underwater noise:

- PTS: quantitative assessment using Southall et al. (2019) dual thresholds
- TTS: quantitative assessment using Southall et al. (2019) dual thresholds
- Disturbance from UXOs: three quantitative assessment methods presented:
  - TTS as a proxy for disturbance (as recommended in Southall et al 2007)
  - 26 km EDR for high-order clearance (as recommended in JNCC et al., 2020)

- 5 km EDR assumed for low-order clearance.
- Disturbance from piling: quantitative assessment using dose-response functions:
  - Harbour porpoise dose-response function (from Graham et al 2017)
  - Harbour seal dose-response function (from Whyte et al 2020) (also applied to grey seals)
- Disturbance from other construction activities: qualitative assessment based on limited evidence in the literature.

7.5.2 These assessment methods are described in detail in the following sections.

ASSESSMENT OF PTS

7.5.3 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 for Very High Frequency (VHF) cetaceans (harbour porpoise) and phocids in water (grey seal and harbour seal) are those presented in Southall *et al*. (2019) (Table 7.4). The method used to calculate PTS-onset impact ranges for both 'instantaneous' PTS (SPL_{peak}), and 'cumulative' PTS (SEL_{cum}, over 24 hours) are detailed in Volume 4, Annex 6.2: Subsea Noise Technical Report.

Table 7.4: PTS-onset threshold for impulsive noise from Southall *et al*. (2019).

Hearing group	Species	Cumulative PTS (SEL_{cum} dB re 1 $\mu Pa^2 s$ weighted)	Instantaneous PTS (SPL_{peak} dB re 1 μPa unweighted)
Very High Frequency (VHF) Cetacean	> Harbour porpoise	155	202
Phocid (PCW)	> Grey seal > Harbour seal	185	218

7.5.4 In calculating the noise level that animals are likely to receive during the whole piling sequence, harbour porpoise and both phocid species 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 et al. 2000). 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.

7.5.5 Southall *et al*. (2019) propose the SPL_{peak} (being either unweighted or flat weighted across the entire frequency band of a hearing group). This is because the direct mechanical damage to the auditory system that is associated with high peak sound pressures is not frequency dependent (i.e., restricted to the audible frequency range of a species).

7.5.6 The physiological damage that sound energy can cause is mainly restricted to energy occurring in the frequency range of a species' hearing range. Therefore, for the cumulative sound exposure level (SEL_{cum}), sound is weighted based on species group-specific weighting curves given in Southall *et al*. (2019) (Figure 7.2).

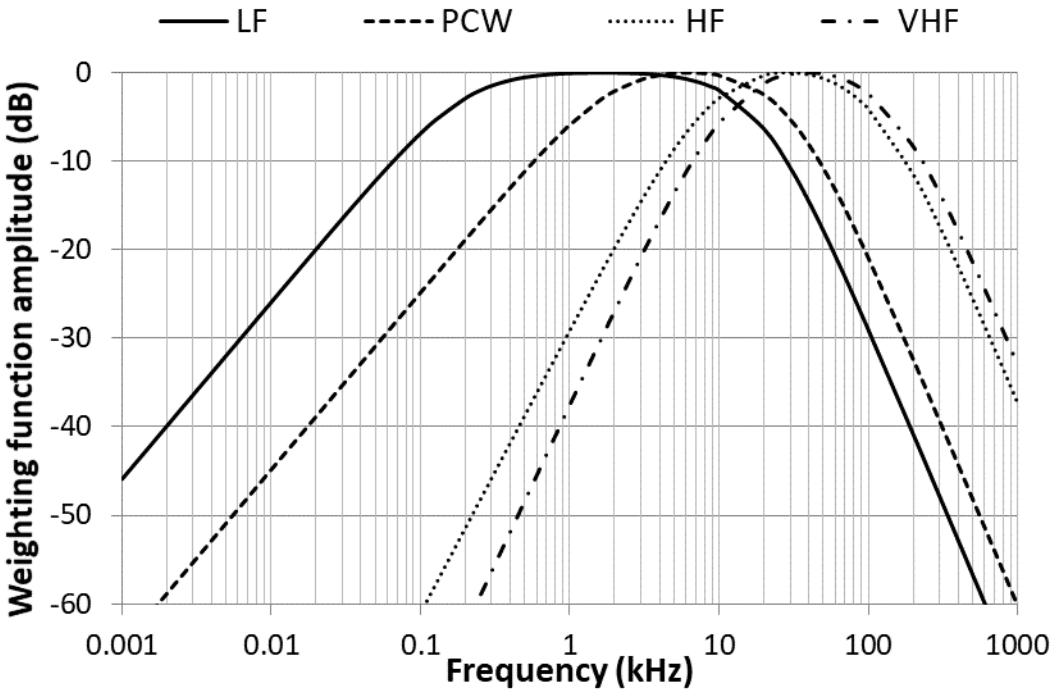


Figure 7.7.2: Auditory weighting functions for low frequency (LF), high frequency (HF) and very high frequency (VHF) cetaceans as well as phocid (PCW) pinnipeds in water (from Southall et al. (2019).

ASSESSMENT OF TTS

7.5.7 It is recognised that TTS is a temporary impairment of an animal's hearing ability with potential consequences for the animal's ability to escape predation, forage and/or communicate, supporting the statement of Kastelein *et al*. (2012c) that *"the magnitude of the consequence is likely to be related to the duration and magnitude of the TTS".* An assessment of the impact based on the TTS thresholds as currently given in Southall *et al*. (2019) (or the former NMFS (2016) guidelines and Southall *et al*. (2007) guidance) would lead to a substantial 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 (see section 7.7), 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 in Sections 7.7.40 - 7.7.48.

7.5.8 The ranges that indicate TTS-onset were modelled and are presented in this impact assessment (Table 7.5:). However, as TTS-onset is defined primarily as a means of predicting PTS-onset, there is currently no threshold for TTS-onset that would indicate a biologically significant level of TTS; therefore, it was not possible to carry out an assessment of the magnitude or significance of the impact of TTS on marine mammals. Therefore, this impact assessment presents the TTS-onset impact range and the number of animals within that range, but does not assign a magnitude, sensitivity or significance score to this impact pathway. This approach is in line with that outlined in Natural England Offshore Wind Best Practice Advice for Marine Environmental Assessessments (2022).

Table 7.5: TTS-onset threshold for impulsive noise from Southall *et al.* (2019).

Hearing group	Species	Cumulative TTS (SEL_{cum} dB re 1 μPa²s weighted)	Instantaneous TTS (SPL_{peak} dB re 1 μPa unweighted)
Very High Frequency (VHF) Cetacean	> Harbour porpoise	140	196
Phocid (PCW)	> Grey seal > Harbour seal	170	212

ASSESSMENT OF PTS FROM UXO CLEARANCE

7.5.9 Southall *et al*. (2019) (see Table 7.4:) has been used to assess the PTS-onset impact from UXO detonation from a range of potential charge sizes. The number of animals expected in the PTS-onset impact range has been calculated and presented as a proportion of the relevant MU.

ASSESSMENT OF DISTURBANCE FROM UXO CLEARANCE

7.5.10 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.

7.5.11 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.

TTS AS PROXY FOR DISTURBANCE

7.5.12 Recent assessments of UXO clearance activities have used the TTS-onset threshold as a proxy for disturbance to indicate the level at which a 'fleeing' response may be expected to occur in marine mammals (e.g., Seagreen and Neart na Goithe). 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..

"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."

7.5.13 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).

26 KM EDR

7.5.14 There is guidance available on the EDR that should be applied to assess the significance of noise disturbance against Conservation Objectives of harbour porpoise SACs in England, Wales & Northern Ireland (JNCC 2020). This guidance advises that an effective deterrence range of 26 km around the source location is used to determine the impact area from high-order UXO detonation (neutralisation of the UXO through full detonation of the original explosive content) with respect to disturbance of harbour porpoise in SACs.

7.5.15 However, the guidance itself acknowledges that this EDR is based on the maximum EDR recommended for pile driving (of monopiles, without noise abatement measures), since there are no equivalent data for explosives.

7.5.16 The guidance from JNCC (2020) states that *"The 26 km EDR is also to be used for the high order detonation of unexploded ordnance (UXOs) despite there being no empirical evidence of harbour porpoise avoidance."*

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

5 KM EDR

7.5.18 Unlike the recommended 26 km EDR for disturbance around high-order detonations (JNCC 2020), there is no currently advised equivalent for low-order detonations (neutralisation of the UXO without full detonation of the original explosive material). In the absence of empirical data with which to set a threshold, the Sofia Offshore Wind Farm Marine Licence Application for UXO detonation[2] assumed a 5 km EDR for low-order detonations. This assumed EDR was justified on the basis of the comparative difference in source level between the high-order and low-order deflagration detonations and the relative changes in empirically derived EDRs for mitigated noise levels for monopile installation (the value on which the high-order EDR is based). Data has shown that low-order deflagration detonations produce underwater noise that is over 20 dB lower than high-order detonation (Robinson et al. 2020). Within the JNCC guidance (JNCC, 2020), a reduction in the EDR for monopiles to 15 km with noise abatement is recommended. It is assumed for the purposes of proposing an EDR for low-order deflagration that the noise abatement used for monopiles would result in a reduction in source level of approximately 10 dB. As such, the reduction in source level of 20 dB between high- and low-order deflagration detonation justifies a greater reduction in source level beyond 15 km, with a 5 km EDR proposed and agreed for that Marine Licence. Note, the Sofia Offshore Wind Farm 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 it is clear whether the low order detonations were effective and empirical data are available to inform the EDR for low-order detonations, the 5 km EDR suggested by Sofia Offshore Wind Farm will be assumed.

SUMMARY

7.5.19 In the absence of agreed thresholds to assess the potential for behaviour disturbance in marine mammals from UXO detonations, the VE impact assessment presents the results for TTS-onset thresholds, the 26 km EDR (high-order) and 5 km EDR (low-order).

7.5.20 While VE OWFL 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.

[2] Case ref: MLA/2020/00489/1, Licence ref: L/2021/00255/2

7.5.21 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.

ASSESSMENT OF PTS FROM PILING

7.5.22 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) has been determined using the recent threshold presented by Southall *et al*. (2019) (see Table 7.4:). Based on agreed density estimates for each species presented in Volume 4, Annex 7.1: Marine Mammal Baseline Characterisation, 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.

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

ASSESSMENT OF DISTURBANCE FROM PILING

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

7.5.25 Noise contours at 5 dB intervals were generated by noise modelling (see Volume 4, Annex 6.2: Subsea Noise Technical Report) 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.

7.5.26 Compared with the EDR and fixed noise threshold approaches, the application of a dose-response function allows for more realistic assumptions about animal response varying with dose, which is supported by a growing number of studies (e.g. Tyack and Thomas 2019, Southall et al. 2021). 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 evidence 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).

HARBOUR PORPOISE DOSE-RESPONSE FUNCTION

7.5.27 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*. (2017) (Figure 7.3). The Graham *et al*. (2017) dose-response function was developed using data on harbour porpoise collected during the first six weeks of piling during Phase 1 of the Beatrice Offshore Wind Farm monitoring program. Changes in porpoise occurrence (detection positive hours per day) were estimated using 47 CPODs[3] placed around the wind farm site during piling and compared with baseline data from 12 sites outside of the wind farm area prior to the commencement of operations, to characterise this variation in occurrence. Porpoise were considered to have exhibited a behavioural response to piling when the proportional decrease in occurrence was greater than 0.5. The probability that porpoise occurrence did or did not show a response to piling was modelled as a function of the estimated received single-pulse sound exposure levels based on measurements of piling noise (Graham et al. 2017).

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

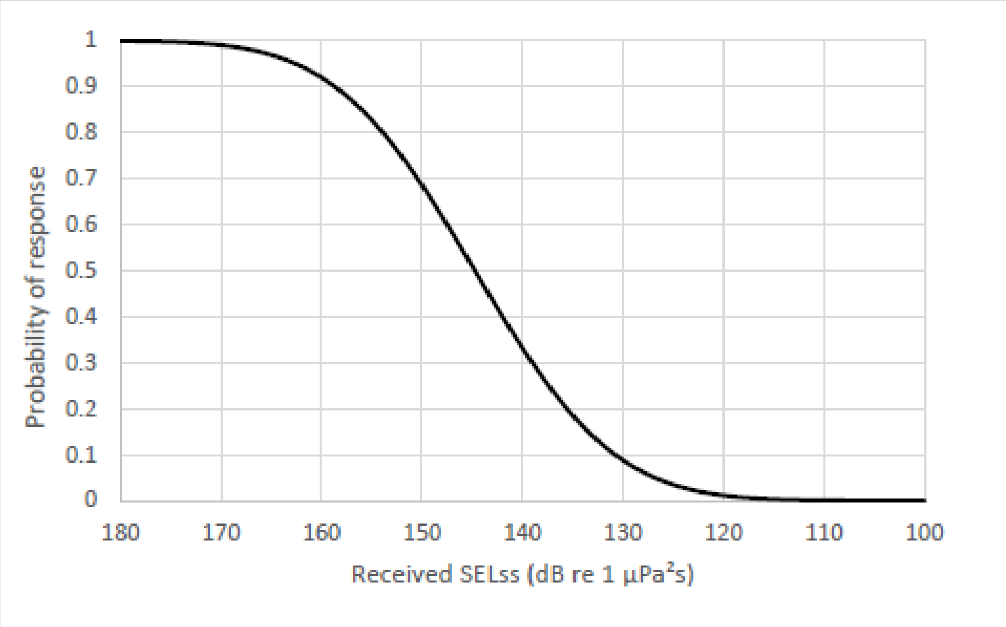


Figure 7.7.3: Relationship between the proportion of animals responding and the received single strike SEL (SEL_{ss}) (not weighted to porpoise hearing), based on passive acoustic monitoring results obtained during Phase 1 of the Beatrice Offshore Wind Farm monitoring program (Graham et al. 2017).

7.5.28 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 *et al*. (2019). The passive acoustic monitoring showed a 50% probability of porpoise response (a significant reduction in detection relative to baseline) within 7.4 km at the first location piled, with decreasing response levels over the construction period to a 50% probability of response within 1.3 km by the final piling location (Figure 7.4) (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.

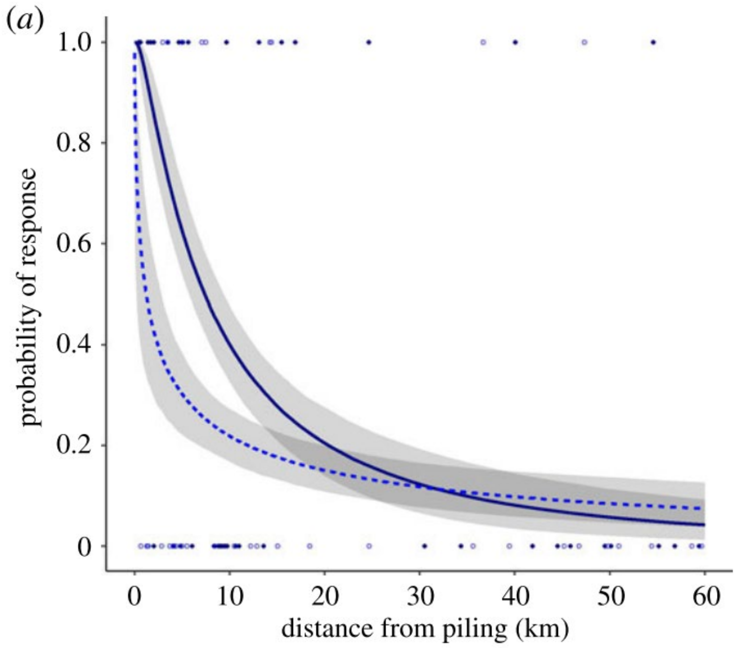


Figure 7.7.4: The probability of a harbour porpoise response (24 h) in relation to the partial contribution of distance from piling for the first location piled (solid navy line) and the final location piled (dashed blue line)[4]. Obtained from Graham *et al*. (2019).

SEAL DOSE-RESPONSE FUNCTION

7.5.29 For both species of seal, the dose-response function (Figure 7.5) adopted was based on the data presented in Whyte *et al*. (2020) where the percentage change in harbour seal density was predicted at the Lincs offshore windfarm. 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[5] 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 Wind farm in 2011-2012.

[4] Predicted assuming the number of AIS vessel locations within 1 km ¼ 0; confidence intervals (shaded areas) estimated for uncertainty in fixed effects only. Harbour porpoise occurrence was considered to have responded to piling when the proportional decrease in occurrence (DPH) exceeded a threshold of 0.5. Points show actual response data for the first location piled (filled navy circles) and the final location piled (open blue circles).

[5] The Wash is situated on the East Coast of England where both Norfolk and Lincolnshire meet the North Sea

7.5.30 In the Whyte *et al*. (2020) dose-response function it has been assumed that all seals are displaced at sound exposure levels above 180 dB re 1 μPa²s (SEL_{SS}, unweighted). This is a conservative assumption since there were no data presented in the study for harbour seal responses at this level. It is also important to note that the percentage decrease in response in the categories 170≤175 and 175≤180 dB re 1 μPa²s 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, for context.

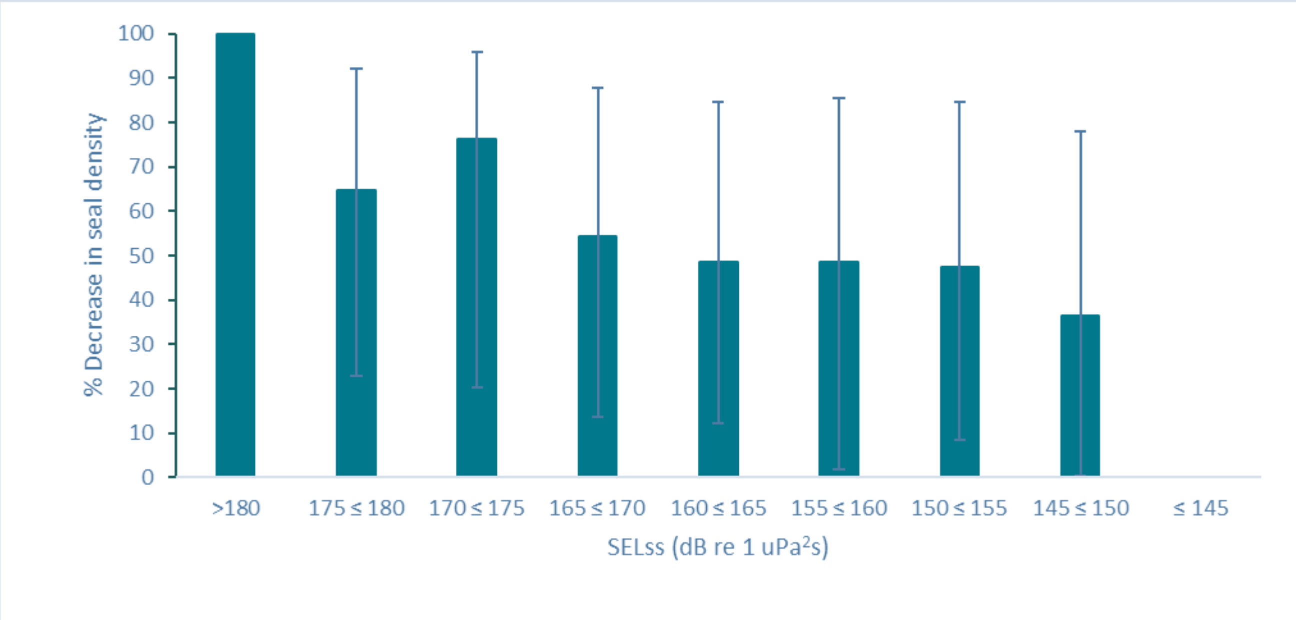


Figure 7.7.5: Predicted decrease in seal density as a function of estimated sound exposure level, error bars show 95% CI (Whyte et al. 2020).

7.5.31 The Whyte *et al*. (2020) harbour seal dose-response function has been applied to the assessment of disturbance to harbour seals during piling for the construction of VE. There are currently no corresponding data for grey seals and, as such, the harbour seal curve 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 exposed to piling noise have shown that there is large individual variation in responses to pile driving, with some animals showing no evidence of a behavioural response (Aarts et al. 2018). Likewise, if the impacted area is considered to be a high quality foraging patch, 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.

ASSESSMENT OF PTS FROM OTHER CONSTRUCTION ACTIVITIES

7.5.32 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) non-impulsive (weighted SEL_{cum}) thresholds. Other construction activities may include vessel activity, dredging, trenching and rock dumping. Results are presented in Volume 4, Annex 6.2: Subsea Noise Technical Report to estimate the number and range of animals predicted to experience PTS from other construction activities.

ASSESSMENT OF DISTURBANCE FROM OTHER CONSTRUCTION ACTIVITIES

7.5.33 There is currently no guidance on the thresholds to be used to assess disturbance of marine mammals from other construction activities. Therefore, the VE 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 VE, with dredging potentially being required for seabed preparation work for foundations as well as for export cable, array cable and interconnector cable installations.

ASSESSMENT OF BARRIER EFFECTS

7.5.34 The assessment of barrier effects has been included in the impacts of disturbance to marine mammals from construction impacts and is based on the results presented in Volume 4, Annex 6.2: Subsea Noise Technical Report.

ASSESSMENT ON CHANGES OF FISH ABUNDANCE/DISTRIBUTION

7.5.35 The assessment for changes of fish abundance and distribution is based on the assessments of fish prey species presented in Volume 4, Chapter 6: Fish and Shellfish Ecology, Volume 4, Chapter 8: Commercial Fisheries and the evidence presented in literature on the impacts to fish and shellfish populations from developments. The assessment considers mortality, TTS and disturbance on the prey species of marine mammals from both piling and UXO clearance with further details and results of the noise modelling on fish receptors presented in Volume 4, Annex 6.2: Subsea Noise Technical Report. The key prey species for consideration are:

- Whiting (M*erlangius merlangus*);
- Sandeel (*Ammodytes marinus*);
- Herring (*Clupea harengus*);
- Haddock (*Melanogrammus aeglefinus*);
- Cod (*Gadus mohua)*;
- Sprat (*Sprattus sprattus*);
- Plaice (*Hippoglossoides platessoides*); and
- Dab (*Limanda limanda*).

7.6 ASSESMENT CRITERIA AND ASSIGNMENT OF SIGNIFICANCE

7.6.1 Determining the significance of effects 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 Volume 1, Chapter 3: Environmental Impact Assessment Methodology).

7.6.2 Information about VE 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, such as Favourable Conservation Status (Table 7.12), 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.

7.6.3 The outcome of the assessment is to determine the significance of these effects against predetermined criteria.

7.6.4 The magnitude of potential impacts is defined by a series of factors including the spatial extent of any interaction, the likelihood, duration, frequency and reversibility of a potential impact. The definitions of the levels of magnitude used in the assessment as shown in Table 7.6.

7.6.5 The sensitivities of marine mammal receptors are defined by both their potential vulnerability to an impact from VE, their recoverability, and the value or importance of the receptor. The definitions of terms relating to the sensitivity of marine mammal ecology chapters are detailed in Table 7.7.

Table 7.6: Impact magnitude definitions.

Magnitude	Definition
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 (Negative).
	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 (Negative).
	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 (Negative).
	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 the any changes in the individual reproductive success or survival therefore no changes to the population size or trajectory (Negative).
	Very minor benefit to the habitat influencing foraging efficiency of a limited number of individuals (Beneficial).

Table 7.7: Sensitivity/importance of the environment.

Receptor sensitivity/ importance	Definition
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).
Medium	> 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).
Low	> 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).
Negligible	> Receptor is able to adapt behaviour so that survival and reproduction rates are not affected.

7.6.6 The matrix used for the assessment of the significance of potential effects is described in Table 7.8. The magnitude of the impact is correlated against the sensitivity of the receptor to provide a level of significance.

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

Table 7.8: Matrix to determine effect significance.

			Sensitivity			
			High	**Medium**	**Low**	**Negligible**
Magnitude	**Negative**	**High**	Major	Major	Moderate	Minor
		Medium	Major	Moderate	Minor	Negligible
		Low	Moderate	Minor	Minor	Negligible
	Neutral	**Negligible**	Minor	Minor	Negligible	Negligible
	Beneficial	**Low**	Moderate	Minor	Minor	Negligible
		Medium	Major	Moderate	Minor	Negligible
		High	Major	Major	Moderate	Minor

Note: shaded cells are defined as significant with regards to the EIA Regulations 2017[6].

7.7 UNCERTAINTY AND TECHNICAL DIFFICULTIES ENCOUNTERED

7.7.1 There are uncertainties relating to the underwater noise modelling and impact assessment for VE. 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

7.7.2 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 (6 dB), and assumes that PTS occurs from exposures resulting in 40 dB or more of TTS measured approximately four minutes after exposure (NMFS 2018). This assumption is used in the Southall et al (2019) thresholds for PTS which are used in this assessment.

PROPORTION IMPACTED

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

[6] The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017

EXPOSURE TO NOISE

7.7.4 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.

7.7.5 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 position in the water column may affect received levels. 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 VE construction are not specifically addressed. The dose-response functions for porpoise include behavioural responses at noise levels down to 120 dB SEL_{ss} which may be indistinguishable from ambient noise at the ranges these levels are predicted.

CUMULATIVE PTS

7.7.6 The cumulative sound exposure level (SEL_{cum}) is energy-based and is a measure of the accumulated sound energy an animal is exposed to over an exposure period. An animal is considered to be at risk of experiencing "cumulative PTS" if the SEL_{cum} exceeds the energy-based threshold. The calculation of SEL_{cum} is done 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.

7.7.7 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.

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

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

7.7.9 However, in practice:

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

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

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

EQUAL ENERGY HYPOTHESIS

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

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

7.7.14 Another detailed example to give is the study of Kastelein *et al*. (2014) where a harbour porpoise was exposed to a series of 1-2 kHz sonar down-sweep pulses of 1 second duration of various combinations, with regard to received sound pressure level, exposure duration and duty cycle (% of time with sound during a broadcast) to quantify the related threshold shift. The porpoise experienced a 6 to 8 dB lower TTS when exposed to sound with a duty cycle of 25% compared to a continuous sound (Figure 7.6). A 1 second silent period in between pulses resulted in a 3 to 5 dB lower TTS compared to a continuous sound (Figure 7.6).

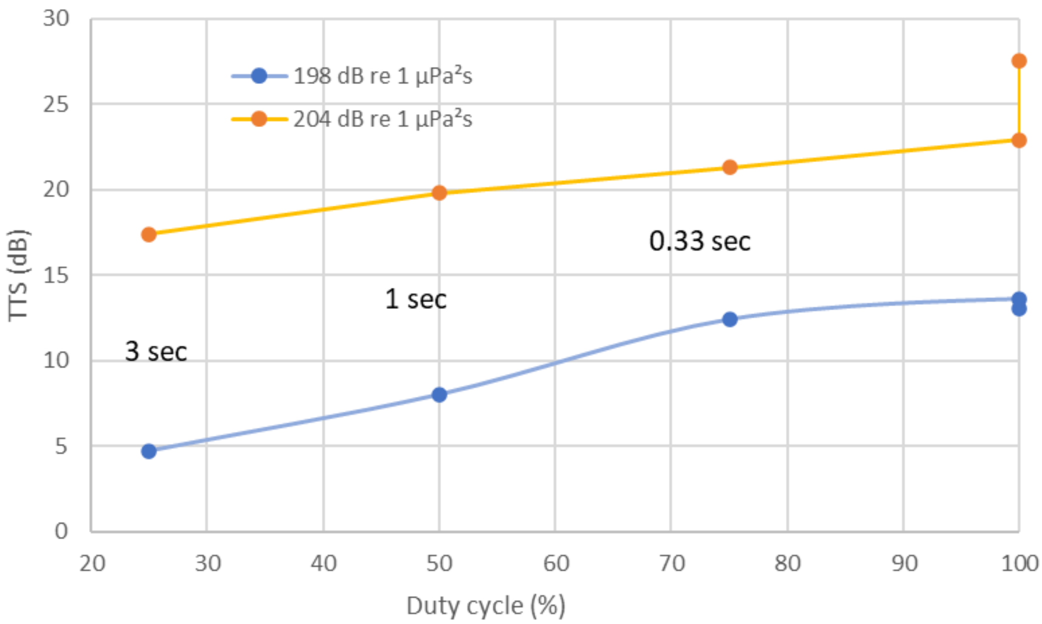


Figure 7.7.6: Temporary threshold shift (TTS) elicited in a harbour porpoise by a series of 1-2 kHz sonar down-sweeps of 1 second duration with varying duty cycle and a constant SEL_{cum} of 198 and 204 dB re1 µPa²s, respectively. Also labelled is the corresponding 'silent period' in-between pulses. Data from Kastelein *et al*. (2014).

7.7.15 Kastelein et al. (2015) showed that the 40 dB hearing threshold shift (the PTS-onset threshold) for harbour porpoise, is expected to be reached at different SEL_{cum} levels depending on the duty cycle: for a 100% duty cycle, the 40 dB hearing threshold shift is predicted to be reached at a SEL_{cum} of 196 dB re 1 μPa^2s, but for a 10% duty cycle, the 40 dB hearing threshold shift is predicted to be reached at a SEL_{cum} of 206 dB re 1 μPa^2s (thus resulting in a 10 dB re 1 μPa^2s difference in the threshold).

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

7.7.17 For the pile driving at VE, the soft-start is 10 blows per minute, increasing to 20 blows per minute over the ramp-up for the worst-case scenario. Assuming a signal duration of around 0.5 sec for a pile strike, the soft-start will be an 8.3% duty cycle (0.5 sec pulse followed by 5.5 sec silence) and the ramp-up will be a 16.7% duty cycle (0.5 sec pulse followed by 2.5 sec silence). In the study of Kastelein *et al*. (2014), a silent period of 3 sec corresponds to a duty cycle of 25%. The reduction in TTS at a duty cycle of 25% is 5.5 - 8.3 dB. Assuming similar effects to the hearing system of marine mammals at VE, the PTS-onset threshold would be expected to be around 2.4 dB higher than that proposed by Southall *et al*. (2019).

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

7.7.19 If a 2 or 3 dB increase in the PTS-threshold is assumed, then this can make a significant difference to the maximum predicted impact range for cumulative PTS. Table 7.9 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, then PTS impact ranges for N-NE decrease from 7.15 km for harbour porpoise to 5.05 km (+2 dB) or 4.10 km (+3 dB).

7.7.20 Therefore, accounting for recovery in hearing between pulses by increasing the PTS-onset threshold by 2 or 3 dB significantly decreases the predicted PTS-onset impact ranges. This approach to modelling cumulative PTS is in development and has not yet been fully assessed or peer reviewed. Therefore, the VE 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 7.9: 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
Harbour porpoise			
PTS	155 SEL_{cum}	7.15	-
PTS + 2 dB	157 SEL_{cum}	5.05	2.1 km
PTS + 3 dB	158 SEL_{cum}	4.10	3.05 km

IMPULSIVE CHARACTERISTICS

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

7.7.22 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).

7.7.23 Using the criteria of signal duration[7], rise time[8], crest factor[9] and peak pressure[10] divided by signal duration[11], Hastie *et al*. (2019) estimated the transition from impulsive to non-impulsive characteristics of impact piling noise during the installation of offshore wind turbine foundations at the Wash and in the Moray Firth. Hastie *et al*. (2019) showed that the noise signal experienced a high degree of change in its impulsive characteristics with increasing distance. Southall *et al*. (2019) state that mammalian hearing is most readily damaged by transient sounds with rapid rise-time, high peak pressures, and sustained duration relative to rise time. Therefore, of the four criteria used by Hastie *et al*. (2019), the rise-time and peak pressure may be the most appropriate indicators to determine the impulsive/non-impulsive transition.

7.7.24 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 ms) reduces to only 20% between ~2 and 5 km from the source. Predicted PTS impact ranges based on the impulsive noise thresholds may therefore be overestimates in cases where the impact ranges lie beyond this. Any animal present beyond that distance when piling starts will only be exposed to non-impulsive noise, and therefore impact ranges should be based on the non-impulsive thresholds.

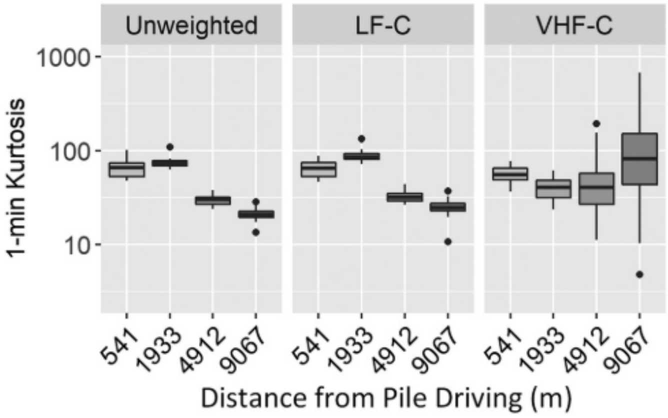
7.7.25 It is acknowledged that the Hastie *et al*. (2019) study is an initial investigation into this topic, and that further data are required in order to set limits to the range at which impulsive criteria for PTS are applied.

7.7.26 Since the Hastie *et al*. (2019) study, Martin *et al*. (2020) investigated the sound emission of different sound sources to test techniques for distinguishing between the sound being impulsive or non-impulsive. For impulsive sound sources, they included impact pile driving of four 4-legged jacket foundation installed at around 20 m water depth (at the Block Island Wind farm in the USA). For the pile driving sound they recorded sound at four distances between ~500 m and 9 km, recording the sound of 24 piling events. To investigate the impulsiveness of the sound, they used three different parameters and suggested the use of kurtosis[12] to further investigate the impulsiveness of sound. Hamernik *et al*. (2007) showed a positive correlation between the magnitude of PTS and the kurtosis value in chinchillas, with an increase in PTS for a kurtosis value from 3 up to 40 (which in reverse also means that PTS decreases for the same SEL with decreasing kurtosis below 40). Therefore, Martin *et al*. (2020) argued that:

- 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.

[7] Time interval between the arrival of 5% and 95% of total energy in the signal.
[8] Measured time between the onset (defined as the 5th percentile of the cumulative pulse energy) and the peak pressure in the signal.
[9] 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.
[10] The greatest absolute instantaneous sound pressure within a specified time interval.
[11] Time interval between the arrival of 5% and 95% of total energy in the signal.
[12] Kurtosis is a measure of the asymmetry of a probability distribution of a real-valued variable.

7.7.27 For the evaluation of their data, Martin *et al*. (2020) used unweighted as well as LF-Cetacean (C) and VHF C weighted sound, based on the species-specific weighting curves in Southall *et al*. (2019) to investigate the impulsiveness of sound. Their results for pile driving are shown in Figure 7.7.



	Median value (1-min kurtosis)		
Distance (km)	Unweighted	LF-C	VHF-C
0.541	65	65	60
1.933	70	85	40
4.912	30	30	40
9.067	20	25	80

Figure 7.7.7: The range of kurtosis weighted by LF-C and VHF-C Southall *et al*. (2019) auditory frequency weighting functions for 30 min of impact pile driving data measured in 25 m of water at the Block Island Wind Farm. Boxplots show the median value (horizontal lines), interquartile range (boxes) and outlier values (dots). Boxplots reproduced from Martin *et al*. (2020) adjacent table shows approximate median values extracted from the boxplot.

7.7.28 Martin *et al*. (2020) used this data to conclude that the change to non-impulsiveness *"is not relevant for assessing hearing injury because sounds retain impulsive character when SPLs are above EQT"* (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. Figure 7.7 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 *et al*. (2019) we argue that the predicted PTS impact ranges based on the impulsive noise thresholds will over-estimate the risk of PTS-onset in cases and at ranges where the likelihood increases that an animal is exposed to sound with much reduced impulsive characteristics.

7.7.29 There are some points that need to be considered 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 resembling a five-day working week. 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, 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. rise time) 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.

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

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

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

ANIMAL DEPTH

7.7.33 Empirical data on SEL_{ss} levels recorded during piling construction at the Lincs offshore wind farm have been compared to estimates obtained using the Aquarius pile driving model[13] (Whyte et al. 2020). This has demonstrated that measured recordings of SEL_{ss} levels made at 1 m depth were all lower than the model predicted single-strike sound exposure levels for the shallowest depth bin (2.5 m). In contrast, measurements made at 9 m 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 SUMMARY

7.7.34 Given the above, VE OWFL considers that the calculated SEL_{cum} PTS-onset impact ranges are highly precautionary and that the true extent of effects (impact ranges and numbers of animals experiencing PTS) will likely be considerably less than that assessed here.

DENSITY

7.7.35 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. The density estimates selected for the quantitative impact assessment for VE are the most recent and most robust density estimates available for each species, as detailed in Volume 4, Annex 7.1: Marine Mammal Baseline Characterisation.

[13] From more information on the Aquarius model see: de Jong, C., Binnerts, B., Prior, M., Colin, M., Ainslie, M., Mulder, I., and Hartstra, I. (2019). “Wozep – WP2: update of the Aquarius models for marine pile driving sound predictions,” TNO Rep. (2018), number R11671, The Hague, Netherlands, p. 94. Retrieved from https://www.noordzeeloket.nl/publish/pages/160801/update_aquarius_models_pile_driving_sound_predeictions_tno_2019.pdf

PREDICTED RESPONSE

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

7.7.37 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 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

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

7.7.39 Analysis of data from monitoring of marine mammal activity during piling of jacket pile foundations at Beatrice Offshore Wind Farm (Graham et al. 2017, 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

7.7.40 It is recognised that TTS is a temporary impairment of an animal's hearing ability with potential consequences for the animal's ability to escape predation, forage and/or communicate, supporting the statement of Kastelein *et al*. (2012c) that *"the magnitude of the consequence is likely to be related to the duration and magnitude of the TTS".* An assessment of the impact based on the TTS thresholds as currently given in Southall *et al*. (2019) (or the former NMFS (2016) guidelines and Southall *et al*. (2007) guidance) would lead to a substantial 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.

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

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

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

7.7.44 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 (2016) and Southall *et al*. (2007) therefore rely on available data from humans and other terrestrial mammals that indicate that a shift in the hearing threshold of 40 dB may lead to the onset of PTS.

7.7.45 For pile driving for offshore wind farm foundations, the TTS and PTS-onset thresholds for impulsive sound are the appropriate thresholds to consider. These consist of a dual metric, a threshold for the peak sound pressure associated with each individual hammer strike, and one for the cumulative sound exposure level (SEL_{cum}), for which the sound energy over successive strokes is summated. Please refer to section 7.7.6 et seq. for full details on the limitations of the SEL_{cum} assessment. The same assumptions and limitations for cumulative PTS apply to cumulative TTS.

7.7.46 It is also important to bear in mind that the quantification of any impact ranges in the environmental assessment process, is done so as 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.

7.7.47 All the data that exists on auditory injury in marine mammals is from studies of TTS and not PTS. Therefore, we may be more confident in our prediction of the range at which any TTS may occur, compared to PTS. 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.

7.7.48 It is important to consider that predictions of PTS and TTS are linked to potential changes in hearing sensitivity at particular hearing frequencies, which for piling noise are generally thought to occur in the 2-10 kHz range and are not considered to occur across the whole frequency spectrum. Studies have shown that exposure to impulsive pile driving noise induces TTS in a relatively narrow frequency band in harbour porpoise and harbour seals (reviewed in Finneran 2015), with statistically significant TTS occurring at 4 and 8 kHz (Kastelein et al. 2016) and centred at 4 kHz (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.

7.8 EXISTING ENVIRONMENT

OVERVIEW

7.8.1 The existing environment for marine mammals is detailed in Volume 4: Annex 7.1 Marine Mammal Baseline Characterisation and HiDef Five Estuaries Annual Survey Reports (HiDef Aerial Surveying Ltd 2020, 2021) with a summary provided here. This PEIR chapter should therefore be read alongside the Volume 4, Annex 7:1 and the Annual Survey Reports (HiDef Aerial Surveying Ltd 2020, 2021) which describe the range of species and the abundance and density of marine mammals that could potentially be impacted by VE, informed by data collected across previous offshore wind farm projects and surveys covering the marine mammal MUs that include the VE array area.

7.8.2 The data available (see section 7.4.4 for details of data sources) have confirmed the likely presence of harbour porpoise, grey seal and harbour seal in the vicinity of VE 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 7.10).

Table 7.10: Marine mammal MU and density estimates (#/km^2) taken forward to impact assessment.

Species	MU	MU size	MU ref	Density (individual/km^2)	Density ref
Harbour porpoise	North Sea	346,601	IAMMWG (2022)	1.82 (average)	HiDef Aerial Surveying Ltd (2020, 2021)
Harbour seal	Southeast England	5,211	Latest counts scaled for seals at sea	Grid cell specific, average 0.018	Carter *et al.*, (2020, 2022)

Species	MU	MU size	MU ref	Density (individual/km^2)	Density ref
Grey seal	Southeast MU and Northeast MU	63,464	Latest counts scaled for seals at sea	Grid cell specific, average 0.106	Carter *et al.*, (2020, 2022)

7.8.3 Harbour porpoise within the North Sea MU have an estimated abundance of 346,601 (95% CI: 289,498 – 419,967, CV: 0.09) (IAMMWG 2022). The conservation status (JNCC, 2019a) concluded an overall assessment of 'Unknown'. Across the three SCANS abundance estimates of harbour porpoise in the North Sea MU (1994, 2005 and 2016) there is no evidence of a trend in abundance (Hammond *et al.,* 2021; SCANS II, 2008; SCANS, 1995). Harbour porpoise were found to have a widespread distribution within the MU and were observed at the VE site during the 24 months of site specific surveys. The site-specific surveys recorded an average of 1.82 individual/km² (Table 7.10).

7.8.4 The latest August haul-out data for harbour seals within the Southeast England MU is the 2016-2019 dataset where 3,752 individuals were counted (SCOS, 2021). In Volume 4, Annex 7.1: Marine Mammal Baseline Characterisation the 2019 count data has been scaled by the estimated proportion hauled out (0.72, 95% CI: 0.54-0.88) (Lonergan *et al*., 2013) to provide an estimate of 4,852 harbour seals in the Southeast England MU in 2019 (95% CI: 3,970 – 6,470). The Southeast England MU harbour seal count has varied over time, the 2019 count was 27.6% lower than the man count between 2012-2018 which indicated the start of a population decline (SCOS, 2021). The counts for 2020 and 2021 have since confirmed a decline as sites between Donna Nook and Scroby Sands have recorded a 38% decline in counts compared to the man of the previous five years. No harbour seals were identified in the site-specific survey.

7.8.5 The latest August haul-out count for grey seals in Southeast England MU is from the 2019 survey where 8,667 individuals were counted (SCOS, 2021). 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 north east and south east 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. In Volume 4, Annex 7.1: Marine Mammal Baseline Characterisation the 2019 count data for the Southeast England MU and combined with the Northeast England MU 2019 count data (13,327 total) has been scaled by the estimated proportion hauled out (0.2515, 95% CI: 0.2145-0.2907) (SCOS, 2022) to produce an estimate of 52,990 grey seals in the Southeast and Northeast England MUs combined (95% CI: 45,845 -62,131). The grey seal population in the Northeast England MU has showed a continuing increase and the Southeast England MU was increasing with a recent levelling off in the past four years (SCOS, 2022). Grey seals were identified occasionally over the two years of site-specific surveys, with a total of 8 sighted in the 24 surveys.

DESIGNATED SITES

7.8.6 A separate HRA RIAA has been completed for VE which included 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 7.11).

7.8.7 There is one UK designated site for harbour porpoise in the North Sea MU: the Southern North Sea SAC. The VE array areas and most of the offshore ECC are located within the winter area of the Southern North Sea SAC and ~50 km from the summer area of the SAC.

7.8.8 There is one harbour seal designated site in Southeast England MU: The Wash and North Norfolk Coast SAC.

7.8.9 There are two designated sites for grey seals within the Southeast and Northeast England MUs: the Humber Estuary SAC and the Berwickshire and North Northumberland Coast SAC.

Table 7.11: Marine nature conservation designations with relevance to marine mammals in VE.

Site	Closest distance to VE	Feature or description
Southern North Sea SAC	Coincident with VE array areas and part of the offshore ECC	Primary reason for site selection – harbour porpoise
The Wash and North Norfolk Coast SAC	~ 140 km swimming distance from the VE array areas	Primary reason for site selection – harbour seal
Humber Estuary SAC	~ 215 km swimming distance from the VE array areas	Qualifying feature – grey seal
Berwickshire and North Northumberland Coast SAC	~ 450 km swimming distance from the VE array areas	Primary reason for site selection – grey seal

EVOLUTION OF THE BASELINE

7.8.10 The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 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*" is included within the ES (EIA Regulations 2017, Schedule 4, Paragraph 3). From the point of assessment, over the course of the development and operational lifetime of VE (operational lifetime anticipated to be up to 40 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 VE is not constructed, using available information and scientific knowledge of marine mammal ecology.

7.8.11 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.

7.8.12 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 7.12. 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. However, it is important to note that this assessment for harbour seals was conducted at a UK wide level, and that the population estimates for harbour seals in both the Southeast and Northeast England MUs are increasing. Harbour porpoise are considered to have an Unknown conservation status, however the UK harbour porpoise population has been assessed as having Favourable future prospects.

Table 7.12: Summary of the conservation status of each marine mammal species (FV = Favourable, XX = Unknown, + = Improving).

Species	Range	Population	Habitat	Future Prospects	Conservation Status	Overall Trend	Reference
Harbour porpoise	FV	XX	XX	FV	XX	XX	JNCC (2019a)
Harbour seal	FV	XX	XX	XX	XX	XX	JNCC (2019b)
Grey seal	FV	FV	FV	FV	FV	+	JNCC (2019c)

7.8.13 The potential impacts of climate change on marine mammals were reviewed and synthesised by Evans and Bjørge (2013) and they concluded that this topic remains poorly understood. In the UK, changes are predicted to manifest in relation to changes in prey abundance and distribution as a result of warmer sea temperatures. The authors also conclude that species likely to be most affected in the future will be those that have relatively narrow habitat requirements and that shelf sea species like the harbour porpoise, white-beaked dolphin and minke whale may come under increased pressure with reduced available habitat, if their range shifts northwards.

7.8.14 Although the main cause of widespread declines in UK harbour seal population is not known, the prevalence of domoic acid derived from toxic algae may be a contributory factor and could be exacerbated by increased sea temperatures (Evans and Bjørge 2013). In addition, sea level rise and an increase in storm frequency and associated wave surges could affect the availability of haul out sites for seals and increased storm frequency and associated conditions could also lead to increased pup and calf mortality (Prime 1985, Gazo *et al*. 2000, Lea *et al*. 2009).

7.9 KEY PARAMETERS FOR ASSESSMENT

7.9.1 Table 7.13 identifies the MDS in environmental terms, defined by the project design envelope. This is to establish the maximum potential impact associated with VE.

Table 7.13: Maximum design scenario.

Potential Effect	Maximum adverse scenario assessed	Justification
Construction		
Impact 1: PTS from UXO Impact 2: Disturbance from UXO	**UXO clearance:** > 2000 expected potential UXO targets; > 60 expected UXO that will require clearance in pre-construction phase: > Maximum of 2 clearance events within 24 hours; > Indicative duration of 30 days; > MDS clearance method is high-order detonation; > Expected to occur prior to foundation installation; > Max charge size is 698 kg; and > Low order (deflagration) charge size is 0.5 kg.	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. VE OWFL is not seeking to licence the disposal of UXO in this application, but it is included in the impact assessment.
Impact 3: PTS from piling Impact 4: TTS (piling) Impact 5: Disturbance from piling	**Monopile WTG:** > 79 small and 41 large; > Max 15 m pile diameter; > Max hammer energy: 7,000 kJ; > Max 7.5 hours per pile; > Max 12 hours piling per day; > Max 2 simultaneous piling events. > Maximum total piling time (hours) (79 small) = 592.5 > Maximum total piling time (hours) (41 large) = 307.5 **Monopile other structures:** > Max 2 Offshore Substation Platforms (OSP); > Max pile diameter 15 m;	The maximum number of piled foundations (and therefore maximum number of piling days) would represent the temporal maximum design scenario for disturbance. The maximum predicted impact range for underwater noise for piled foundations would represent the spatial maximum design scenario for disturbance.

Potential Effect	Maximum adverse scenario assessed	Justification
	> Max hammer energy 7,000 kJ; and > Max 6 hours piling per monopile. > Maximum total piling time (hours) (2 OSP) = 12 **Mult-leg jacket WTG:** > Max 79 WTG; > 4 legs per foundation; > Max 316 legs in total; > Max leg diameter 3.5 m; > Max hammer energy 3,000 kJ; > Max 24 hours piling per day; > Max 2 simultaneous piling events; > Maximum total piling time (hours) (79 small) = 1,264 > Maximum total piling time (hours) (41 large) = 656 **Multi-leg jacket OSP:** > Max 12 legs; > 2 pin piles per leg; > Max 24 pin piles in total; > Max 4 hours per pile; > Max leg diameter 3.5 m; > Max hammer energy 3,000 kJ; and Maximum total piling time (hours) (2 OSP) = 96Foundation installation: 2028-2029 Total monopiles (WTG + OSPs): 81 Total pin piles (WTG + OSPs): 340 Piling construction duration: 1 year	

Potential Effect	Maximum adverse scenario assessed	Justification
Impact 6: PTS and disturbance from other construction activities	**Seabed preparation for foundations:**; > 79 small Gravity Base Structures (GBS) foundations for WTG = 1,137,600 m³; and > 2 GBS foundations for OSP = 56,000 m³ **Cable route clearance methods:** > max flow excavation; and > 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:** 2027-2030	Maximum potential for underwater noise impacts from pre-construction works.
Impact 7: Collision risk from vessels	Max total construction vessels: 101 Max total round trips: 5,110 Indicative peak vessels on-site simultaneously: 35 Offshore construction indicative dates: 2027-2030 Max round trips over 4 years: 20,440	The maximum numbers of vessels and associated vessel movements represents the maximum potential for collision risk and disturbance
Impact 8: Disturbance from vessels		
Impact 9: Change in water quality	Maximum amount of suspended sediment released during construction activities and associated duration - see Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes and Volume 2 Chapter 3: Marine Water and Sediment Quality.	

Potential Effect	Maximum adverse scenario assessed	Justification
Impact 10: Change in fish abundance/distribution	Assessment is based on the MDS presented in Volume 2, Chapter 6: Fish and Shellfish Ecology.	
Operation		
Impact 7: Collision risk from vessels Impact 8: Disturbance from vessels	Maximum total operation vessels: 27 Maximum total annual round trips: 1,776 Indictive peak vessels on-site simultaneously : 27	The maximum numbers of vessels and associated vessel movements represents the maximum potential for collision risk and disturbance.
Impact 10: Change in fish abundance/distribution	Assessment is based on the MDS presented in Volume 2, Chapter 6: Fish and Shellfish Ecology.	
Impact 11: Operational noise	Operational noise from offshore wind farms 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 scoped in as a precaution.	
Decommissioning		
Impact 12: PTS and disturbance	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 7: Collision risk from vessels Impact 8: Disturbance from vessels	Assumed to be similar vessel types, numbers and movements to construction phase (or less) therefore maximum: > Maximum total decommissioning vessels: 101 > Maximum total annual round trips: 5,110 > Indicative peak vessels on-site simultaneously: 35	The maximum numbers of vessels and associated vessel movements represents the maximum potential for collision risk and disturbance.
Impact 10: Change in fish abundance/distribution	Assessment is based on the MDS presented in Volume 2, Chapter 6: Fish and Shellfish Ecology.	

7.10 EMBEDDED MITIGATION

7.10.1 Mitigation measures that were identified and adopted as part of the evolution of the VE project design (embedded into the project design) are listed in Table 7.14. 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 array, export cable corridor and landfall are described separately (these will be secured though the requirements of the DCO as appropriate).

7.10.2 The embedded mitigation contained in Table 7.14 are mitigation measures or commitments that have been identified and adopted as part of the evolution of the project design of relevance to marine mammal ecology, these include project design measures, compliance with elements of good practise and use of standard protocols.

Table 7.14: Embedded mitigation relating to marine mammal ecology.

Project phase	Mitigation measures embedded into the project design
General	
Project design	The development boundary selection was made following a series of constraints analyses, with the array area and offshore ECC selected to ensure the impacts on the environment and other marine users are minimised.
Pollution prevention	A Project Environmental Management Plan (PEMP) will be is proposed to be produced to ensure that the potential for contaminant release is strictly controlled. The PEMP will include a Marine Pollution Contingency Plan (MPCP) and will also incorporate plans to cover accidental spills, potential contaminant release and include key emergency contact details (e.g. NE, Maritime Coastguard Agency and the project site co-ordinator). The PEMP will be secured as a condition in the deemed Marine Licence (dML). Typical measures will include: > Storage of all chemicals in secure designated areas with impermeable bunding (generally to 110% of the volume); > Double skinning of pipes and tanks containing hazardous materials; and > The purpose of these measures is to ensure that potential for contaminant release is strictly controlled and provides protection to marine life across all phases of the life of the wind farm.

Project phase	Mitigation measures embedded into the project design
Pollution prevention	VE OWFL commits to the disposal of sewage and other waste in a manner which complies with all regulatory requirements, including but not limited to the IMO MARPOL requirements.[14]
Construction	
Project design	Identification of maximum hammer energy to be used during pile driving (7,000 kJ for monopile, 3,000 kJ for pin pile). Inclusion of soft-start and ramp up procedures for pile driving. Maximum of 2 simultaneous (concurrent) piling events (two piling operations occurring at exactly the same time from two separate vessels). Maximum of 4 sequential (consecutive) piling events (four pin piles installed one after another within 24 hours – for jackets only)
MMMP (Piling specific)	A piling Marine Mammal Mitigation Protocol will be implemented as a condition in the dML (see Volume 7, Report 8: Outline MMMP). The MMMP will be secured as a condition within the dML.
MMMP (UXO specific)	Implementation of a UXO Marine MMMP subject to a separate Marine Licence application should UXO clearance be required.
Vessel Management Plan (VMP)	The VMP will reduce the risk of vessel disturbance and collision risk. The VMP will be secured as a condition within the dML.
Operation	
RWE document 'Working in Proximity to Wildlife in the Marine Environment Code of Conduct'	The document sets out guidelines for working in proximity to wildlife, following best practice guidelines to reduce and minimise injury and collision to wildlife
Decommissioning	
Decommissioning Plan	A Decommissioning Programme will be developed to cover the decommissioning phase as required under Part 2, Chapter 3 of the Energy Act 2004. As the decommissioning phase will be a similar process to the construction phase but in reverse (i.e., increased project vessels on-site, partially deconstructed structures) the embedded mitigation measure will be similar to those for the construction phase. The Decommissioning Plan will be secured as a condition in the dML.

[14] https://www.imo.org/en/About/Conventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-%28MARPOL%29.aspx

Project phase	Mitigation measures embedded into the project design
MMMP (decommissioning)	Implementation of a decommissioning MMMP subject to a separate Marine Licence application prior to decommissioning should this be required

7.11 ENVIRONMENTAL ASSESSMENT: CONSTRUCTION PHASE

7.11.1 The potential environmental impacts arising from the construction of VE are listed in Table 7.13 along with the MDS against which each construction phase impact has been assessed. A description of the potential effect on marine mammal ecology receptors caused by each identified impact is given below.

IMPACT 1: PTS FROM UXO CLEARANCE

7.11.2 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 VE may include:

- High-order detonation;
- Low-order detonation (deflagration);
- Removal/ relocation; and
- Other less intrusive means of neutralising the UXO.

7.11.3 The current position of both Natural England and the MMO is that low order must always be the primary method of disposal.

7.11.4 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. It is anticipated that UXOs have the potential to be present in the area due to its close proximity to coastal areas with historical industrial/commercial significance, such as Clacton- on Sea, which may have been subject to bombing during World War II.

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

7.11.6 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 VE site boundary has been estimated as 698 kg. This has been modelled alongside a range of smaller high-order charges at 25 kg, 55 kg, 120 kg and 525 kg. In addition, a low-order deflagration has been assessed, which assumes that the donor or shaped-charge (charge weight 0.5 kg) detonates fully but without the follow-up detonation of the UXO. No mitigation measures have been considered for this modelling.

7.11.7 Full details of the underwater noise modelling and the resulting PTS-onset impact areas and ranges are detailed in Volume 4, Annex 6.2: Subsea Noise Technical Report. 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.

7.11.8 In line with the recommendations outlined within the recent position statement on UXO clearance (Department for Environment Food & Rural Affairs et al. 2021), this impact assessment includes an assessment for high-order detonations, though this is considered unlikely to occur in practice since low-order clearance methods are now the industry standard. The results for PTS from high order UXO clearance are presented in Table 7.15.

7.11.9 The results for the impact of low-order UXO with a charge size of 0.5 kg are presented in Table 7.16.

Table 7.15: PTS-onset impact ranges, number of animals and percentage of MU predicted to experience PTS-onset for high-order UXO detonation.

Species	Threshold	Metric	Charge size 25 kg + donor	55 kg + donor	120 kg + donor	240 kg + donor	525 kg + donor	698 kg + donor
Unweighted SPL_{peak} (dB re 1μPa)								
Harbour porpoise	202 dB (VHF)	Impact range (km)	4.6	6.0	7.8	9.8	12	13
		# porpoise	121	206	348	549	823	966
		% MU	0.1%	0.1%	0.2%	0.2%	0.3%	0.3%
Harbour (HS) & grey seal (GS)	218 dB (PCW)	Impact range (km)	0.91	1.1	1.5	1.9	2.5	2.7
		# HS	0	<1	<1	<1	<1	<1
		% MU	0.001%	0.002%	0.004%	0.001%	0.01%	0.01%
		# GS	<1	<1	<1	1	2	2
		% MU	<0.001 %	0.001%	0.001%	0.002%	0.003 %	0.003 %
Weighted SEL_{ss} (dB re 1μPa²s)								
Harbour porpoise	155 dB (VHF)	Impact range (km)	0.57	0.74	0.95	1.1	1.4	1.5
		# porpoise	2	3	5	7	11	13
		% MU	0.001%	0.001%	0.001%	0.002%	0.003 %	0.004 %
Harbour (HS) & grey seal (GS)	185 dB (PCW)	Impact range (km)	0.39	0.57	0.83	1.1	1.6	1.9
		# HS	0	0	0	<1	<1	<1
		% MU	<0.001 %	<0.001 %	<0.001 %	0.001%	0.003 %	0.004 %
		# GS	<1	<1	<1	<1	<1	1
		% MU	<0.001 %	<0.001 %	<0.001 %	0.001%	0.001 %	0.002 %

Table 7.16: PTS-onset impact ranges, number of animals and percentage of MU predicted to experience PTS-onset for low-order UXO detonation.

Species	Threshold	Metric	Charge size 0.5 kg
Unweighted SPL_{peak} (dB re 1µPa)			
Harbour porpoise	202 dB (VHF)	Impact range	1.2 km
		# porpoise	8
		% MU	0.002%
Harbour seal & grey seal	218 dB (PCW)	Impact range	240 m
		# harbour seals	<1
		% MU	<0.001%
		# grey seals	<1
		% MU	<0.001%
Weighted SEL_{ss} (dB re 1µPa²s)			
Harbour porpoise	155 dB (VHF)	Impact range	110 m
		# porpoise	<1
		% MU	<0.001%
Harbour seal & grey seal	185 dB (PCW)	Impact range	60 m
		# harbour seals	<1
		% MU	<0.001%
		# grey seals	<1
		% MU	<0.001%

SENSITIVITY

7.11.10 Most of the acoustic energy produced by a high-order detonation is below a few hundred Hz, decreasing on average by about SEL 10 dB per decade above 100 Hz, and there is a pronounced drop-off in energy levels above ~5-10 kHz (von Benda-Beckmann et al. 2015, Salomons et al. 2021). Therefore, the primary acoustic energy from a high-order UXO detonation is below the region of greatest sensitivity for harbour porpoise, harbour seals and grey 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. Therefore, a **Low** sensitivity for harbour porpoise, harbour seals and grey seals is deemed appropriate.

HARBOUR PORPOISE

MAGNITUDE

7.11.11 **High-order:** At the largest modelled charge size (698 kg + donor charge), the impact range for harbour porpoise using unweighted SPL_{peak} is expected to be 13 km, resulting in PTS-onset in 966 harbour porpoise (Table 7.15), equating to 0.1% of the MU population. Using weighted SEL_{ss}, the maximum impact range calculated for harbour porpoise was 1.5 km, impacting 13 harbour porpoise, equating to 0.004% of the MU population (Table 7.15).

7.11.12 **Low-order:** The PTS-onset impact ranges for low-order UXO detonations are negligible. Using unweighted SPL_{peak}, the maximum impact range for harbour porpoise is 1.2 km, with 8 harbour porpoise being impacted, equating to 0.002% of the MU population (Table 7.16). Using weighted SEL_{ss}, <1 harbour porpoise was predicted to be impacted, equating to <0.001% of the MU population, with an impact range of 110 m (Table 7.16).

7.11.13 The impact of PTS-onset from high-order and low-order UXO clearance is predicted to be of local spatial extent, short-term duration and intermittent and is predicted to impact a very low number of animals relative to the harbour porpoise MU. However, since PTS is a permanent change in the hearing threshold, it is not recoverable. Due to the larger impact range (13 km) and the number of harbour porpoise predicted to be impacted (966) using unweighted SPL_{peak} noise criteria from Southall *et al*. (2019), the magnitude of the impact to harbour porpoise is considered to be **Low (negative)**.

7.11.14 As part of any future consent for UXO removal VE will be required to implement a UXO-specific MMMP to ensure that the effect significance of PTS is reduced to negligible. The exact mitigation measures contained with the UXO MMMP are yet to be determined and will be agreed with NE. Standard mitigation measures used to date in English waters include the use of ADDs to displace animals to beyond the PTS impact range and/or noise abatement techniques such as bubble curtains. The magnitude of this impact is therefore considered to be reduced to **Negligible (Neutral)** for harbour porpoise with the implementation of mitigation methods.

SIGNIFICANCE

7.11.15 The magnitude of the impact has been assessed as **negligible** and the sensitivity of harbour porpoise as **low**. Therefore, the significance of PTS from UXO clearance is concluded to be of **negligible** significance, which is **not significant** in terms of the EIA Regulations 2017.

7.11.16 However, as there is a risk of PTS-onset to European Protected Species, this needs to be considered in the MMMP, a Marine License will be required and an EPS licence is likely to be required.

HARBOUR SEAL

MAGNITUDE

7.11.17 **High-order:** At the largest modelled charge size (698 kg + donor charge), the impact range for harbour seals using unweighted SPL_{peak} is expected to be 2.7 km, equating to <1 harbour seal (Table 7.15) and 0.01% of the MU population. Using weighted SEL_{ss}, the maximum impact range calculated for harbour seal was 1.9 km, also equating to <1 harbour seal (Table 7.15) and 0.004% of the MU population.

7.11.18 **Low-order:** The PTS-onset impact ranges for low-order UXO detonations are negligible. The maximum impact range is 240 m, with <1 seal being impacted species (Table 7.16), equating to <0.001% of the MU population.

7.11.19 The impact of PTS-onset from both high-order and low-order UXO clearance is predicted to be of local spatial extent, short term duration and intermittent, and is predicted to impact a very low number of animals relative to the harbour seal MU. However, since PTS is a permanent change in the hearing threshold, it is not recoverable. Less than 1 harbour seal was predicted to be impacted using noise criteria from Southall *et al*. (2019) over a maximum of 2.7 km, which is considered to be of **Negligible (neutral)** magnitude.

7.11.20 As part of any future consent for UXO removal, VE will be required to implement a UXO-specific MMMP to ensure that the effect significance of PTS is reduced to negligible.. The magnitude of this impact will continue to be of **Negligible (neutral)** magnitude for harbour seals with the implementation of mitigation methods via the MMMP.

SIGNIFICANCE

7.11.21 The magnitude of the impact has been assessed as **negligible** and the sensitivity of harbour seals as **low**. Therefore, the significance of PTS from UXO clearance is concluded to be of **negligible** significance, which is **not significant** in terms of the EIA Regulations.

GREY SEAL

MAGNITUDE

7.11.22 **High-order:** At the largest modelled charge size (698 kg + donor charge), the impact range for grey seals using unweighted SPL_{peak} is expected to be 2.7 km, impacting 2 grey seals, equating to 0.004% of the MU population (Table 7.15). Using weighted SEL_{ss}, the maximum impact range calculated was 1.9 km, equating to 1 grey seal and 0.002% of the MU population (Table 7.15).

7.11.23 **Low-order:** The PTS-onset impact ranges for low-order UXO detonations are negligible. The maximum impact range is 240 m, with <1 seal being impacted (Table 7.16) and <0.001% of the MU population.

7.11.24 The impact of PTS-onset from both high-order and low-order UXO clearance is predicted to be of local spatial extent, short term duration and intermittent, and is predicted to impact a very low number of animals relative to the harbour seal MU However, since PTS is a permanent change in the hearing threshold, it is not recoverable. A maximum of 2 grey seals were predicted to be impacted using noise criteria from Southall *et al*. (2019) over a maximum of 2.7 km, which is considered to be of **Negligible (neutral)** magnitude.

7.11.25 As part of any future consent for UXO removal VE will be required to implement a UXO-specific MMMP to ensure that the effect significance of PTS is reduced to negligible.. The magnitude of this impact will continue to be of **Negligible (neutral)** magnitude for harbour seals with the implementation of mitigation methods via the MMMP.

SIGNIFICANCE

7.11.26 The magnitude of the impact has been assessed as **negligible** and the sensitivity of grey seals as **low**. Therefore, the significance of PTS from UXO clearance is concluded to be of **negligible** significance, which is **not significant** in terms of the EIA Regulations.

IMPACT 2: DISTURBANCE FROM UXO CLEARANCE

7.11.27 There are currently no empirically derived dose-response functions for disturbance arising from UXO detonation. Therefore, in the absence of agreed thresholds to assess the potential for behaviour disturbance in marine mammals from UXO detonations, the VE impact assessment presents the results for the 26 km EDR (high-order; Table 7.17), 5 km EDR (low-order; Table 7.18) and TTS-onset thresholds (Table 7.19).

7.11.28 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 7.17: Disturbance from high-order UXO clearance using an EDR of 26 km.

Species	Density (#/km^2)	Area (km^2)	# impacted	MU	% MU disturbed
Harbour porpoise	1.82	2,123.72	3,865	346,601	1.1%
Harbour seal	0.018	2,123.72	38	5,211	0.73%
Grey seal	0.106	2,123.72	225	63,464	0.35%

Table 7.18: Disturbance from low-order UXO clearance using an EDR of 5 km.

Species	Density (#/km^2)	Area (km^2)	# impacted	MU	% MU disturbed
Harbour porpoise	1.82	78.54	143	346,601	0.04%
Harbour seal	0.018	78.54	1	5,211	0.03%
Grey seal	0.106	78.54	8	63,464	0.01%

Table 7.19: Disturbance from UXO clearance using TTS-onset as a proxy for disturbance. All charge sizes ≥25 kg also include a donor charge.

Species	Threshold	Metric	0.5 kg	25 kg	55 kg	120 kg	240 kg	525 kg	698 kg
Unweighted SPL_{peak} (dB re 1μPa)									
Harbour porpoise	196 dB (VHF)	Impact range (km)	2.3	8.5	11	14	18	23	25
		# porpoise	30	413	692	1,121	1,853	3,025	3,574
		% MU	<0.01%	0.12%	0.20%	0.32%	0.53%	0.87%	1.03%
Harbour seal (HS) & grey seal (GS)	212 dB (PCW)	Impact range (km)	0.45	1.6	2.1	2.8	3.5	4.6	5.0
		# HS	<1	<1	<1	<1	<1	1	1
		% MU	<0.01%	<0.01%	<0.01%	0.01%	0.01%	0.02%	0.03%
		# GS	<1	<1	1	3	4	7	8
		% MU	<0.01%	<0.01%	<0.01%	<0.01%	0.01%	0.01%	0.01%
Weighted SEL_{ss} (dB re 1μPa^{2}s)									
Harbour porpoise	140 dB (VHF)	Impact range	0.93	2.4	2.8	3.2	3.5	4.0	4.1
		# porpoise	5	33	45	59	70	91	96
		% MU	<0.01%	0.01%	0.01%	0.02%	0.02%	0.03%	0.03%
Harbour seal (HS) & grey seal (GS)	170 dB (PCW)	Impact range	0.80	5.2	7.5	10	14	19	22
		# HS	<1	2	3	6	11	20	27
		% MU	<0.01%	0.03%	0.06%	0.11%	0.21%	0.39%	0.53%
		# GS	<1	9	19	33	65	120	161
		% MU	<0.01%	0.01%	0.03%	0.05%	0.10%	0.19%	0.25%

SENSITIVITY

7.11.29 It is noted in the JNCC (2020) guidance that *"...a one-off explosion would probably only elicit a startle response and would not cause widespread and prolonged displacement..."*. Therefore, it is not expected that disturbance from a single UXO detonation would result in any significant impacts, and that disturbance from a single noise event would not be sufficient to result in any changes to the vital rates of individuals. Therefore, the sensitivity of marine mammals for disturbance from UXO clearance is expected to be **Low**.

HARBOUR PORPOISE

MAGNITUDE

7.11.30 **Using the 26 km EDR for disturbance from high-order detonations (JNCC, 2020):** it is estimated that 3,865 harbour porpoise would be disturbed by UXO clearance, equating to 1.1% of the MU population (Table 7.17). Given the number and proportion of the MU expected to be disturbed by high-order UXO clearance, the impact is assessed as a **Low (negative)** magnitude to harbour porpoise.

7.11.31 **Using the 5 km EDR for disturbance from low-order detonations (see paragraph 7.5.16):** it is anticipated that 143 harbour porpoise would be disturbed by UXO clearance, equating to 0.04% of the MU population (Table 7.18). Given the number and proportion of the MU expected to be disturbed by low-order UXO clearance, the impact is assessed as a **Low (negative)** magnitude.

7.11.32 **Using TTS-onset as a proxy for behavioural disturbance:** the impact range for harbour porpoise for high-order UXO clearance of a 698 kg UXO (+ donor) was calculated at a maximum of 25 km, impacting 3,574 harbour porpoise, equating to 1.03% of the MU population (Table 7.19). Given the number and proportion of the MU expected to be disturbed by high-order UXO clearance, the impact is assessed as a **Low (negative)** magnitude.

SIGNIFICANCE

7.11.33 The magnitude of the impact has been assessed as **low** and the sensitivity of harbour porpoise as **low**. Therefore, the significance of disturbance from UXO clearance is concluded to be of **minor** significance, which is **not significant** in terms of the EIA Regulations.

HABOUR SEAL

MAGNITUDE

7.11.34 **Using the 26 km EDR for disturbance from high-order detonations:** it is anticipated that estimated 38 harbour seals will be disturbed, equating to 0.73% of the MU population (Table 7.17). Given the low number and proportion of the MU predicted to be impacted, harbour seals are assessed as **Negligible (Neutral)** magnitude.

7.11.35 **Using the 5 km EDR for disturbance from low-order detonations:** it is anticipated that 1 harbour seal would be disturbed by UXO clearance, equating to 0.03% of the MU population (Table 7.18). Given the number and proportion of the MU expected to be disturbed by low-order UXO clearance, the impact is assessed as a **Negligible (Neutral)** magnitude.

7.11.36 **Using TTS-onset as a proxy for behavioural disturbance:** the impact range for harbour seals for high-order UXO clearance of a 698 kg UXO (+ donor) was calculated at a maximum of 22 km, impacting 27 harbour seals, equating to 0.03% of the MU population (Table 7.19). Given the number and proportion of the MU expected to be disturbed by high-order UXO clearance, the impact is assessed as **Negligible (Neutral)** magnitude.

SIGNIFICANCE

7.11.37 The magnitude of the impact has been assessed as **negligible** and the sensitivity of harbour seals as **low**. Therefore, the significance of disturbance from UXO clearance is concluded to be of **negligible** significance, which is **not significant** in terms of the EIA Regulations.

GREY SEAL

MAGNITUDE

7.11.38 **Using the 26 km EDR for disturbance from high-order detonations:** it is anticipated that estimated 225 grey seals will be disturbed, equating to 0.35% of the MU population (Table 7.17). Given the low number and proportion of the MU predicted to be impacted, grey seals are assessed as **Negligible (Neutral)** magnitude.

7.11.39 **Using the 5 km EDR for disturbance from low-order detonations:** it is anticipated that 8 grey seals would be disturbed by UXO clearance, equating to 0.01% of the MU population (Table 7.18). Given the number and proportion of the MU expected to be disturbed by low-order UXO clearance, the impact is assessed as a **Negligible (Neutral)** magnitude.

7.11.40 **Using TTS-onset as a proxy for behavioural disturbance:** the impact range for grey seals for high-order UXO clearance of a 698 kg UXO (+ donor) was calculated at a maximum of 22 km, impacting 161 grey seals, equating to 0.25% of the MU population (Table 7.19). Given the number and proportion of the MU expected to be disturbed by high-order UXO clearance, the impact is assessed as **Negligible (Neutral)** magnitude.

SIGNIFICANCE

7.11.41 The magnitude of the impact has been assessed as **negligible** and the sensitivity of grey seals as **low**. Therefore, the significance of disturbance from UXO clearance is concluded to be of **negligible** significance, which is **not significant** in terms of the EIA Regulations.

IMPACT 3: PTS FROM PILING

7.11.42 The following section provides the quantitative assessment of the impact of injury (PTS) from pile driving on marine mammal species. Results are presented for the impact ranges, numbers of animals disturbed, and the percentage of the MU population impacted for all species in Table 7.20 at maximum hammer energy for both monopiles (7,000 kJ) and pin piles (3,000 kJ).

Table 7.20: Impact area, maximum range from the pile, number of harbour porpoise, harbour seal and grey seal and percentage of MU predicted to experience PTS-onset from piling.

	Pile type	Monopile (7,000 kJ)			Pin pile (3,000 kJ)		
Species	**Location**	**S-SW**	**N-NE**	**N-N**	**S-SW**	**N-NE**	**N-N**
Instantaneous PTS (SPLpeak)							
Harbour porpoise	Area (km²)	1.6	1.7	1.7	1	1.1	1.1
	Max range (km)	0.74	0.73	0.74	0.58	0.58	0.59
	# porpoise	3	3	3	2	2	2
	% MU	0.001%	0.001%	0.001%	0.001%	0.001%	0.001%
Harbour & Grey seal	Area (km²)	0.01	0.01	0.01	0.01	0.01	0.01
	Max range (km)	0.06	0.06	0.06	<0.05	<0.05	<0.05
	# harbour seals	<1	<1	<1	<1	<1	<1
	% MU	<0.02%	<0.02%	<0.02%	<0.02%	<0.02%	<0.02%
	# grey seals	<1	<1	<1	<1	<1	<1
	% MU	<0.002%	<0.002%	<0.002%	<0.002%	<0.002%	<0.002%
Cumulative PTS (SELcum)							
Harbour porpoise	Area (km²)	110	130	130	58	72	71
	Max range (km)	7.1	7.2	7.3	5.2	5.3	5.4
	# porpoise	200	237	237	106	131	129
	% MU	0.06%	0.07%	0.07%	0.03%	0.04%	0.04%
Harbour & Grey seals	Area (km²)	<0.01	<0.1	<0.1	<0.1	<0.1	<0.1
	Max range (km)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	# harbour seals	<1	<1	<1	<1	<1	<1
	% MU	<0.02%	<0.02%	<0.02%	<0.02%	<0.02%	<0.02%
	# grey seals	<1	<1	<1	<1	<1	<1
	% MU	<0.002%	<0.002%	<0.002%	<0.002%	<0.002%	<0.002%

HARBOUR PORPOISE

SENSITIVITY TO PTS FROM PILING

7.11.43 The ecological consequences of PTS for marine mammals are uncertain. At a Department for Business, Energy & Industrial Strategy (BEIS) funded expert elicitation workshop held at the University of St Andrews (March 2018), experts in marine mammal hearing discussed the nature, extent and potential consequence of PTS to UK marine mammal species (Booth and Heinis 2018). This workshop outlined and collated the best and most recent empirical data available on the effects of PTS on marine mammals. 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.

7.11.44 For piling noise, most energy is between ~30-500 Hz, with statistically significant TTS occurring at 4 and 8 kHz (Kastelein *et al*., 2016) and centred at 4 kHz (Kastelein et al. 2012a, Kastelein et al. 2012b, Kastelein et al. 2013b, Kastelein et al. 2017). Therefore, during the expert elicitation, the experts agreed that any threshold shifts as a result of pile driving would manifest themselves in the 2-10 kHz range (Kastelein et al. 2017) and that a PTS 'notch' of 6-18 dB in a narrow frequency band in the 2-10 kHz region is unlikely to significantly affect the fitness of individuals (ability to survive and reproduce). The expert elicitation concluded that:

"… the effects of a 6 dB PTS in the 2-10 kHz band was unlikely to have a large effect on survival or fertility of the species of interest.

… for all species experts indicated that the most likely predicted effect on survival or fertility as a result of 6 dB PTS was likely to be very small (i.e., <5 % reduction in survival or fertility).

… the defined PTS was likely to have a slightly larger effect on calves/pups and juveniles than on mature females survival or fertility."

7.11.45 For harbour porpoise, the predicted decline in vital rates from the impact of a 6 dB PTS in the 2-10 kHz band for different percentiles of the elicited probability distribution are provided in Table 7.21. Figure 7.8, 7.9 and 7.10 provide a visual representation of Table 7.21. These data should be interpreted as:

- Experts estimated that the median decline in an individual mature female harbour porpoise's fertility was 0.09% (due to a 6 dB PTS (a notch a few kHz wide and 6 dB high) occurring somewhere in the hearing between 2-10 kHz) (Figure 7.8).
- Experts estimated that the median decline in an individual mature female harbour porpoise's survival was 0.01% (due to a 6 dB PTS (a notch a few kHz wide and 6 dB high) occurring somewhere in the hearing between 2-10 kHz) (Figure 7.9).
- Experts estimated that the median decline in an individual harbour porpoise juvenile or dependent calf survival was 0.18% (due to a 6 dB PTS (a notch a few kHz wide and 6 dB high) occurring somewhere in the hearing between 2-10 kHz) (Figure 7.10).

Table 7.21: 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

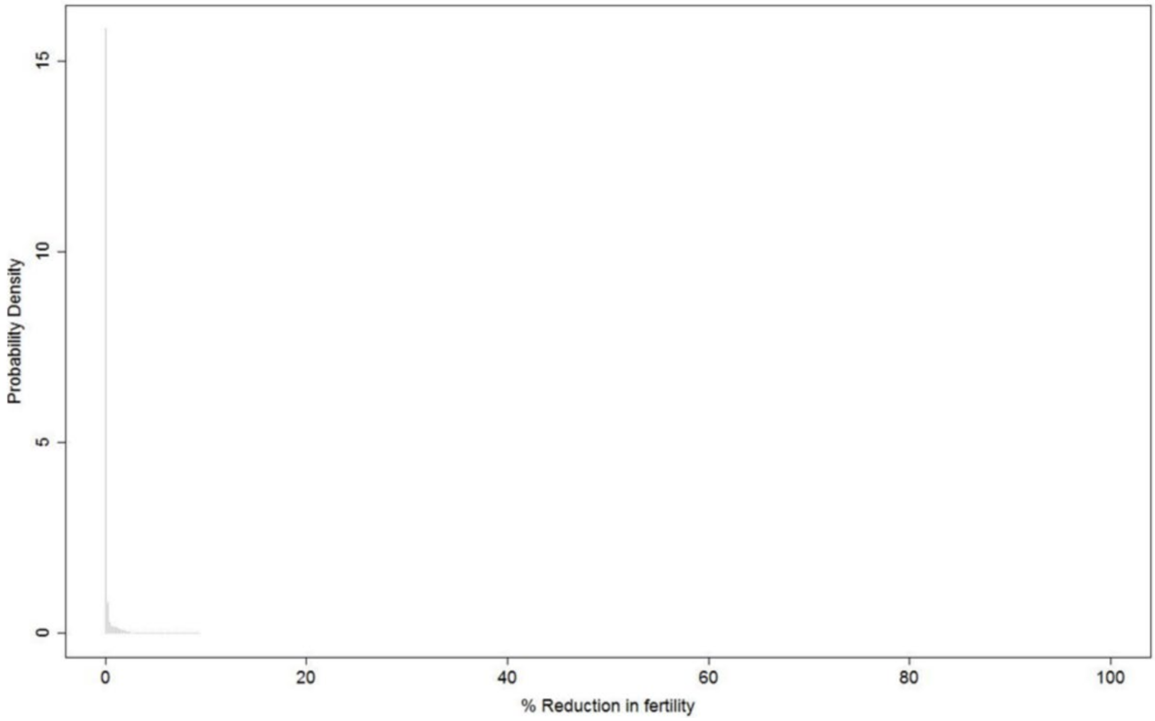


Figure 7.8: Probability distribution showing the consensus distribution for the effects on fertility of a mature female harbour porpoise as a consequence of a maximum 6 dB of PTS within a 2-10 kHz band. Image taken from Booth and Heinis (2018).

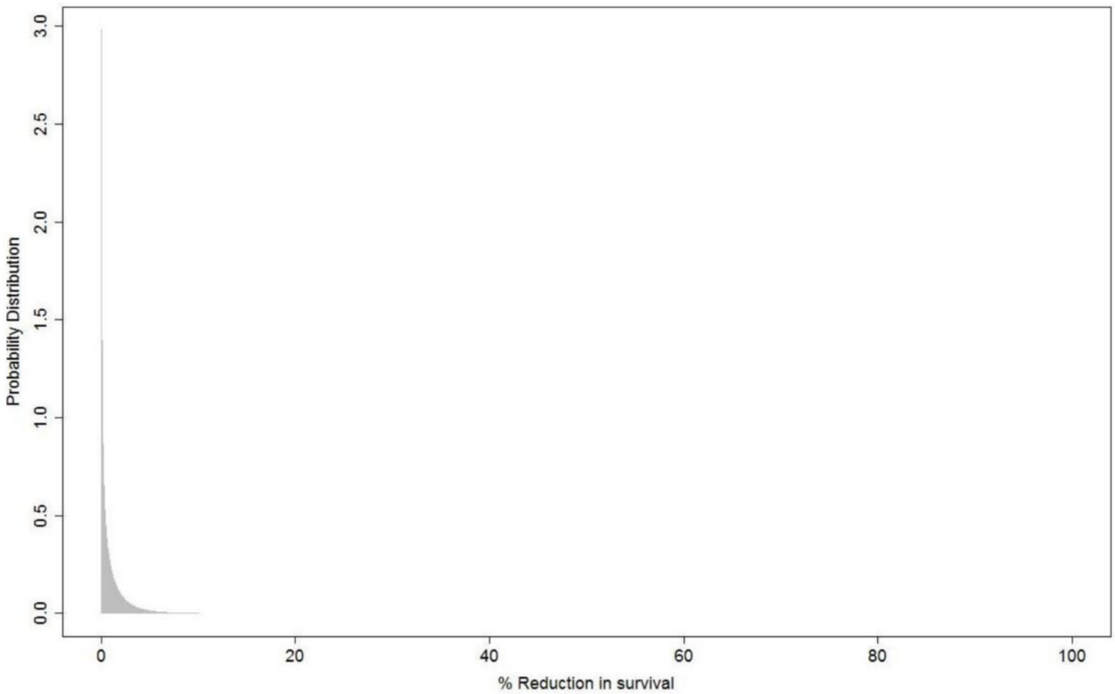


Figure 7.9 Probability distribution showing the consensus distribution for the effects on survival of a mature female harbour porpoise as a consequence of a maximum 6 dB of PTS within a 2-10 kHz band. Image taken from Booth and Heinis (2018).

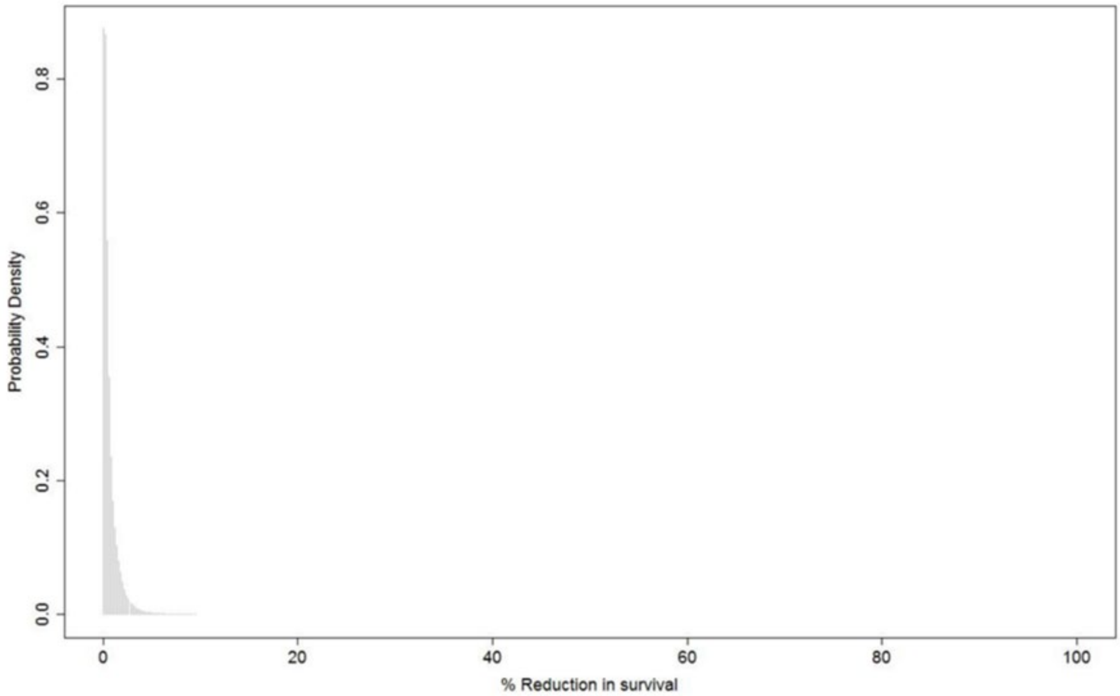


Figure 7.10: Probability distribution showing the consensus distribution for the effects on survival of juvenile or dependent calf harbour porpoise as a consequence of a maximum 6 dB of PTS within a 2-10 kHz band. Image taken from Booth and Heinis (2018).

7.11.46 Furthermore, data collected during wind farm 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. 2020). Therefore, the presence of construction-related vessels prior to the start of piling (and before use of any ADDs or bubble curtains) can act as a local scale deterrent for harbour porpoise and therefore reduce the effect significance 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.

7.11.47 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, all cetaceans have been assessed as having a **Low** sensitivity to PTS.

MAGNITUDE

7.11.48 Table 7.20 presents the PTS-onset impact area, impact range and number of harbour porpoise within the PTS-onset impact area using the maximum hammer energy. The instantaneous PTS-onset impact ranges are low, with a maximum of 0.74 km at the S-SW monopile location, which equates to 3 harbour porpoise experiencing PTS-onset. This represents 0.001% of the MU population.

7.11.49 For the onset of cumulative PTS, the maximum predicted impact is for N-NE monopile location, where impact ranges reach 7.3 km. Due to the density of 1.82 harbour porpoise/km^2 estimate at VE from the sites-specific surveys, this equates to 237 harbour porpoise and 0.07% of the MU population.

7.11.50 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. In addition, the sound is modelled as being fully impulsive irrespective of the distance to the pile which is highly precautionary and results in predictions that are unlikely to be realised (e.g., it is unlikely that the sound will be fully impulsive at 7.3 km from the pile). Therefore, PTS-onset is considered to be of **Low (negative)** magnitude.

7.11.51 Although the numbers and percentage of harbour porpoise predicted to be at risk from PTS-onset are low, harbour porpoise are an 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 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. Therefore, the impact of PTS-onset from piling for harbour porpoise continues to be assessed as having a **Negligible (Neutral)** magnitude given embedded mitigation.

SIGNIFICANCE

7.11.52 The magnitude of the impact has been assessed as **negligible** (with the use of a piling MMMP) and the sensitivity of harbour porpoise as **low**. Therefore, the significance of PTS from piling is concluded to be of **negligible** significance, which is **not significant** in terms of the EIA Regulations.

7.11.53 However, as there is a risk of PTS-onset to EPS, this needs to be considered in the MMMP (which will be secured in the dML), a Marine License will be required and an EPS licence may be required.

HARBOUR SEAL

SENSITIVITY TO PTS FROM PILING

7.11.54 The predicted decline in harbour and grey seals vital rates from the impact of a 6 dB PTS in the 2-10 kHz band for different percentiles of the elicited probability distribution are provided in Table 7.22. The data provided in Table 7.22 should be interpreted as:

- Experts estimated that the median decline in an individual mature female seal's survival was 0.39% (due to a 6 dB PTS (a notch a few kHz wide and 6 dB high) occurring somewhere in the hearing between 2-10 kHz) (Figure 7.12).
- Experts estimated that the median decline in an individual mature female seal's fertility was 0.27% (due to a 6 dB PTS (a notch a few kHz wide and 6 dB high) occurring somewhere in the hearing between 2-10 kHz) (Figure 7.13).
- Experts estimated that the median decline in an individual seal pup/juvenile survival was 0.52% (due to a 6 dB PTS (a notch a few kHz wide and 6 dB high) occurring somewhere in the hearing between 2-10 kHz) (Figure 7.14).

7.11.55 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 harbour and grey seals have been assessed as having a **Low** sensitivity to PTS.

Table 7.22: 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	0.00	0.04	0.15	0.32	0.52	0.8	1.21	1.88	3.00

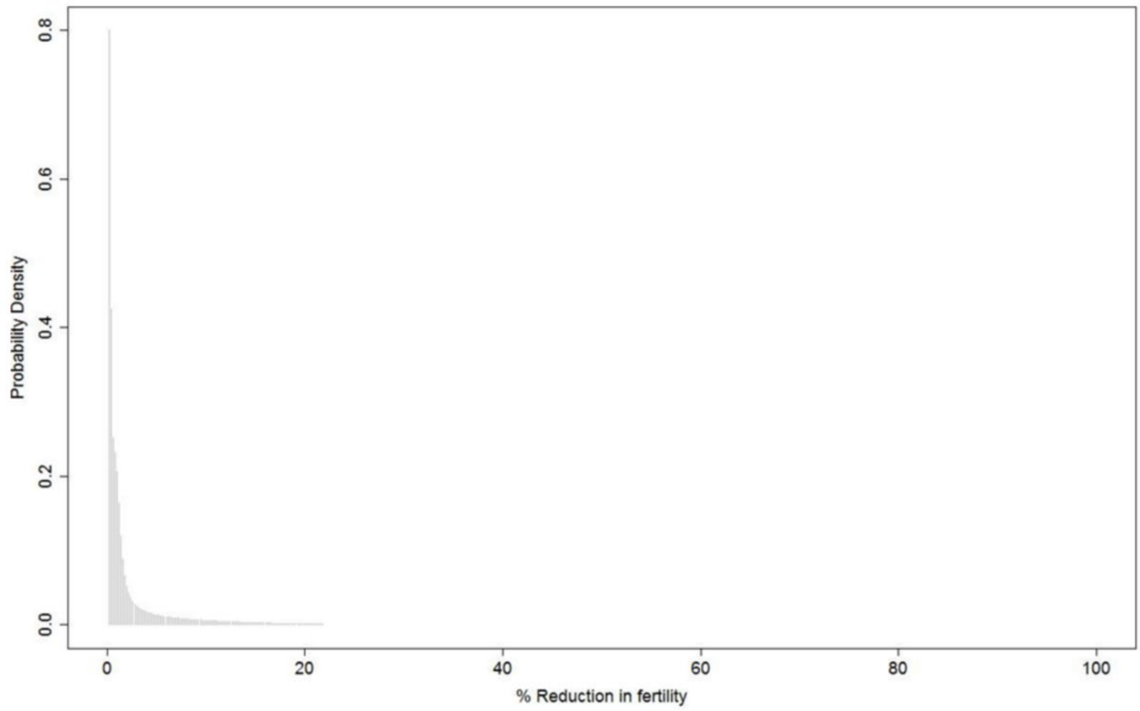


Figure 7.11: Probability distribution showing the consensus distribution for the effects on fertility of a mature female (harbour or grey) seal as a consequence of a maximum 6 dB of PTS within a 2-10 kHz band. Image taken from Booth and Heinis (2018).

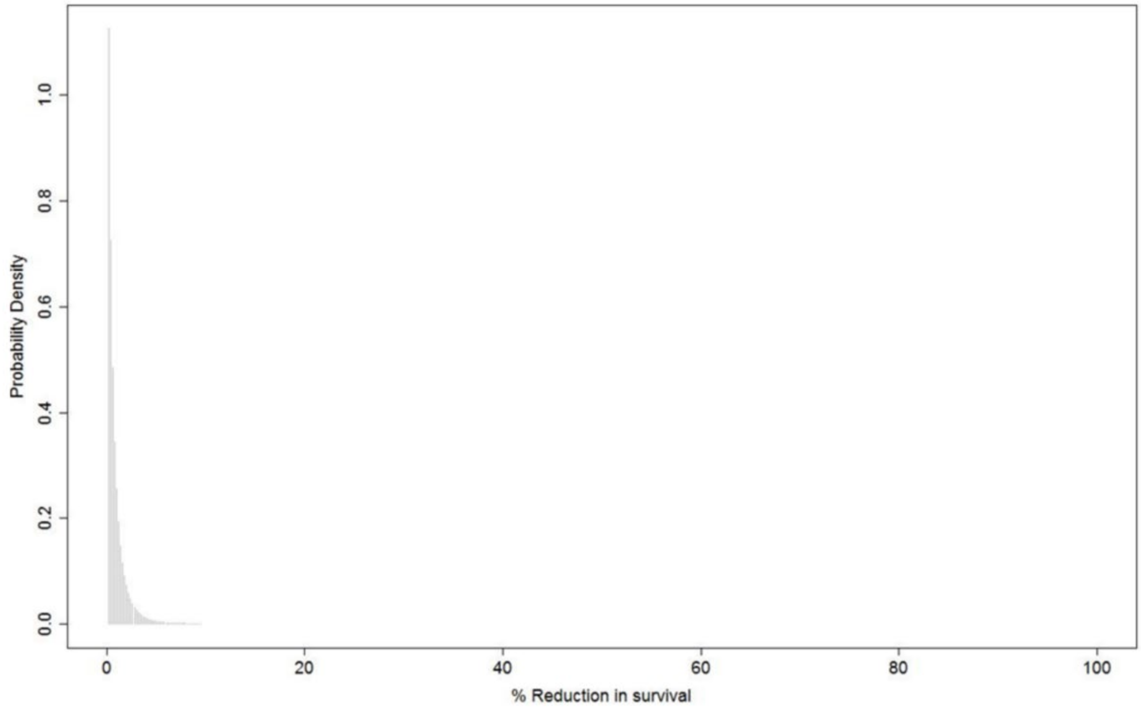


Figure 7.12: Probability distribution showing the consensus distribution for the effects on survival of a mature female (harbour or grey) seal as a consequence of maximum 6 dB of PTS within a 2-10 kHz band. Image taken from Booth and Heinis (2018).

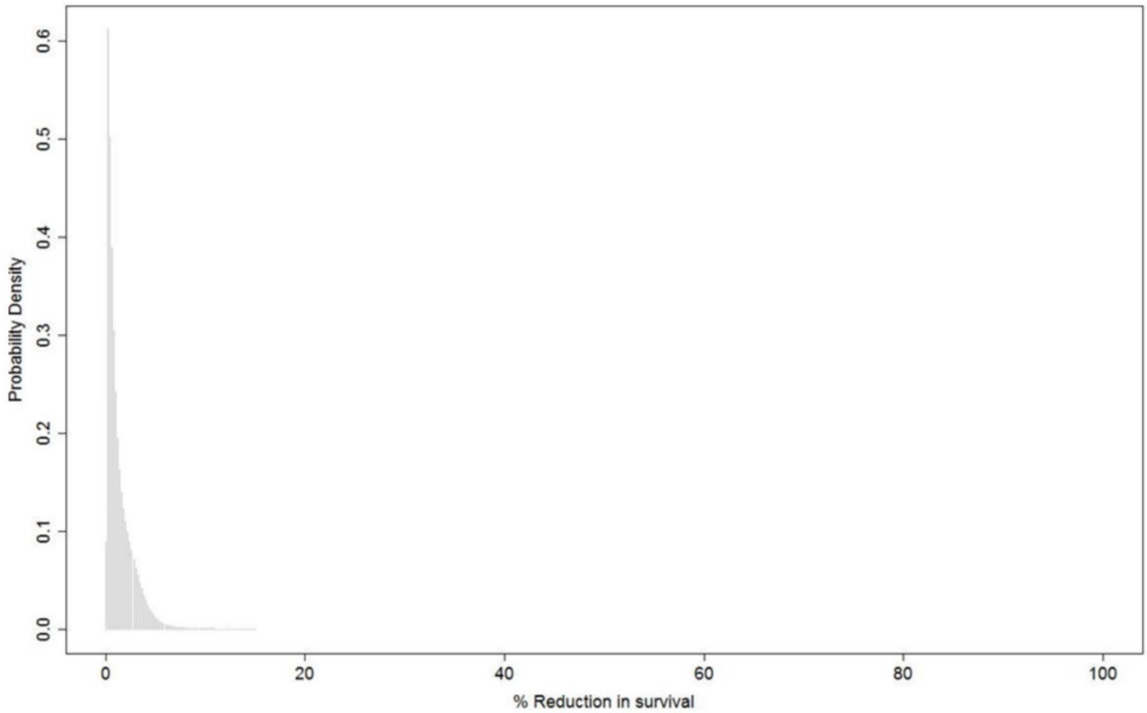


Figure 7.13: Probability distribution showing the consensus distribution for the effects on survival of juvenile or dependent pup (harbour or grey) seal as a consequence of a maximum 6 dB of PTS within a 2-10 kHz band. Image taken from Booth and Heinis (2018).

MAGNITUDE

7.11.56 Table 7.20 presents the PTS-onset impact area, impact range and number of harbour seals within the PTS-onset impact area.

7.11.57 The instantaneous PTS-onset impact ranges are negligible, with a maximum impact range of 0.06 km at all monopile locations, which equates to <1 harbour seal experiencing PTS-onset. This represents <0.02% of the MU population.

7.11.58 For the onset of cumulative PTS, the maximum predicted impact range is <0.01 km at all monopile and pin pile location. This equates to <1 harbour seal in each scenario and represents <0.002% of the MU population.

7.11.59 Due to the low number and percentage of harbour seals predicted to be impacted, alongside the small impact ranges, the magnitude of PTS-onset has been assessed as **Negligible (Neutral)**. The addition of mitigation through the implementation of a piling MMMP will ensure the effect significance of PTS remain negligible.

SIGNIFICANCE

7.11.60 The magnitude of the impact has been assessed as **negligible** and the sensitivity of harbour seals as **low**. Therefore, the significance of PTS from piling is concluded to be of **negligible** significance, which is **not significant** in terms of the EIA Regulations.

GREY SEAL

SENSITIVITY TO PTS FROM PILING

7.11.61 The sensitivity of grey seals to PTS form piling is considered to be the same as for harbour seals: **Low**. This is due to the evidence suggesting that PTS from piling will not cause a significant impact on either survival or reproductive rates (see Paragraph 7.11.55 for additional details).

MAGNITUDE

7.11.62 Table 7.20 presents the PTS-onset impact area, impact range and number of grey seals within the PTS-onset impact area.

7.11.63 The instantaneous PTS-onset impact ranges are negligible, with a maximum impact range of 0.06 km at all monopile locations, which equates to <1 grey seal experiencing PTS-onset. This represents <0.02% of the MU population.

7.11.64 For the onset of cumulative PTS, the maximum predicted impact range is <0.1 km at all monopile and pin pile location. This equates to <1 harbour seal in each scenario and represents <0.002% of the MU population.

7.11.65 Due to the low number and percentage of harbour seals predicted to be impacted, alongside the small impact ranges, the magnitude of PTS-onset has been assessed as **Negligible (Negative)**. The addition of embedded mitigation through the implementation of a piling MMMP will ensure the risk of PTS remain negligible.

SIGNIFICANCE

7.11.66 The magnitude of the impact has been assessed as **negligible** and the sensitivity of grey seals as **low**. Therefore, the significance of PTS from piling is concluded to be of **negligible** significance, which is **not significant** in terms of the EIA regulations 2017.

IMPACT 4: TTS FROM PILING

7.11.67 Full details of the underwater noise modelling and the resulting TTS-onset impact areas and ranges are detailed in Volume 4, Annex 6.2: Subsea Noise Technical Report. As previously outlined (see paragraphs 7.7.40 - 7.7.48), 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 & Marine Ecology Expert Topic Group (21st September 2020) and aligns with the advice provided in Natural England (2022).

7.11.68 The following section provides the quantitative presentation of the impact of TTS from pile driving on marine mammal species (Table 7.23).

7.11.69 Using instantaneous TTS-onset thresholds (SPL_{peak}), the maximum impact range for harbour porpoise was calculated at 1.8 km for all three monopile locations. This equated to a maximum of 18 harbour porpoise at both the North Array North East corner (N-NE) and North Array North edge (N-N) locations and 0.005% of the MU population. For harbour seals, the maximum impact range was 0.16 km at the N-N monopile and pin pile locations. This equated to <1 harbour seal and <0.02% of the MU population (also applicable to all other monopile and pin pile locations). For grey seals, the maximum impact range was 0.16 km at the N-N monopile location. This equated to <1 grey seal and <0.002% of the MU population (also applicable to all other monopile and pin pile locations).

7.11.70 Using the cumulative TTS-onset thresholds (SEL_{cum}) the maximum impact range for harbour porpoise was calculated at 30 km for all three monopile locations. This equated to a maximum of 3,640 harbour porpoise (at the N-NE monopile location) and 1.05% of the MU population. For harbour seals, the maximum impact range was 14 km at the N-NE and N-N monopile locations. This still equated to <1 harbour seal and <0.02% of the MU population (also applicable to all other monopile and pin pile locations). For grey seals, the maximum impact range was also 14 km at the N-NE and N-N monopile locations. This equated to a maximum of 21 grey seals and <0.033% of the MU population at the N-N monopile location.

Table 7.23: Impact area, maximum range, number of harbour porpoise, harbour seal and grey seal and percentage of MU predicted to experience TTS-onset from piling.

	Pile type	Monopile (7,000 kJ)			Pin pile (3,000 kJ)		
Species	**Location**	**S-SW**	**N-NE**	**N-N**	**S-SW**	**N-NE**	**N-N**
Instantaneous TTS (SPL_{peak})							
Harbour porpoise	Area (km^2)	9.4	9.9	10	6.1	6.4	6.6
	Max range (km)	1.8	1.8	1.8	1.4	1.4	1.5
	# porpoise	17	18	18	11	12	12
	% MU	0.005%	0.005%	0.005%	0.003%	0.003%	0.003%
Harbour & Grey Seals	Area (km^2)	0.07	0.07	0.07	0.04	0.04	0.07
	Max range (km)	0.15	0.15	0.16	0.12	0.12	0.16
	# harbour seals	<1	<1	<1	<1	<1	<1
	% MU	<0.02%	<0.02%	<0.02%	<0.02%	<0.02%	<0.02%
	# grey seals	<1	<1	<1	<1	<1	<1
	% MU	<0.002%	<0.002%	<0.002%	<0.002%	<0.002%	<0.002%
Cumulative TTS (SEL_{cum})							
Harbour porpoise	Area (km^2)	1700	2000	1900	1400	1600	1600
	Max range (km)	30	30	30	26	27	27
	# porpoise	3,094	3,640	3,458	2,548	2,912	2,912
	% MU	0.89%	1.05%	1.00%	0.74%	0.84%	0.84%

	Pile type	Monopile (7,000 kJ)			Pin pile (3,000 kJ)		
Harbour & Grey Seals	Area (km^2)	370	460	450	290	370	360
	Max range (km)	13	14	14	12	12	12
	# harbour seals	<1	<1	<1	<1	<1	<1
	% MU	<0.02%	<0.02%	<0.02%	<0.02%	<0.02%	<0.02%
	# grey seals	15	17	21	12	13	17
	% MU	0.024%	0.027%	0.033%	0.019%	0.020%	0.027%

IMPACT 5: DISTURBANCE FROM PILING

7.11.71 The following section provides the quantitative assessment of disturbance from pile driving on marine mammal species using the Graham *et al*. (2017) dose-response function for harbour porpoise and the dose-response function based on the data presented in Whyte *et al*. (2020) for both seal species (Table 7.24).

Table 7.24: Number of marine mammals and percentage of the MU predicted to experience potential behavioural disturbance from piling.

	Pile type	Monopile (7,000 kJ)					Pin pile (3,000 kJ)				
Species	**Modelling location**	**S-SW**	**N-NE**	**N-N**	**S-SW & N-NE**	**S-SW & N-N**	**S-SW**	**N-NE**	**N-N**	**S-SW & N-NE**	**S-SW & N-N**
Harbour porpoise	# porpoise	5,987	7,031	6,906	9,498	9,370	5,164	6,057	5,965	8,333	8,229
	% MU	1.73%	2.03%	1.99%	2.74%	2.70%	1.49%	1.75%	1.72%	2.40%	2.37%
Harbour seal	# seals (mean & 95% CI)	2 <1-3	1 <1-2	1 <1-3	2 <1-4	3 <1-5	1 <1-2	1 <1-1	1 <1-2	1 <1-3	2 <1-3
	% MU (mean & 95% CI)	0.03% 0.002-0.06	0.02% 0.001-0.03	0.02% 0.002-0.05	0.04% 0.003-0.08	0.05% 0.004-0.10	0.02% 0.001-0.04	0.01 0.001-0.02	0.02% 0.001-0.03	0.03% 0.002-0.05	0.03% 0.002-0.06
Grey seal	# seals (mean & 95% CI)	89 10-169	101 10-193	112 12-212	158 17-297	168 19-315	70 7-133	79 8-151	89 9-168	127 13-237	134 14-253
	% MU (mean & 95% CI)	0.14% 0.02-0.27	0.16% 0.02-0.30	0.18% 0.02-0.33	0.25% 0.03-0.47	0.26% 0.03-0.50	0.11% 0.01-0.21	0.12% 0.01-0.24	0.14% 0.01-0.27	0.20% 0.02-0.37	0.21% 0.02-0.40

HABOUR PORPOISE

SENSITIVITY

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

7.11.73 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). However, Hoekendijk *et al*. (2018) point out that this could be an extreme short-term response to capture in nets, and may not reflect natural harbour porpoise behaviour. Nevertheless, if the foraging efficiency of harbour porpoise is disturbed or if they are displaced from a high-quality foraging ground, and are unable to find suitable alternative feeding grounds, they could potentially be at risk of changes to their overall fitness if they are not able to compensate and obtain sufficient food intake in order to meet their metabolic demands.

7.11.74 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.

7.11.75 Monitoring of harbour porpoise activity at the Beatrice Offshore Wind Farm 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 7 km early in the construction period (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 1.3 km. In addition, the study indicated that porpoise activity recovered between pile driving events.

7.11.76 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 420-690 m (SEL 135-147 dB re 1 $\mu Pa^2 s$), one individual showed rapid and directed movements away from the source. Two individuals displayed shorter and shallower dives immediately after exposure and the remaining two animals did not show any quantifiable response. Therefore, there is expected to be a high level of variability in responses from individual harbour porpoises exposed to low frequency broadband pulsed noise (including both airguns and pile driving).

7.11.77 At an expert elicitation workshop held in Amsterdam in June 2018, experts in marine mammal physiology, behaviour and energetics discussed the nature, extent and potential consequences of disturbance to harbour porpoise from exposure to low frequency broadband pulsed noise (e.g. pile-driving, airgun pulses) (Booth et al. 2019). Experts were asked to estimate the potential consequences of a six-hour period of zero energy intake, assuming that disturbance from a pile driving event resulted in missed foraging opportunities for this duration. A Dynamic Energy Budget model for harbour porpoise (based on the Dynamic Energy Budget (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.

7.11.78 The experts agreed that first year calf survival (post-weaning) and fertility were the most likely vital rates to be affected by disturbance, but that juvenile and adult survival were unlikely to be significantly affected as these life-stages were considered to be more robust. Experts agreed that the final third of the year was the most critical for harbour porpoises as they reach the end of the current lactation period and the start of new pregnancies, therefore it was thought that significant impacts on fertility would only occur when animals received repeated exposure throughout the whole year. Experts agreed it would likely take high levels of repeated disturbance to an individual before there was any effect on that individual's fertility (Figure 7.14 left), and that it was very unlikely an animal would terminate a pregnancy early. The experts agreed that calf survival could be reduced by only a few days of repeated disturbance to a mother/calf pair during early lactation (Figure 7.14 right); however, it is highly unlikely that the same mother-calf pair would repeatedly return to the area in order to receive these levels of repeated disturbance.

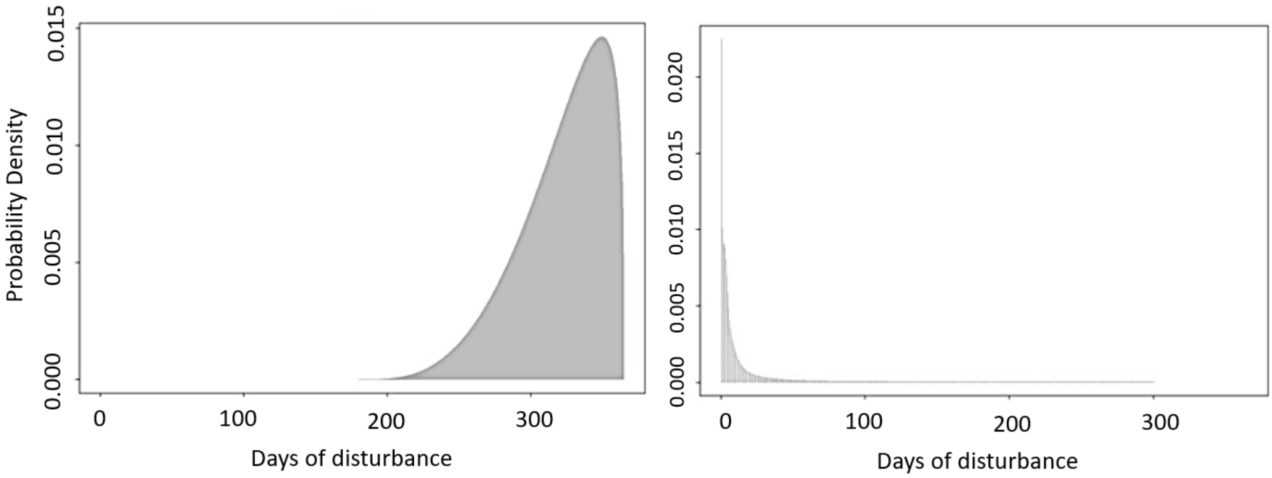


Figure 7.14: Probability distributions showing the consensus of the expert elicitation for harbour porpoise disturbance from piling (Booth *et al.*, 2019). Left: the number of days of disturbance (i.e. days on which an animal does not feed for six hours) a pregnant female could 'tolerate' before it has any effect on fertility. Right: the number of days of disturbance a mother/ calf pair could 'tolerate' before it has any effect on survival.

7.11.79 A recent study by Benhemma-Le Gall *et al*. (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 (2 km) 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 increasing foraging activities beyond the impact range (Figure 7.15). Therefore, porpoise that experience displacement are expected to be able to compensate for the lost foraging opportunities and increased energy expenditure of fleeing.

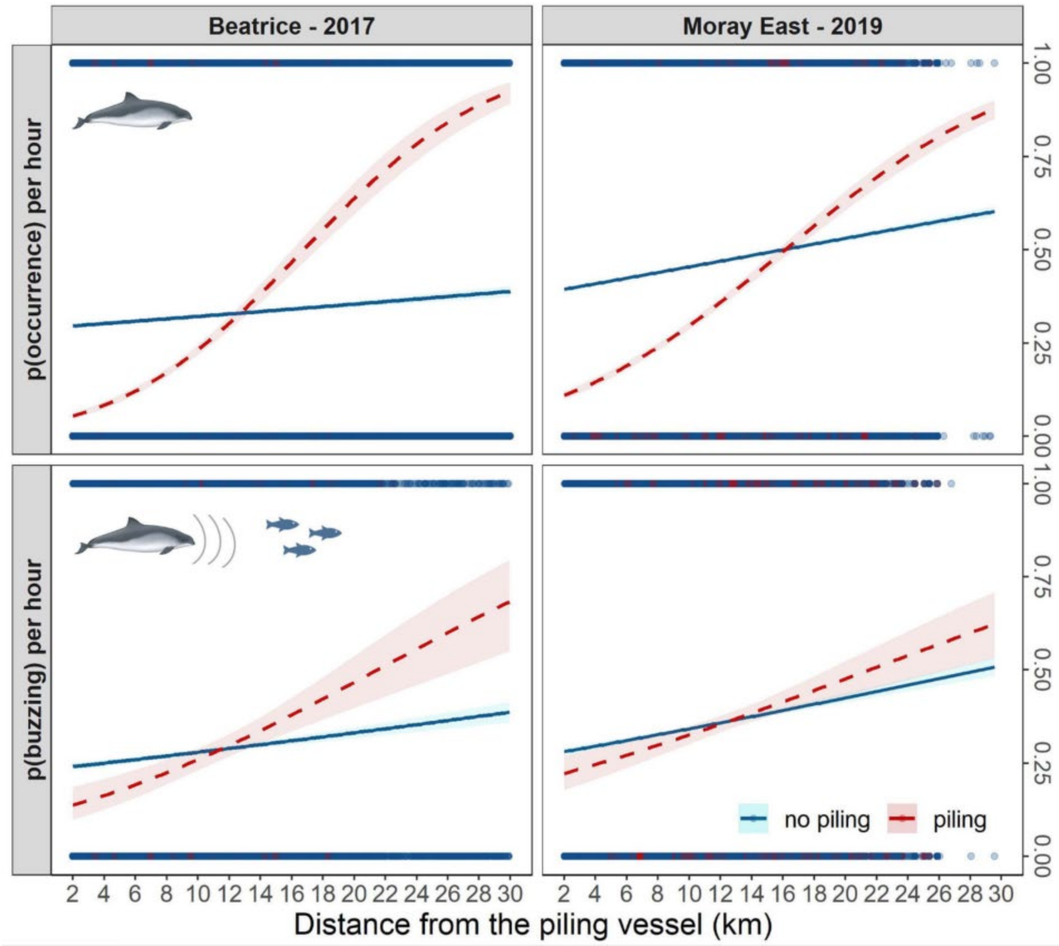


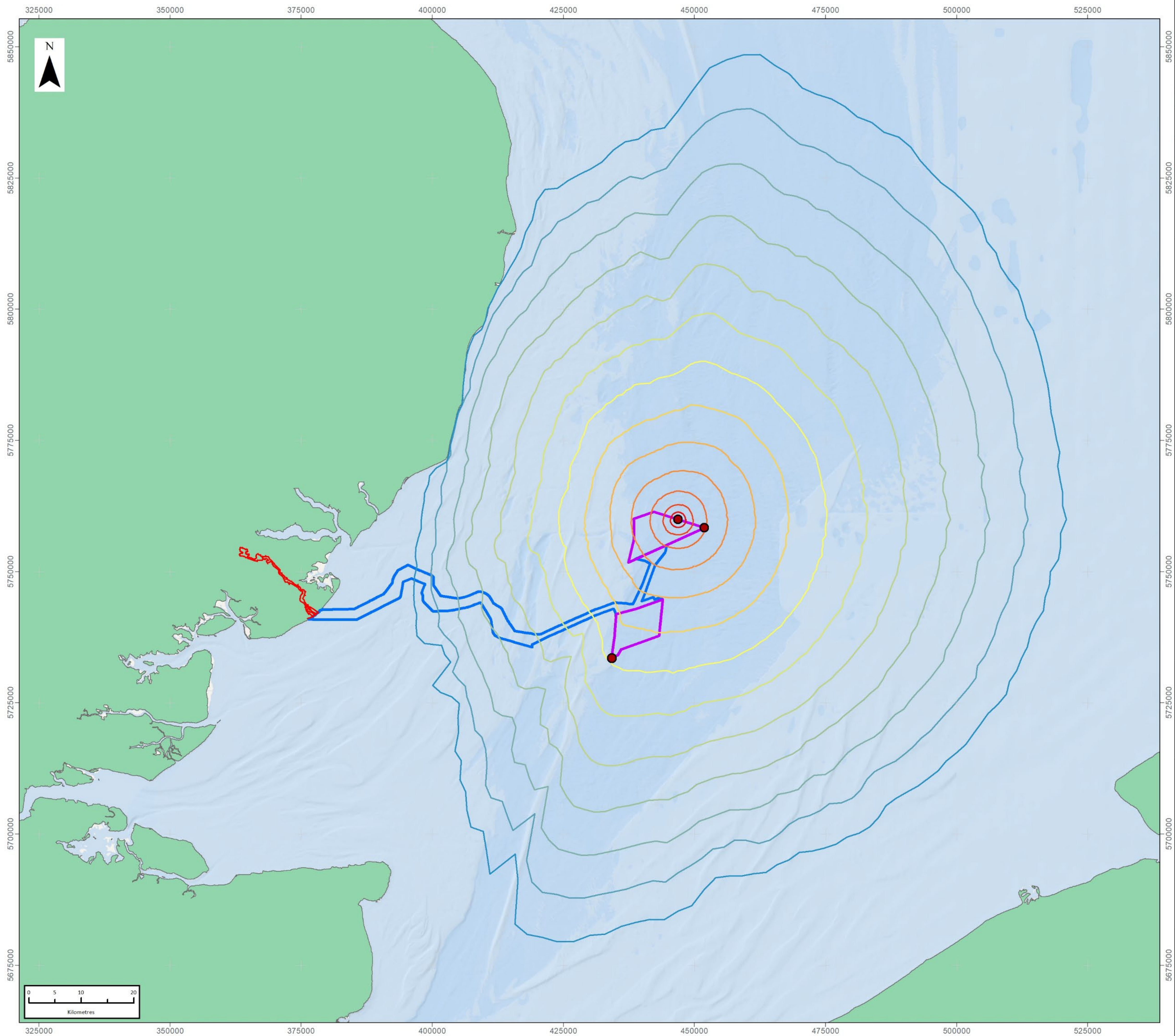
Figure 7.15: The probability of harbour porpoise occurrence and buzzing activity per hour during (dashed red line) and out with (blue line) pile-driving hours, in relation to distance from the pile-driving vessel at Beatrice (left) and Moray East (right). Obtained from Benhemma-Le Gall *et al.* (2021).

7.11.80 Due to observed responsiveness to piling, their income breeder life history, and the low numbers of days of disturbance expected to effect calf survival, harbour porpoises have been assessed here as having a **Low** sensitivity to disturbance and resulting displacement from foraging grounds.

MAGNITUDE

7.11.81 The results of disturbance to harbour porpoise from pile driving are presented in Table 7.24. From a single piling event, the maximum disturbance is predicted to occur at the N-NE monopile location, disturbing 7,031 harbour porpoise which is equivalent to 2.03% of the MU population.

7.11.82 During concurrent piling, the maximum disturbance is predicted to occur during piling at the S-SW and N-NE monopile locations. This is predicted to disturb 9,498 harbour porpoise, equivalent to 2.74% of the MU population.



LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Red Line Boundary
- Noise modelling locations

Noise contours, dB:

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

Data Source:
Basemap: Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

Harbour porpoise behavioural disturbance ontours from worst case scenario

VER	DATE	REMARKS	Drawn	Checked
1	20/02/2023	For Issue	SWM	N/A

DRAWING NUMBER:

7.2

SCALE:	PLOT SIZE:	DATUM:	PROJECTION:
1:750,000	A3	WGS84	UTM31N

FIVE ESTUARIES
OFFSHORE WIND FARM

Z:\GIS\GIS_Projects\0144 Five Estuaries\GIS\Figures\PEIR\Mammals\VE_Mammals_PEIR_Fig2_Noise_HP.mxd

7.11.83 Given the results of the expert elicitation on the likely effects of behavioural disturbance on harbour porpoise vital rates (Booth et al. 2019), 81 days of piling is unlikely to cause any effect on fertility rates, although there is the potential for calf survival to be affected. 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 over this many days. Any potential impact on calf survival rates is likely to be temporary and is not expected to result in any changes in the population trajectory or overall size. The impact is predicted to be of local spatial extent, short term duration, intermittent and is reversible. Given the number of porpoise predicted to be impacted and the proportion of the population this represents, this is considered to be a **Low (Negative)** magnitude.

SIGNIFICANCE

7.11.84 The magnitude of the impact has been assessed as **low** and the sensitivity of harbour porpoise as **low**. Therefore, the significance of disturbance from piling is concluded to be of **minor** significance, which is **not significant** in terms of the EIA Regulations.

HABOUR SEAL

SENSITIVITY

7.11.85 A study of tagged harbour seals in the Wash has shown that they are displaced from the vicinity of piles during impact piling activities. Russell *et al*. (2016a) showed that seal abundance was significantly reduced within an area with a radius of 25 km from 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.

7.11.86 At an expert elicitation workshop to address issues of seal responses to disturbance from low-frequency impulsive noise (Booth et al. 2019), experts considered the most likely potential consequences of a six hour period of zero energy intake, assuming that disturbance (from exposure to low frequency broadband pulsed noise (e.g., impact piling, airgun pulses) resulted in missed foraging opportunities. In general, it was agreed that harbour seals were considered to have a reasonable ability to compensate for lost foraging opportunities due to their generalist diet, mobility, life history and adequate fat stores. The survival of 'weaned of the year' animals and fertility were determined to be the most sensitive life history parameters to disturbance (i.e., leading to reduced energy intake). Juvenile harbour seals are typically considered to be coastal foragers (Booth *et al*. 2019) and so less likely to be exposed to disturbances and similarly pups were thought to be unlikely to be exposed to disturbance due to their proximity to land. Unlike for harbour porpoise, there was no DEB model available to simulate the effects of disturbance on seal energy intake and reserves, therefore, the opinions of the experts were less certain. Experts considered that the location of the disturbance would influence the effect of the disturbance, with a greater effect if animals were disturbed at a foraging ground as opposed to when animals were transiting through an area. It was thought that for an animal in bad condition, moderate levels of repeated disturbance might be sufficient to reduce fertility (Figure 7.16 left); however, there was a large amount of uncertainty in this estimate. The 'weaned of the year' were considered to be most vulnerable following the post-weaning fast, and that during this time, experts felt it might take ~60 days of repeated disturbance before there was expected to be any effect on the probability of survival (Figure 7.16 right); however, again, there was a lot of uncertainty surrounding this estimate. Similar to above, it is considered unlikely that individual harbour seals would repeatedly return to a site where they had been previously displaced from in order to experience this number of days of repeated disturbance.

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

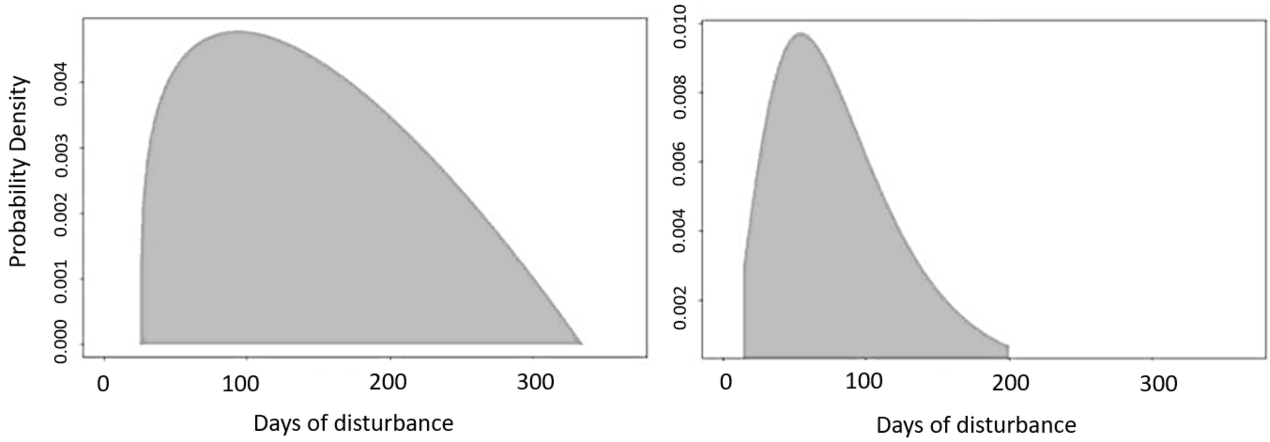
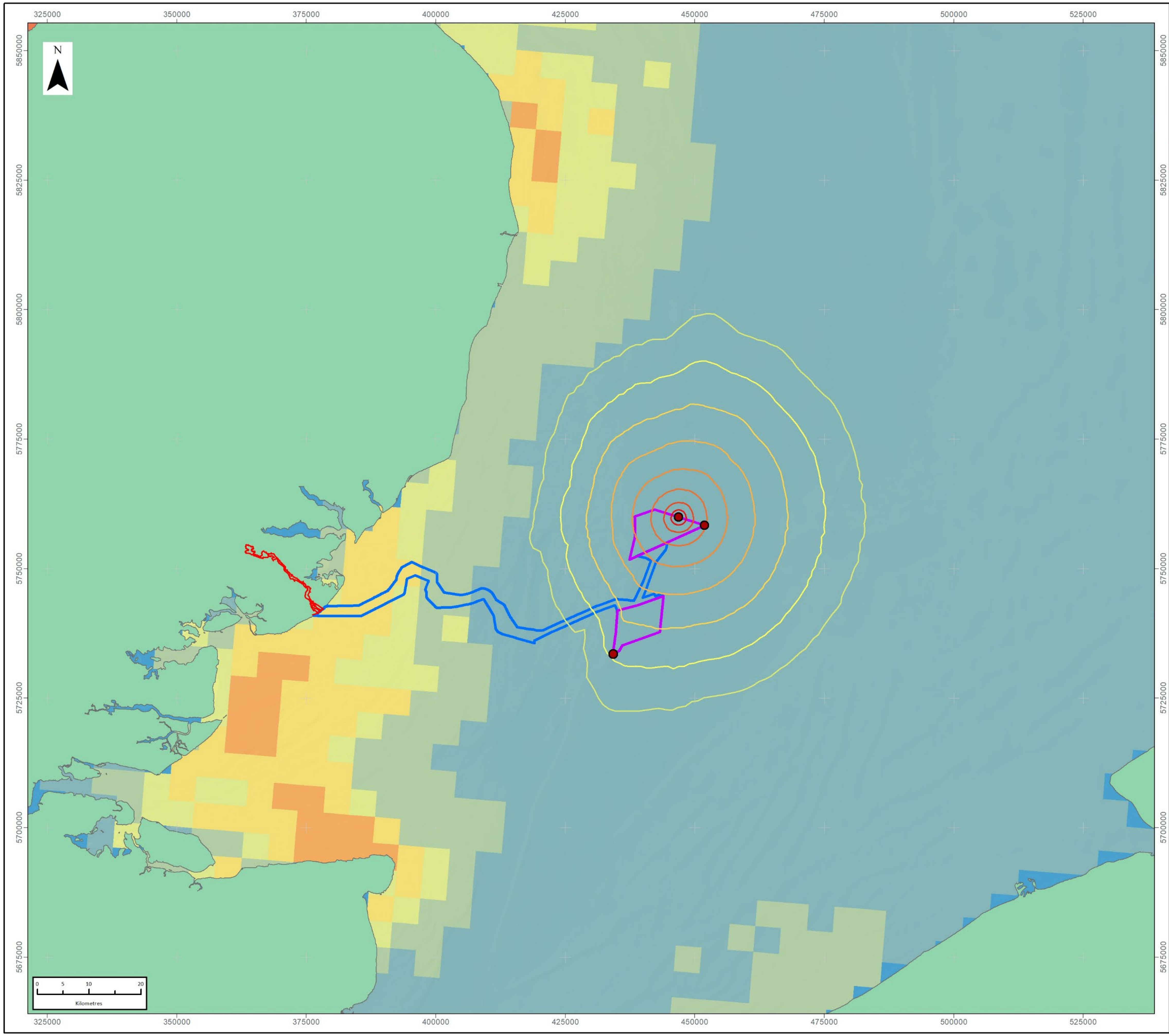


Figure 7.17: Probability distributions showing the consensus of the expert elicitation for harbour seal disturbance from piling. X-axis = days of disturbance; y-axis = probability density. Left: the number of days of disturbance (i.e. days on which an animal does not feed for six hours) a pregnant female could 'tolerate' before it has any effect on fertility. Right: the number of days of disturbance (of six hours zero energy intake) a 'weaned of the year' harbour seal could 'tolerate' before it has any effect on survival. Figures obtained from Booth *et al.* (2019).

MAGNITUDE

7.11.88 The results of disturbance to harbour seals from pile driving are presented in Table 7.24. The 95% confidence intervals are provided for harbour seals as there was a large amount of uncertainty in the results that informed the dose-response function. From a single piling event, the maximum disturbance is predicted to occur at the S-SW monopile location, disturbing 2 harbour seals (95% CI: <1-3) which is equivalent to 0.03% (95% CI: 0.002-0.06%) of the MU population.

7.11.89 During concurrent piling, the maximum disturbance is predicted to occur during piling at the S-SW and N-N monopile locations. This is predicted to disturb 3 harbour seals (95% CI: <1-5), equivalent to 0.05% (95% CI: 0.004-0.10%) of the MU population.



LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Red Line Boundary
- Noise modelling locations

Noise contours, dB:
- 145
- 150
- 155
- 160
- 165
- 170
- 175
- 180

Harbour Seals, at sea population per 25km (Carter 2022):
- 0
- 0 - 0.001
- 0.001 - 0.005
- 0.005 - 0.01
- 0.01 - 0.025
- 0.025 - 0.05
- 0.05 - 0.1
- >0.1

Data Source:
Basemap: Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

Harbour seal behavioural disturbance contours from worst case scenario

VER	DATE	REMARKS	Drawn	Checked
1	20/02/2023	For Issue	SWM	JB

DRAWING NUMBER:

7.4

SCALE:	PLOT SIZE:	DATUM:	PROJECTION:
1:750,000	A3	WGS84	UTM31N

FIVE ESTUARIES
OFFSHORE WIND FARM

Z:\GIS\GIS_Projects\0144 Five Estuaries\GIS\Figures\PEIR\Mammals\VE_Mammals_PEIR_Fig4_Noise_HS.mxd

7.11.90 The impact is predicted to be of local spatial extent, short term duration (up to 81 piling days within a one-year construction window), intermittent and is reversible. Given their ability to store energy, and the fact that they are generalist and adaptable foragers, it is expected that harbour seals would require moderate-high levels of repeated disturbance before there was any effect on fertility rates. Given the low number of harbour seals predicted to be impacted and the proportion of the population this represents, along with the short-term duration of the overall impact, this is considered to be a **Negligible (adverse)** magnitude.

SIGNIFICANCE

7.11.91 The magnitude of the impact has been assessed as **negligible** and the sensitivity of harbour seals as **low**. Therefore, the significance of disturbance from piling is concluded to be of **negligible** significance, which is **not significant** in terms of the EIA Regulations.

GREY SEAL

SENSITIVITY

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

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

7.11.94 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 (Figure 7.17 left). The 'weaned of the year' were considered to be most vulnerable following the post-weaning fast, and that during this time it might take ~60 days of repeated disturbance before there was expected to be any effect on weaned-of-the-year survival (Figure 7.17 right); however, there was a lot of uncertainty surrounding this estimate.

7.11.95 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.

7.11.96 Hastie *et al*. (2021) found that grey seal avoidance rates in response to pile driving sounds were dependent on the quality of the prey patch, with grey seals continuing to feed at high density prey patches when exposed to pile driving sounds but showing reduced feeding 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.

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

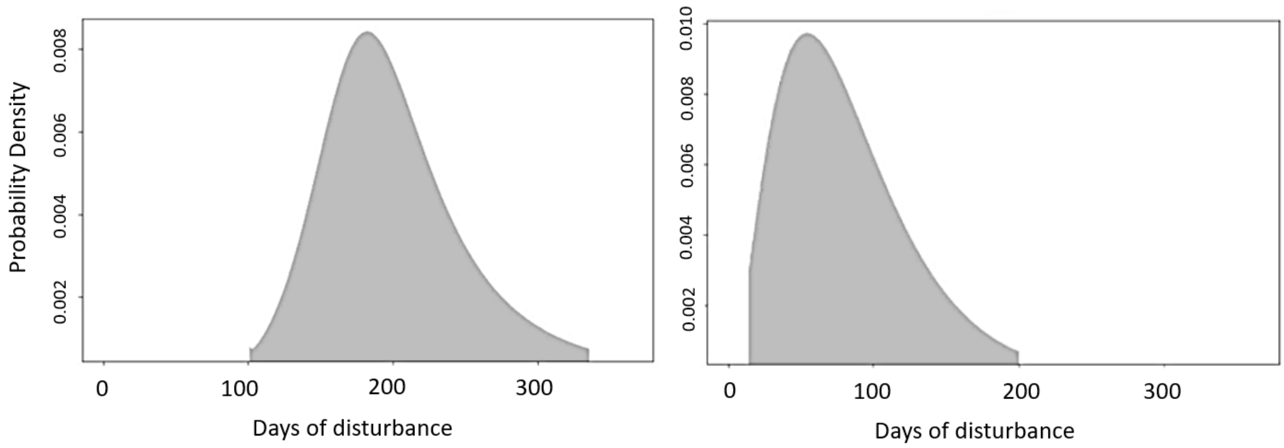
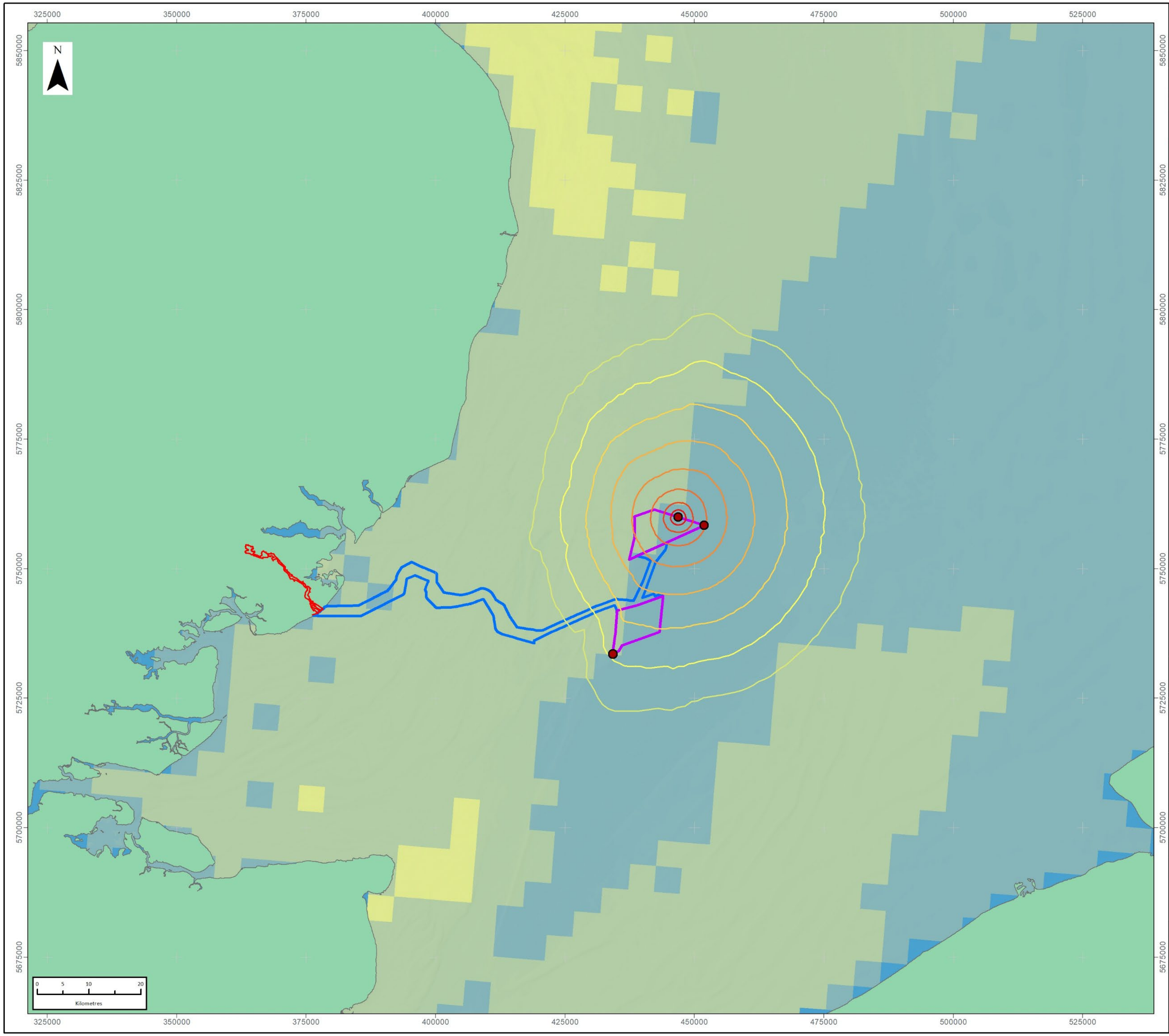


Figure 7.19: Probability distributions showing the consensus of the expert elicitation for grey seal disturbance from piling (Booth *et al*., 2019). Left: the number of days of disturbance (i.e. days on which an animal does not feed for six hours) a pregnant female could 'tolerate' before it has any 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

7.11.98 The results of disturbance to grey seals from pile driving are presented in Table 7.24. The 95% confidence intervals are provided for grey seals as there was a large amount of uncertainty in the results that informed the dose-response function. From a single piling event, the maximum disturbance is predicted to occur at the N-N monopile location, disturbing 112 grey seals (95% CI: 12-212) which is equivalent to 0.18% (95% CI: 0.02-0.33%) of the MU population (Figure 7.20).

7.11.99 During concurrent piling, the maximum disturbance is predicted to occur during piling at the S-SW and N-N monopile locations. This is predicted to disturb 168 grey seals (95% CI: 19-315), equivalent to 0.26% (95% CI: 0.03-0.50%) of the MU population.



LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Red Line Boundary
- Noise modelling locations

Noise contours, dB:

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

Grey Seals, % at-sea population per 25km (Carter 2022):

- 0
- 0 - 0.001
- 0.001 - 0.005
- 0.005 - 0.01
- 0.01 - 0.025
- 0.025 - 0.05
- 0.05 - 0.1
- >0.1

Data Source:
Basemap: Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

Grey seal behavioural disturbance contours from worst case scenario

VER	DATE	REMARKS	Drawn	Checked
1	20/02/2023	For Issue	SWM	JB

DRAWING NUMBER:

7.3

SCALE: 1:750,000	PLOT SIZE: A3	DATUM: WGS84	PROJECTION: UTM31N

FIVE ESTUARIES
OFFSHORE WIND FARM

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7.11.100 The impact is predicted to be of local spatial extent, short term duration (up to 81 piling days within a one-year construction window), intermittent and is reversible. Given their ability to store energy, and the fact that they are generalist and adaptable foragers, it is expected that grey seals would require moderate-high levels of repeated disturbance before there was any effect on fertility rates. Given the low number of grey seals predicted to be impacted and the proportion of the population this represents, along with the short-term duration of the overall impact, this is considered to be a **Negligible (Neutral)** magnitude.

SIGNIFICANCE

7.11.101 The magnitude of the impact has been assessed as **negligible** and the sensitivity of grey seals as **negligible**. Therefore, the significance of disturbance from piling is concluded to be of **negligible** significance, which is **not significant** in terms of the EIA Regulations.

IMPACT 6: PTS FROM OTHER CONSTRUCTION ACTIVITIES

7.11.102 The following section provides the quantitative assessment of the impact of injury (PTS) from other construction activities on marine mammal species (Table 7.25:).

Table 7.25: 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	Suction dredging	Trenching	Rock placement
173 dB (VHF)	< 100 m	< 100 m	< 100 m	< 100 m
201 dB (PCW)	< 100 m	< 100 m	< 100 m	< 100 m

SENSITIVITY

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

7.11.104 **Trenching:** 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 100 Hz – 1 kHz and in general the sound levels were generally only 10-15 dB above background levels (Nedwell et al. 2003). For the marine mammal species considered here, the hearing sensitivity below 1 kHz is relatively poor and thus it is expected that a PTS at these low frequency ranges would result in little impact to vital rates. Therefore, the sensitivity of marine mammals to PTS from trenching is assessed as **Low**.

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

7.11.106 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 <1 kHz. For the marine mammal species considered here, the hearing sensitivity below 1 kHz is relatively poor and thus it is expected that a PTS at these low frequency ranges would result in little impact to vital rates. Therefore, the sensitivity of marine mammals to PTS from these low frequency, continuous noise sources is assessed as **Low**.

MAGNITUDE

7.11.107 Non-piling construction noise sources will have a local spatial extent, and are transient and intermittent, meaning that, with the most precautionary estimates, a marine mammal would have to remain within close proximity (< 100 m). The following section provides the quantitative assessment of the impact of injury (PTS) from other construction activities on marine mammal species (Table 7.25:).

TABLE 7.25:SIGNIFICANCE

7.11.108 The magnitude of the impact has been assessed as **negligible** and the sensitivity of marine mammals (both porpoise and seals) as **low**. Therefore, the significance of PTS other construction activities is concluded to be of **negligible** significance, which is **not significant** in terms of the EIA Regulations.

IMPACT 7: TTS FROM OTHER CONSTRUCTION ACTIVITIES

7.11.109 The TTS-onset impact areas and ranges for other construction activities are detailed in Volume 4, Annex 6.2: Subsea Noise Technical Report. As previously outlined (see Sections 7.7.40 - 7.7.48), 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.

7.11.110 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 7.26). For both seal species, all impact ranges are predicted to be <100 m (Table 7.26).

7.11.111 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 marine mammal would have to remain within close proximity for a 24hour period for TTS-onset to occur, which is extremely unlikely.

Table 7.26 TTS 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	Suction dredging	Trenching	Rock placement
153 dB (VHF)	< 100 m	230 m	< 100 m	990 m
181 dB (PCW)	< 100 m	< 100 m	< 100 m	< 100 m

IMPACT 8: DISTURBANCE FROM OTHER CONSTRUCTION ACTIVITIES

SENSITIVITY

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

7.11.113 Harbour porpoise occurrence decreased at the Beatrice and Moray East offshore wind farms during non-piling construction periods. 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 57 dB (Benhemma-Le Gall et al. 2021) (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 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 (Benhemma-Le Gall et al. 2021). 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 **Low**.

7.11.114 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 offshore 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 2 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 wind farm, individual seals travelled in and out of the Wash which suggests that the motivation to forage offshore and come ashore to haul out could outweigh the deterrence effect of piling. The VE array areas are 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 seals to disturbance from other construction activities is considered to be **Negligible**.

MAGNITUDE

7.11.115 For harbour porpoise, dredging at a source level of 184 dB re 1 μPa at 1 m was found to result in avoidance up to 5 km from the dredging site (Verboom 2014). Conversely, Diederichs *et al*. (2010) found much more localised impacts; using Passive Acoustic Monitoring there was short term avoidance (~3 hours) at distances of up to 600 m from the dredging vessel, but no significant long-term impacts. Modelling potential impacts of dredging using a case study of the Maasvlatke port expansion (assuming maximum source levels of 192 dB re 1 μPa) predicted a disturbance range of 400 m, while a more conservative approach predicted avoidance of harbour porpoise up to 5 km (McQueen et al. 2020). For pinnipeds, based on the generic threshold of behavioural avoidance (140 dB re 1 μPa SPL) from Southall *et al*. (2007), acoustic modelling of dredging demonstrated that disturbance could be caused to individuals between 400 m to 5 km from site (McQueen et al. 2020).

7.11.116 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) (though it is important to note that response is likely to be highly site and context dependent and therefore disturbance ranges measured at one site may not be applicable to others).

7.11.117 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 5 km). The indicative offshore construction period is expected to start in 2027 with:

- offshore export cable installation lasting up to 6 months,
- foundation installation lasting up to 12 months,
- array cable installation lasting up to 12 months, and
- wind turbine installation lasting up to 9 months.

7.11.118 Given that there will be overlap in these activities, it is expected that offshore construction related work will occur within a 27-month period. Therefore, the duration of disturbance will be limited to two breeding cycles. This aligns with the definition of **Low (negative)** magnitude.

SIGNIFICANCE

7.11.119 The magnitude of the impact has been assessed as **low** (for all marine mammals) and the sensitivity as **negligible** (seals) to **low** (porpoise). Therefore, the significance of disturbance from other construction activities is concluded to be of **negligible** significance, which is **not significant** in terms of the EIA Regulations.

IMPACT 9: COLLISION RISK FROM CONSTRUCTION VESSELS

7.11.120 The area surrounding VE already experiences high levels of vessel traffic (see Volume 2, Chapter 9: Shipping and Navigation for full details). The maximum design scenario (Table 7.13) states there will be a maximum of 101 construction vessels with an indicative peak number of vessels on site simultaneously as 35. The introduction of additional vessels during construction of VE is not a novel impact for marine mammals present in the area.

7.11.121 During construction of the wind farm, 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.

7.11.122 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[15], 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.

7.11.123 Harbour porpoises 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. 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 best practice vessel handing protocols (e.g. following the Codes of Conduct provided by the WiSe Scheme[16], Scottish Marine Wildlife Watching Code[17] or Guide to Best Practice for Watching Marine Wildlife[18]) as appropriate and possible during construction will minimise the potential for any impact. Therefore, the risk of vessel collisions occurring is of **negligible** magnitude. 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. In addition, the region has high vessel densities associated with numerous ports in the Outer Thames.

7.11.124 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 serious consequences of a strike, marine mammal receptors are considered to have a **high** sensitivity to vessel collisions.

7.11.125 The magnitude of the impact has been assessed as **negligible** and the sensitivity of receptors as **high**. Therefore, the significance of the effect of collisions from vessels is concluded to be of **minor (adverse) significance**, which is not significant in terms of the EIA regulations 2017.

[15] CSIP (2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018)
[16] https://www.wisescheme.org/
[17] https://www.nature.scot/scottish-marine-wildlife-watching-code-smwwc-part-1
[18] https://www.nature.scot/guide-best-practice-watching-marine-wildlife-smwwc-part-2

IMPACT 10: DISTURBANCE FROM CONSTRUCTION VESSELS

7.11.126 As stated above, the area surrounding VE already experiences high levels of vessel traffic (see Volume 2, Chapter 9: Shipping and Navigation for full details). The maximum design scenario (Table 7.13) states there will be a maximum of 101 construction vessels with an indicative peak number of vessels on site simultaneously as 35. introduction of additional vessels during construction of VE is not a novel impact for marine mammals present in the area.

7.11.127 Vessel noise levels from construction vessels will result in an increase in non-impulsive, continuous sound in the vicinity of the VE array areas, typically in the range of 10 – 100 Hz (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 @ 1 m (RMS). It is anticipated there will be maximum of 101 construction vessels in total, of which 35 may be on site during peak periods. There are very few studies that indicate a critical level of activity in relation to risk of disturbance but an analysis presented in Heinänen and Skov (2015) suggested that harbour porpoise density was significantly lower in areas with vessel transit rates of greater than 80 per day (within a 5 km^2 area). Vessel traffic in the vicinity of VE, even considering the addition of VE construction traffic will still be well below this figure. The adoption of 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 impact is expected to be of **low** (adverse) magnitude.

7.11.128 Harbour porpoise have a high frequency generalised hearing range (275 Hz – 160 kHz) 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.

7.11.129 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 <100 m from a large vessel for a 24-hour period to experience either TTS or PTS (Table 1.48 in Annex 6.2: Subsea Noise Technical Report). These impacts are unrealistic as it is expected that any marine mammal within the injury zone would not remain in the vicinity of the vessel and the construction activity for a 24-hour period. The sensitivity of harbour porpoise to vessel disturbance has, therefore, been assessed as **low**.

7.11.130 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 50 km 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 (~2 kHz) and large (~0.25 kHz) vessels at approximately 400 m. The sensitivity of grey and harbour seals for vessel disturbance has, therefore, been assessed as **negligible**.

7.11.131 The magnitude of the impact has been assessed as **low** (negative) and the sensitivity of receptors as **low** (cetaceans) or **negligible** (grey seals). Therefore, the significance of the effect of disturbance from vessels is concluded to be of **minor** (adverse) significance for cetaceans and **negligible** significance for grey and harbour seals, which is **not significant** in terms of the EIA regulations 2017.

IMPACT 11: CHANGE IN WATER QUALITY FROM CONSTRUCTION ACTIVITIES

7.11.132 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 (see paragraphs 7.11.139 to 7.11.143). Direct impacts include the impairment of visibility and therefore foraging ability which might be expected to reduce foraging success.

7.11.133 During construction of VE, 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.

7.11.134 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 2, Chapter 2: Marine Geology, Oceanography and Physical Processes and Volume 4, Annex 2.2 Physical Processes Results Technical Report found that:

- Within 0 to 50 m will be the zone of highest SSC (tens of hundreds to thousands of mg/l) lasting for the duration of active disturbance plus up to 30 minutes following end of disturbance;
  - More than one hour after the end of active disturbance there is no change to SSC (no measurable ongoing deposition);
- From 500 m to the tidal excursion buffer distance there is low to intermediate SSC increase (tens to low hundreds of mg/l) at the time of active disturbance;
  - One to six hours after end of active disturbance there is decreasing low SSC increase (tens of mg/l); and

- Six to 24 hours after end of active disturbance the SSC decreases gradually through dispersion to background SSC (no measurable local increase)/

7.11.135 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.

7.11.136 Any disturbance to the seabed will be localised and any resultant increase in SSC will be temporary so will be of **negligible** magnitude. Short-term increased turbidity is not anticipated to impact marine mammals which rely primarily on hearing, resulting in **negligible** sensitivity to changes in water quality.

7.11.137 The magnitude of the impact has been assessed as **negligible** and the sensitivity of receptors as **negligible**. Therefore, the significance of the effect of changes in water quality is concluded to be of **negligible** significance, which is **not significant** in terms of the EIA regulations 2017.

IMPACT 12: CHANGE IN FISH ABUNDANCE/DISTRIBUTION FROM CONSTRUCTION ACTIVITIES

7.11.138 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 7.27.

7.11.139 During construction activities, there are no significant effects on fish and shellfish populations from construction activities. The assessment of impacts upon fish and shellfish species is presented in Volume 2, Chapter 6: Fish and Shellfish Ecology.

7.11.140 UXO operations will also be conducted as part of construction. Individual UXO detonations will have the potential to result in mortality, mortal injury, recoverable injury, TTS and disturbance to fish species, depending on the proximity of the individuals to the UXO location and the size of the UXO. Small scale mortality of fish as a result of UXO detonation are frequently recorded (Dahl *et al.,* 2020), with dead fish recorded floating at the surface in the immediate vicinity of the detonation. Recordings of dead fish floating to the surface (made by MMObs) are typically within the vicinity of the detonation (Dahl *et al.,* 2020) and as such, this is expected to be a small-scale impact (see paragraph 6.11.138 of Volume 4, Chapter 6: Fish and Shellfish Ecology for more details).

7.11.141 Fishing pressure will be reduced during construction at VE due to the required safety distances around construction vessels 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 which reduces the impact on all receptors to minor adverse (see section 8.10.30 in Volume 2, Chapter 8: Commercial Fisheries).

Table 7.27: Key prey species of the marine mammal receptors (bold = species present at VE).

	Prey species	Reference
Harbour porpoise	**Whiting**, **sandeel**, **herring**, **haddock**, saithe, pollock, bobtail squid	Pierce *et al*. (2007)
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 (2022)
Grey seal	**Sandeel**, **cod**, **whiting**, **haddock**, ling, **plaice**, sole, flounder, **dab**	SCOS (2022)

7.11.142 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 VE, the magnitude of changes to prey availability to during construction activities 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.

7.11.143 Whilst it is not predicted that there will be any changes to the populations or general distributions of fish species within the vicinity of VE, it possible that small localised changes could occur. However, as marine mammals are generalists, they can switch prey species removing the requirement for additional energy expenditure to hunt a specific species. No impact on survival and reproduction is predicted and therefore the sensitivity of the receptor is considered to be **low**.

7.11.144 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 fish abundance/distribution is concluded to be of **negligible** significance, which is **not significant** in terms of the EIA regulations 2017.

7.12 ENVIRONMENAL ASSESSMENT: OPERATIONAL PHASE

IMPACT 13: OPERATIONAL NOISE

PTS

SENSITIVITY

7.12.1 Operational noise is primarily low frequency (well below 1 kHz) (Thomsen et al. 2006). For both porpoise and seal species, the hearing sensitivity below 1 kHz is relatively poor and thus it is expected that a PTS at this frequency would result in little impact to vital rates. Therefore, the sensitivity of marine mammals to operational noise is assessed as **Negligible**.

MAGNITUDE

7.12.2 PTS-onset impact ranges have been calculated based on the latest data on noise from operational OWFs in Europe and the US (Tougaard et al. 2020). Please see Volume 4, Annex 6.2: Subsea Noise Technical Report for full details.

7.12.3 Table 7.28: shows that a marine mammal would have to remain within close proximity (< 100 m) to an operational turbine for a 24-hour period for PTS-onset to occur, which is unrealistic. Therefore, the magnitude of impact of PTS from operational noise is considered **Negligible (Neutral)**.

Table 7.28: Operational WTG noise PTS and TTS impact ranges.

Southall *et al.* (2019) Weighted SEL$_{cum}$		**Operational WTG**
PTS (impulsive)	173 dB (VHF)	< 100 m
	201 dB (PCW)	< 100 m
TTS (non-impulsive	153 dB (VHF)	< 100 m
	181 dB (PCW)	< 100 m

SIGNIFICANCE

7.12.4 The magnitude of the impact has been assessed as **negligible** and the sensitivity of marine mammals as **negligible**. Therefore, the significance of PTS from operational noise is concluded to be of **negligible** significance, which is **not significant** in terms of the EIA regulations 2017.

DISTURBANCE

SENSITIVITY

7.12.5 As detailed is paragraph 7.12.1, the sensitivity of harbour porpoise and both harbour and grey seals to disturbance from operational noise is assessed as **Negligible**.

MAGNITUDE

7.12.6 A number of studies have reported the presence of marine mammals within wind farm footprints. For example, at the Horns Rev and Nysted offshore wind farms 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 (Lindeboom et al. 2011) also suggest that harbour porpoise may be attracted to increased foraging opportunities within operating offshore wind farms. In addition, recent tagging work by 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 wind farm noise will have negligible barrier effects (Madsen et al. 2006, Teilmann et al. 2006a, Teilmann et al. 2006b, 2010, Brasseur et al. 2012).

7.12.7 These studies were all conducted at wind farms with relatively small sized turbines, and thus there is uncertainty as to how applicable the results are to future larger turbine sizes. Tougaard *et al*, (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 (with sound transmitted into the water via the tower of the structure). 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 10 dB compared to the same size geared turbine) (Stöber and Thomsen 2021).

7.12.8 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. Notwithstanding the above, the modelling undertaken to predict the noise level from larger turbine sizes assumes a linear relationship between turbine size and emitted sound level (see Volume 4, Annex 6:2: Subsea Noise Technical Report). As this does not take into consideration the reduction in sound level associated with direct drive, this is considered to be conservative. VE OWFL 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 wind farms and the conservatism within the modelling, 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

7.12.9 The magnitude of the impact has been assessed as **negligible** and the sensitivity of marine mammals as **negligible**. Therefore, the significance of PTS from operational noise is concluded to be of **negligible** significance, which is **not significant** in terms of the EIA regulations 2017.

IMPACT 9: COLLISION RISK FROM O&M VESSELS

7.12.10 As stated in section 7.11.120, the area surrounding VE already experiences a high amount of vessel traffic (see Volume 2, Chapter 9: Shipping and Navigation). Volume 2, Chapter 1: Offshore Project Description states there will be 25 total vessels and an indicative peak number of 25 vessels on site simultaneously during operation. The introduction of additional vessels during construction of VE is not a novel impact for marine mammals present in the area.

7.12.11 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 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, SOV, 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 VE offshore windfarm (see Table 7.13 for maximum estimated annual round trips). However, it is still highly likely that a proportion of vessels will be stationary or slow moving throughout operations at VE for significant periods of time.

7.12.12 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 best practice vessel handing protocols during O&M will minimise the potential for any impact. Therefore, the risk of vessel collisions occurring is of **Negligible** magnitude.

7.12.13 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 **High** sensitivity to vessel collisions.

7.12.14 The magnitude of the impact has been assessed as **Negligible** and the sensitivity of receptors as **high**. Therefore, the significance of the effect of collisions from O&M vessels is concluded to be of **minor** (adverse) significance, which is **not significant** in terms of the EIA regulations 2017.

IMPACT 10: DISTURBANCE FROM O&M VESSELS

7.12.15 As stated in paragraph 7.11.127, the area surrounding VE already experiences a high amount of vessel traffic (see Volume 2, Chapter 9: Shipping and Navigation for full details). Volume 2, Chapter 1: Offshore Project Description states there will be an indicative peak number of 25 vessels on site simultaneously during operation. The introduction of additional vessels during construction of VE is not a novel impact for marine mammals present in the area.

7.12.16 Vessel noise levels from vessels during operations will result in an increase in non-impulsive, continuous sound in the vicinity of the VE array areas, typically in the range of 10 – 100 Hz (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 @ 1 m (RMS). It is anticipated that numerous different vessel types would be conducting round trips to and from port and the VE array areas, but peak numbers for jack-up vessels would be 3 and SOVs would be 2.

7.12.17 Heinänen and Skov (2015) suggested that harbour porpoise density was significantly lower in areas with vessel transit rates of greater than 80 per day (within a 5 km^2 area). Vessel traffic in the VE area, even considering the addition of VE O&M traffic will still be well below this figure. The adoption of 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** (negative) magnitude.

7.12.18 All marine mammal receptors are deemed to be of low vulnerability given the existing evidence of behavioural responses to vessels. Therefore, the sensitivity of marine mammal receptors to vessel disturbance is considered to be **negligible**.

7.12.19 The magnitude of the impact has been assessed as **low** (negative) and the sensitivity of receptors as **negligible**. Therefore, the significance of the effect of disturbance from O&M vessels is concluded to be of **negligible** significance, which is **not significant** in terms of the EIA regulations 2017.

IMPACT 12: CHANGE IN FISH ABUNDANCE/DISTRIBUTION FROM OPERATION

7.12.20 Any change in fish abundance and/or distribution as a result of VE 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 7.27.

7.12.21 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 2, Chapter 6: Fish and Shellfish Ecology).

7.12.22 Fishing pressure in the VE array area will be reduced as a result of operations due to advisory safety zones around infrastructure and the physical presence of the infrastructure restricting access to certain types of fishing vessels. Conversely, fishing pressure outside the VE array area may be increased due to displacement (see Volume 4, Chapter 8: Commercial Fisheries). These impacts will be highly localised and therefore will have a **negligible** magnitude on prey availability for marine mammals.

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

7.12.24 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 fish abundance/distribution during O&M is concluded to be of **negligible** significance, which is not significant in terms of the EIA regulations 2017.

7.13 ENVIRONMENTAL ASSESSMENT: DECOMMISSIONING PHASE

7.13.1 The impacts of the offshore decommissioning of VE have been assessed on marine mammals. The environmental impacts arising from the decommissioning of VE are listed in Table 7.13 along with the MDS against which each decommissioning phase impact has been assessed. Decommissioning would involve the dismantling of structures and removal of offshore structures above the seabed, in reverse order to the construction sequence. The effects of these activities on marine mammals are considered to be similar to or less (as a result of there being no piling) than those occurring as a result of construction. Therefore, the effects of decommissioning are considered to be no greater than those described for the construction phase.

IMPACT 14: PTS AND DISTURBANCE FROM DECOMMISSIONING

7.13.2 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. The indicative methodology would be:

- Deployment of remotely operated vehicles (ROV's) or divers to inspect each pile footing and reinstate lifting attachments if necessary;
- Mobilise a jack-up barge/heavy lifting vessel;
- Remove any scour protection or sediment obstructing the cutting process. It may be necessary to dig a small trench around the foundation;
- Deploy crane hooks from the decommissioning vessel and attach to the lift points;
- Cut piles at just below (approx. 1 m) seabed level;
- Inspect seabed for debris and remove debris where necessary;
- Considering the current technology, the decommissioned components are likely to be transported back to shore by lifting onto a jack-up or heavy lift vessels, freighter, barge, or by buoyant tow;
- Transport all components to an onshore site where they will be processed for reuse/recycling/disposal; and
- Inspect seabed and remove debris.

7.13.3 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 mitigation in the form of a Decommissioning Plan/Programme)as will be required under a requirement of the DCO or condition of the dML) and a MMMP specific to decommissioning activities (Table 7.14) 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** (adverse) significance, which is not significant in terms of the EIA regulations 2017.

IMPACT 9: COLLISION RISK FROM DECOMMISSIONING VESSELS

7.13.4 As stated in paragraph 7.11.120, the area surrounding VE already experiences a high amount of vessel traffic (see Volume 2, Chapter 9: Shipping and Navigation). Volume 2, Chapter 1: Offshore Project Description states that vessel numbers during decommissioning will be equal to or less then during construction phase. The introduction of additional vessels during construction of VE is not a novel impact for marine mammals present in the area.

7.13.5 The adoption of 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 VE 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.

7.13.6 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 best practice vessel handing protocols will minimise the potential for any impact. Therefore, the risk of vessel collisions occurring is of **negligible** magnitude.

7.13.7 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 **high** sensitivity to vessel collisions.

7.13.8 The magnitude of the impact has been assessed as **negligible** and the sensitivity of receptors as **high**. Therefore, the significance of the effect of collision risk from decommissioning vessels is concluded to be of **minor** (adverse) significance, which is **not significant** in terms of the EIA regulations 2017.

IMPACT 10: DISTURBANCE FROM DECOMMISSIONING VESSELS

7.13.9 Vessel noise levels from decommissioning vessels will result in an increase in non-impulsive, continuous sound in the vicinity of the VE array, typically in the range of 10 – 100 Hz (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 @ 1 m (RMS). It is anticipated that levels and types of vessel traffic during decommissioning would be similar to that during construction.

7.13.10 Heinänen and Skov (2015) suggested that harbour porpoise density was significantly lower in areas with vessel transit rates of greater than 80 per day (within a 5 km^2 area). Vessel traffic in the VE area, even considering the addition of VE decommissioning traffic will still be well below this figure. The adoption of 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.

7.13.11 All marine mammal receptors are deemed to be of low vulnerability given the existing evidence of behavioural responses to vessels (see Section 11.9). Therefore, the sensitivity of harbour porpoise to vessel disturbance is considered to be **low** and for grey and harbour seals as **negligible**.

7.13.12 The magnitude of the impact has been assessed as **low** (negative) and the sensitivity of harbour porpoise as **low** and grey and harbour seals as **negligible**. Therefore, the maximum significance of the effect of disturbance from decommissioning vessels is concluded to be of **minor** (adverse) significance, which is **not significant** in terms of the EIA regulations 2017

IMPACT 12: CHANGE IN FISH ABUNDANCE/ DISTRIBUTION FROM DECOMMISSIONING

7.13.13 Any change in fish abundance and/or distribution as a result of VE 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 7.27. While there may be certain species that comprise the main part of their diet, all marine mammals in this assessment are considered to be generalist feeders and are thus not reliant on a single prey species. Therefore, they are assessed as having a **low** sensitivity to changes in prey abundance and distribution.

7.13.14 Decommissioning of offshore infrastructure for VE may result in temporarily elevated underwater noise levels which may have effects on fish. However, Volume 4, Annex 6.2: Subsea Noise Technical Report assesses the maximum noise levels to be far below that during pile driving during construction phase, therefore, the impacts would also be less. The assessment provided in Volume 2, Chapter 6: Fish and Shellfish Ecology indicates that the overall adverse impacts to fish species from the decommissioning of VE will be of **negligible** significance and thus the predicted impact on marine mammals is of **negligible** magnitude.

7.13.15 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 fish abundance/distribution is concluded to be of **negligible** significance, which is **not significant** in terms of the EIA regulations 2017.

7.14 ENVIRONMENTAL ASSESSMENT: CUMULATIVE EFFECTS

7.14.1 Cumulative effects can be defined as effects upon a single receptor from VE when 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 VE. The full list of such projects that have been identified in relation to the offshore environment are set out in Volume 1, Annex 3.1: Cumulative Effects Assessment.

7.14.2 In assessing the potential cumulative impacts for VE, it is important to bear in mind 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.

7.14.3 With this in mind, all projects and plans considered alongside VE 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 7.29. The proposed tier structure for marine mammals is different to that presented for other receptors. This is due to the need to take into account greater levels of uncertainty in the degree and timing of overlap of activities which will generate significant levels of underwater noise during the construction phase of projects. This aligns with the new tier system proposed in Natural England (2022).

Table 7.29: Description of tiers of other developments considered within the marine mammal cumulative effect assessment (from Natural England, 2022).

Tier	Stage	Data availability
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 e.g. "background" distribution or mortality rate for birds.	Pre-construction (and possibly post-construction) survey data from the built project(s) and environmental characterisation survey data from proposed project (including data analysis and interpretation within the ES for the project).
2	Tier 1 + projects under construction.	As Tier 1 but not including post-construction survey data.
3	Tier 2 + projects that have been consented (but construction has not yet commenced).	Environmental characterisation survey data from proposed project (including data analysis and interpretation within the ES for the project) and possibly pre-construction survey data from built project.
4	Tier 3 + projects that have an application submitted to the appropriate regulatory body that have not yet been determined.	Environmental characterisation survey data from proposed project (including data analysis and interpretation within the ES for the project).
5	Tier 4 + 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).	Possibly environmental characterisation survey data (but strong likelihood that this data will not be publicly available at this stage).
6	Tier 5 + projects that have been identified in relevant strategic plans or programmes.	Historic survey data collected for other purposes/by other projects or industries or at a strategic level. See Natural England (2021) for guidance on using existing datasets.

SCREENING PROJECTS

7.14.4 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 (all projects were screened based on publicly available information). 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, Southeast MU for harbour seals, combined Southeast and Northeast MUs for grey seals).

7.14.5 The time period considered in the CEA for marine mammals is 2024-2030 inclusive. This allows for the quantification of impacts to the MUs both prior to the construction of VE (since the baseline was collated) and during the potential construction window for VE (the potential piling window for VE is expected to be sometime between 2028-2030 inclusive).

7.14.6 The CEA methodology and long-list are described in Volume 1, Annex 3.1: Cumulative Effects Assessment. 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.

7.14.7 The following offshore project types were screened out of the marine mammal CEA short list:

- 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); and
- Military, Aviation & Radar (all active: ongoing impact and part of the baseline)

7.14.8 The marine mammal CEA short list therefore consists of the following offshore project types:

- Offshore wind farms;
- Cables and pipelines;
- Tidal developments;
- Wave developments;
- Coastal developments
- Carbon capture and storage;
- Oil and Gas decommissioning; and
- Oil and Gas seismic surveys.

Table 7.30: Marine mammal CEA short list.

Project	Type	Status	TIER[19]	HP	HS	GS
VE	OWF	Consented	n/a	Y	Y	Y
Dogger Bank A	OWF	Consented	3	Y	Y	Y
Dogger Bank B	OWF	Consented	3	Y	Y	Y
Sofia	OWF	Consented	3	Y	Y	Y
Dogger Bank C	OWF	Consented	3	Y	Y	Y
Moray West	OWF	Consented	3	Y	N	N
Hornsea 3	OWF	Consented	3	Y	Y	Y
Norfolk Vanguard	OWF	Consented	3	Y	Y	Y
Norfolk Boreas	OWF	Consented	3	Y	Y	Y
East Anglia 1 N	OWF	Consented	3	Y	Y	Y
East Anglia 2	OWF	Consented	3	Y	Y	Y
East Anglia 3	OWF	Consented	3	Y	Y	Y
Blyth Demo	OWF	Pre-consent	3	Y	N	Y
PTEC	Tidal	Pre-consent	3	Y	N	N
Borkum Rifgrund W	OWF	Pre-consent	3	Y	N	N
EnBW He Dreidt	OWF	Pre-consent	3	Y	N	N
Gode Wind 3	OWF	Pre-consent	3	Y	N	N
Pentland	OWF	Application submitted	4	Y	N	N
Hornsea 4	OWF	Application submitted	4	Y	Y	Y
Outer Dowsing	OWF	Pre-consent	5	Y	Y	Y
Dudgeon Extension	OWF	Pre-consent	5	Y	Y	Y
Sheringham Extension	OWF	Pre-consent	5	Y	Y	Y
North Falls	OWF	Pre-consent	5	Y	Y	Y
Rampion 2	OWF	Pre-consent	5	Y	N	N
Berwick Bank	OWF	Pre-consent	5	Y	N	N
Dunkerque	OWF	Pre-consent	5	Y	N	N
DBS West	OWF	Pre-consent	5	Y	Y	Y
DBS East	OWF	Pre-consent	5	Y	Y	Y
N-3.7	OWF	Pre-consent	5	Y	N	N

[19] This information is correct as of the time of the assessment (October 2022)

Project	Type	Status	TIER[19]	HP	HS	GS
N-3.8	OWF	Pre-consent	5	Y	N	N
N-7.2	OWF	Pre-consent	5	Y	N	N
Thor	OWF	Pre-consent	5	Y	N	N
Scotwind E1	OWF	Pre-consent	5	Y	N	N
Seagreen C	OWF	Pre-consent	5	Y	N	Y
Parc Eolien Normadie (AO4)	OWF	Pre-consent	5	Y	N	N
Scotwind NE6	OWF	Pre-consent	5	Y	N	N
Scotwind NE8	OWF	Pre-consent	5	Y	N	N
Scotwind N1	OWF	Pre-consent	5	Y	N	N
Seismic Survey 1	Seismic	NA	6	Y	Y	Y
Seismic Survey 2	Seismic	NA	6	Y	Y	Y
Seismic Survey 3	Seismic	NA	6	Y	N	N
Seismic Survey 4	Seismic	NA	6	Y	N	N

Table 7.31: Projects considered within the marine mammal CEA.

Project	VE	Dogger Bank A	Dogger Bank B	Sofia	Dogger Bank C	Moray West	Hornsea 3	Norfolk Vanguard	Norfolk Boreas	East Anglia 1 N	East Anglia 2	Blyth Demo	PTEC	Borkum Rifgrund W	EnBW He Dreidt	Gode Wind 3	Pentland	Hornsea 4	Outer Dowsing	Dudgeon Ext.	Sherringham Ext.	North Falls	Rampion 2	Berwick Bank	Dunkerque	DBS West	DBS East	N-3.7	N-3.8	N-7.2	Thor	Scotwind E1	Seagreen C	Parc Eolien Normadie (AO4)	Scotwind NE6	Scotwind NE8	Scotwind N1	Seismic Survey 1	Seismic Survey 2	Seismic Survey 3	Seismic Survey 4
TIER		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6	6	6
Q1 2024		P	P	P	P	P	U	U			U	P	P	P	P	P							P	P								P	P		P	P	P	S	S	S	S
Q2 2024		P	P	P	P	P	U	P			U	P	P	P	P	P							P	P								P	P		P	P	P	S	S	S	S
Q3 2024		P	P	P	P	P	U	P			U	P	P	P	P	P							P	P								P	P		P	P	P	S	S	S	S
Q4 2024		P	P	P	P	P	U	P			U	P	P	P	P	P	P						P	P								P	P		P	P	P	S	S	S	S
Q1 2025					P		U	P		U	P	P		P		P	P						P	P	P			P	P			P	P		P	P	P	S	S	S	S
Q2 2025					P		U			U	P			P		P	P			U	U		P	P	P			P	P			P	P		P	P	P	S	S	S	S
Q3 2025					P		U		U	U	P			P		P	P			U	U		P	P	P			P	P			P	P	P	P	P	P	S	S	S	S
Q4 2025					P		U		U	U	P			P		P	P			U	U		P	P	P			P	P		P	P	P	P	P	P	P	S	S	S	S
Q1 2026					P				U	P	P						P			U	U	P	P	P	P					P	P	P		P	P	P	P	S	S	S	S
Q2 2026					P				P	P	P							U		P	P	P	P	P	P	P	P			P	P	P		P	P	P	P	S	S	S	S
Q3 2026					P				P	P	P							U		P	P	P	P	P	P	P	P			P	P	P			P	P	P	S	S	S	S
Q4 2026					P				P	P	P							U		P	P	P	P	P	P	P	P			P	P	P			P	P	P	S	S	S	S
Q1 2027	U						P		P	P	P							P	P			P	P		P	P	P				P	P			P	P	P	S	S	S	S

Project	VE	Dogger Bank A	Dogger Bank B	Sofia	Dogger Bank C	Moray West	Hornsea 3	Norfolk Vanguard	Norfolk Boreas	East Anglia 1 N	East Anglia 2	Blyth Demo	PTEC	Borkum Rifgrund W	EnBW He Dreidt	Gode Wind 3	Pentland	Hornsea 4	Outer Dowsing	Dudgeon Ext.	Sherringham Ext.	North Falls	Rampion 2	Berwick Bank	Dunkerque	DBS West	DBS East	N-3.7	N-3.8	N-7.2	Thor	Scotwind E1	Seagreen C	Parc Eolien Normadie (AO4)	Scotwind NE6	Scotwind NE8	Scotwind N1	Seismic Survey 1	Seismic Survey 2	Seismic Survey 3	Seismic Survey 4
TIER		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6	6	6
Q2 2027	U						P	P	P	P	P							P	P			P	P		P	P	P				P	P			P	P	P	S	S	S	S
Q3 2027	U						P	P	P	P	P							P	P			P	P		P	P	P				P	P			P	P	P	S	S	S	S
Q4 2027	U						P	P	P	P	P							P	P			P	P		P	P	P				P	P			P	P	P	S	S	S	S
Q1 2028	P						P	P		P									P			P	P			P	P											S	S	S	S
Q2 2028	P						P			P									P			P				P	P											S	S	S	S
Q3 2028	P									P									P			P				P	P											S	S	S	S
Q4 2028	P																		P							P	P											S	S	S	S
U = UXO, P = Piling, S = Seismic Survey, HP = Harbour porpoise, HS = Harbour seal, GS = Grey seal, Y = Project screened in for the specific species (within MU), N = Project screened out for the specific species (not in MU)																																									
Q1 2029	P																		P							P	P											S	S	S	S
Q2 2029	P																		P							P	P											S	S	S	S
Q3 2029	P																		P							P	P											S	S	S	S
Q4 2029	P																		P							P	P											S	S	S	S
Q1 2030	P																		P							P	P											S	S	S	S
Q2 2030	P																		P							P	P											S	S	S	S
Q3 2030	P																		P							P	P											S	S	S	S

Project	VE	Dogger Bank A	Dogger Bank B	Sofia	Dogger Bank C	Moray West	Hornsea 3	Norfolk Vanguard	Norfolk Boreas	East Anglia 1 N	East Anglia 2	Blyth Demo	PTEC	Borkum Rifgrund W	EnBW He Dreidt	Gode Wind 3	Pentland	Hornsea 4	Outer Dowsing	Dudgeon Ext.	Sherringham Ext.	North Falls	Rampion 2	Berwick Bank	Dunkerque	DBS West	DBS East	N-3.7	N-3.8	N-7.2	Thor	Scotwind E1	Seagreen C	Parc Eolien Normadie (AO4)	Scotwind NE6	Scotwind NE8	Scotwind N1	Seismic Survey 1	Seismic Survey 2	Seismic Survey 3	Seismic Survey 4
TIER		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6	6	6
Q4 2030	P																		P							P	P											S	S	S	S
HP	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
HS	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	N	N	N	N	N	Y	Y	Y	Y	Y	N	N	N	Y	Y	N	N	N	N	N	N	N	N	N	N	Y	Y	N	N
GS	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	N	N	N	N	N	Y	Y	Y	Y	Y	N	N	N	Y	Y	N	N	N	N	N	Y	N	N	N	N	Y	Y	N	N

U = UXO, P = Piling, S = Seismic Survey, HP = Harbour porpoise, HS = Harbour seal, GS = Grey seal, Y = Project screened in for the specific species (within MU), N = Project screened out for the specific species (not in MU)

SCREENING IMPACTS

7.14.9 Certain impacts assessed for VE alone are not considered in the marine mammal CEA due to:

a) the highly localised nature of the impacts,

b) management and mitigation measures in place at VE and on other projects will reduce the risk occurring, and

c) where the potential significance of the impact from VE alone has been assessed as negligible.

7.14.10 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 vessel management plan 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
- Operational noise: highly localised and negligible significance.

7.14.11 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.

CEA MDS

7.14.12 The MDS for the marine mammal CEA is described in Table 7.32:. Projects with impacts that overlap with the VE construction period (2026-2030 inclusive) or with impacts that are expected to occur 1 year before or after the VE construction period are included in the assessment. This therefore limits the CEA to projects that have impact pathways predicted to occur between 2025 and 2031 inclusive.

Table 7.32: Cumulative MDS for marine mammals.

Potential effect	Scenario	Justification
Disturbance	Underwater noise produced by construction (piling and UXO clearance) and decommissioning activities in combination with ongoing seismic activities. Included in CEA: Only projects where construction or decommissioning periods are expected to overlap with or	Maximum potential for cumulative effects from underwater noise associated with offshore wind farm construction and decommissioning activities is considered within the relevant MU for each species. This spatial scale was chosen as a result of the spatial extent of

Potential effect	Scenario	Justification
	occur ±1 year either side of the construction activity at VE.	noise related impacts as well as the high mobility of marine mammal receptors.
	Vessel activity during construction, O&M and decommissioning. Included in CEA: All projects that have vessel activity between 2025-2031 that wasn't included in the baseline.	Maximum potential for cumulative effects from the increased risk of disturbance from an increase in vessel activity is considered within the relevant MU for each species. This spatial scale was chosen as a result of the high mobility of marine mammal receptors.

DISTURBANCE FROM UNDERWATER NOISE

METHOD

UXO CLEARANCE

7.14.13 For all offshore projects that had a quantitative impact assessment publicly available for UXO clearance (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.

7.14.14 For all projects that have no quantitative impact assessment publicly available (PEIR or ES chapter), a 26 km EDR was assumed for high order UXO clearance, based on the guidance in JNCC (2020). The density of harbour porpoise used to calculate the number of animals impacted was the relevant SCANS III block-wide density estimate for each project. The density of harbour and grey seals used to calculate the number of animals impacted was the average habitat preference at-sea usage estimate throughout the array area for each project.

PILING FOR OWF

7.14.15 For all offshore projects that had a quantitative impact assessment for pile driving publicly 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.

7.14.16 For all projects that have no quantitative impact assessment available (PEIR or ES chapter), a 26 km EDR was assumed for disturbance from pile driving, based on the guidance in JNCC (2020). The density of harbour porpoise used to calculate the number of animals impacted was the relevant SCANS III block wide density estimate for each project. The density of harbour and grey seals used to calculate the number of animals impacted was the average habitat preference at sea usage estimate throughout the array area for each project.

TIDAL PROJECTS

7.14.17 For tidal projects it is assumed there will be no pile driving. Therefore, construction-related impacts are limited to a 5 km EDR.

SEISMIC SURVEYS

7.14.18 The potential number of seismic surveys that could be undertaken is unknown. 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 EDR for seismic surveys is 12 km as per the advice provided in JNCC (2020). It is considered that this approach is sufficiently precautionary (i.e. it is unlikely that this number of seismic surveys will be occurring concurrently, less so concurrently with VE construction).

7.14.19 It is acknowledged that seismic surveys are a moving sound source and not a point source. Therefore, the approach presented in BEIS (2020) has been adopted here. Therefore, it has been assumed that a seismic survey vessel travelling at 4.5 knots (8.3 km/h) could, in theory, survey a total of 199 km of survey line in a single 24 hr period and therefore impact an area of 5,228 km² per day (Figure 7.18).

7.14.20 To estimate the number of harbour porpoise predicted to be disturbed from seismic surveys in the North Sea, the average density across the North Sea was calculated (abundance in North Sea MU (346,601) / area of MU (680,487 km^2) = 0.51 porpoise/km^2).

7.14.21 To estimate the number of harbour and grey seals predicted to be disturbed from seismic surveys in the North Sea, the average habitat preference at-sea usage estimate throughout the MU was used (this is highly conservative since seals are generally in higher densities closer to shore, whereas seismic surveys tend not to occur close to shore). Given that the MUs for seals are smaller than that for harbour porpoise, it was assumed that the CEA for both harbour and grey seals would incorporate two seismic survey operations within their respective MUs at any one time.

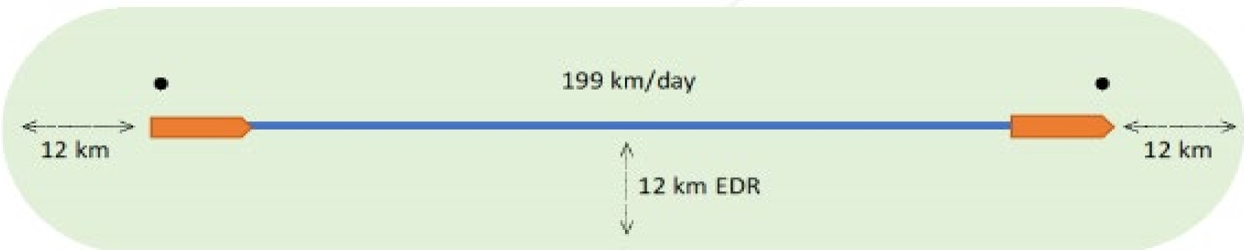

Figure 7.21: Maximum worst-case theoretical area of impact over a single day from a seismic survey travelling 199 km/day at 4.5 knots using 12 km EDR (BEIS, 2020).

PRECAUTION IN THE CEA

7.14.22 A combination of uncertainties in project timelines and the need to apply precautionary assumptions leads to significant 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 1-6 projects would require that 36 offshore wind farm developments, 1 tidal energy development and 4 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, no ES chapter or no submitted information at all (Tiers 4, 5 and 6) then worst-case scenarios have to be assumed in the absence of other information.
- The assumption that UXO clearance or pile driving can occur at any point throughout the construction window for each development. This results in most projects having UXO and piling activities occurring over multiple consecutive years. For example, the piling window for VE is listed as 2028-2030 (which results in 3 years of potential impact in the CEA); however, piling would only occur within a 1-year period within this window. Since the exact timing of the UXO and 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 (15 km instead of 26 km) (JNCC, 2020), and are therefore considered to disturb far fewer animals.
- The impact area from seismic surveys. This approach was highlighted by BEIS (2020) as being highly precautionary and should be considered as an unrealistic worst-case scenario. This is mainly since the approach does not take into consideration time when the seismic airguns are not firing within a survey day. Airguns are required to be turned off at the end of every survey line as the vessel turns, which can take 2-3 hours per turn and several turns can occur each day. Additionally, it is unlikely that a survey area would be 199 km in length and multiple lines would be shot in parallel which results in a significant overlap in the area subject to disturbance in a single day, reducing the overlap impact area.

HARBOUR PORPOISE

7.14.23 The potential number of harbour porpoise disturbed per day by project is provided in Table 7.33.

7.14.24 A summary of the total disturbance impact to harbour porpoise per day by Tier, is provided in Table 7.34.

7.14.25 A summary of the total disturbance impact to harbour porpoise per day across all projects in Tier 1-3 is provided in Figure 7.20.

7.14.26 Across all years considered in the CEA (2024-2030 inclusive), the periods with highest levels of predicted disturbance to harbour porpoise are in the years preceding the piling window for VE.

7.14.27 When considering the potential impact from VE 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 porpoise across the North Sea MU is in 2024, when several central/southern North Sea projects may be in construction (Dogger Bank projects, Hornsea 3, Norfolk Vanguard, East Anglia projects). At this time, a maximum of 20,452 porpoise (5.9% 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).

7.14.28 By comparison, the total impact to the North Sea MU is expected to be lower throughout the VE construction window (2028-2030). At this time, a maximum of 15,995 porpoise (4.6% MU) may be disturbed per day in 2028 (assuming all Tier 1-3 projects are constructing at the same time, and that disturbance is additive across projects), reducing to only 7,031 porpoise (2.0% MU) in 2029 and 2030 (as no Tier 1-3 projects are due to be piling then).

Table 7.33: Number of harbour porpoise potentially disturbed by underwater noise by project.

Type	OWF	OWF	OWF	OWF	OWF	OWF	OWF	OWF	OWF	OWF	OWF	OWF	TIDAL	OWF	OWF	OWF	OWF	OWF
Project	**VE**	**Dogger Bank A**	**Dogger Bank B**	**Sofia**	**Dogger Bank C**	**Moray West**	**Hornsea 3**	**Norfolk Vanguard**	**Norfolk Boreas**	**East Anglia 1 N**	**East Anglia 2**	**Blyth Demo**	**PTEC**	**Borkum Rifgrund W**	**EnBW He Dreidt**	**Gode Wind 3**	**Pentland**	**Hornsea 4**
Tier		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4
Q1 2024		1288	2276	2035	1920	1377	1896	2676			1551	1272	17	1778	1778	588		
Q2 2024		1288	2276	2035	1920	1377	1896	2676			1551	1272	17	1778	1778	588		
Q3 2024		1288	2276	2035	1920	1377	1896	2676			1551	1272	17	1778	1778	588		
Q4 2024		1288	2276	2035	1920	1377	1896	2676			1551	1272	17	1778	1778	588	641	
Q1 2025					1920		1896	2676		1289	1551	1272		1778		588	641	
Q2 2025					1920		1896			1289	1551			1778		588	641	
Q3 2025					1920		1896		2251	1289	1551			1778		588	641	
Q4 2025					1920		1896		2251	1289	1551			1778		588	641	
Q1 2026					1920				2251	1289	1551						641	
Q2 2026					1920				2251	1289	1551							3394
Q3 2026					1920				2251	1289	1551							3394
Q4 2026					1920				2251	1289	1551							3394
Q1 2027	3865						4999		2251	1289	1551							6417
Q2 2027	3865						4999	2676	2251	1289	1551							6417
Q3 2027	3865						4999	2676	2251	1289	1551							6417
Q4 2027	3865						4999	2676	2251	1289	1551							6417
Q1 2028	**7031**						**4999**	**2676**		**1289**								
Q2 2028	**7031**						**4999**			**1289**								
Q3 2028	**7031**									**1289**								
Q4 2028	**7031**																	
Q1 2029	**7031**																	
Q2 2029	**7031**																	
Q3 2029	**7031**																	
Q4 2029	**7031**																	
Q1 2030	**7031**																	
Q2 2030	**7031**																	
Q3 2030	**7031**																	
Q4 2030	**7031**																	
Method	PEIR	EIA	EIA	EIA	EIA	EIA	EIA	EIA	EIA	EIA	EIA	CALC	CALC	CALC	CALC	CALC	EIA	EIA

Type	OWF	OWF	OWF	OWF	OWF	OWF	OWF	OWF	OWF	OWF	OWF	OWF	OWF	OWF	OWF	OWF	OWF	OWF	OWF	SS	SS	SS	SS
Project	**Outer Dowsing**	**Dudgeon Extension**	**Sherringham Extension**	**North Falls**	**Rampion 2**	**Berwick Bank**	**Dunkerque**	**DBS West**	**DBS East**	**N-3.7**	**N-3.8**	**N-7.2**	**Thor**	**Scotwind E1**	**Seagreen C**	**Parc Eolien Normadie (AO4)**	**Scotwind NE6**	**Scotwind NE8**	**Scotwind N1**	**Seismic Survey 1**	**Seismic Survey 2**	**Seismic Survey 3**	**Seismic Survey 4**
Tier	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6	6	6
Q1 2024					633	1272								1272	1272		323	323	323	2663	2663	2663	2663
Q2 2024					633	1272								1272	1272		323	323	323	2663	2663	2663	2663
Q3 2024					633	1272								1272	1272		323	323	323	2663	2663	2663	2663
Q4 2024					633	1272								1272	1272		323	323	323	2663	2663	2663	2663
Q1 2025					633	1272	1289			588	588			1272	1272		323	323	323	2663	2663	2663	2663
Q2 2025		3483	1886		633	1272	1289			588	588			1272	1272		323	323	323	2663	2663	2663	2663
Q3 2025		3483	1886		633	1272	1289			588	588			1272	1272	452	323	323	323	2663	2663	2663	2663
Q4 2025		3483	1886		633	1272	1289			588	588		588	1272	1272	452	323	323	323	2663	2663	2663	2663
Q1 2026		3483	1886	1289	633	1272	1289					1778	588	1272		452	323	323	323	2663	2663	2663	2663
Q2 2026		3483	1886	1289	633	1272	1289	1886	1886			1778	588	1272		452	323	323	323	2663	2663	2663	2663
Q3 2026		3483	1886	1289	633	1272	1289	1886	1886			1778	588	1272			323	323	323	2663	2663	2663	2663
Q4 2026		3483	1886	1289	633	1272	1289	1886	1886			1778	588	1272			323	323	323	2663	2663	2663	2663
Q1 2027	1886			1289	633		1289	1886	1886				588	1272			323	323	323	2663	2663	2663	2663
Q2 2027	1886			1289	633		1289	1886	1886				588	1272			323	323	323	2663	2663	2663	2663
Q3 2027	1886			1289	633		1289	1886	1886				588	1272			323	323	323	2663	2663	2663	2663
Q4 2027	1886			1289	633		1289	1886	1886				588	1272			323	323	323	2663	2663	2663	2663
Q1 2028	**1886**			**1289**	**633**			**1886**	**1886**											**2663**	**2663**	**2663**	**2663**
Q2 2028	**1886**			**1289**				**1886**	**1886**											**2663**	**2663**	**2663**	**2663**
Q3 2028	**1886**			**1289**				**1886**	**1886**											**2663**	**2663**	**2663**	**2663**
Q4 2028	**1886**							**1886**	**1886**											**2663**	**2663**	**2663**	**2663**
Q1 2029	**1886**							**1886**	**1886**											**2663**	**2663**	**2663**	**2663**
Q2 2029	**1886**							**1886**	**1886**											**2663**	**2663**	**2663**	**2663**
Q3 2029	**1886**							**1886**	**1886**											**2663**	**2663**	**2663**	**2663**
Q4 2029	**1886**							**1886**	**1886**											**2663**	**2663**	**2663**	**2663**
Q1 2030	**1886**							**1886**	**1886**											**2663**	**2663**	**2663**	**2663**
Q2 2030	**1886**							**1886**	**1886**											**2663**	**2663**	**2663**	**2663**
Q3 2030	**1886**							**1886**	**1886**											**2663**	**2663**	**2663**	**2663**
Q4 2030	**1886**							**1886**	**1886**											**2663**	**2663**	**2663**	**2663**
Method	CALC	PEIR	PEIR	CALC	PEIR	CALC	CALC	CALC	CALC	CALC	CALC	CALC	CALC	CALC	CALC	CALC	CALC	CALC	CALC	CALC	CALC	CALC	CALC

Table 7.34: Total number of harbour porpoise disturbed by underwater noise across the Tiers. Results including lower Tier projects, and thus with lower data confidence, are denoted by grey text.

	VE alone		VE + T1-3		VE + T1-4		VE + T1-5		VE + T1-6	
	#	% MU	#	% MU	#	% MU	#	% MU	#	% MU
Q1 2024	0	0.0%	20452	5.9%	20452	5.9%	25870	7.5%	36522	10.5%
Q2 2024	0	0.0%	20452	5.9%	20452	5.9%	25870	7.5%	36522	10.5%
Q3 2024	0	0.0%	20452	5.9%	20452	5.9%	25870	7.5%	36522	10.5%
Q4 2024	0	0.0%	20452	5.9%	21093	6.1%	26511	7.6%	37163	10.7%
Q1 2025	0	0.0%	12970	3.7%	13611	3.9%	21494	6.2%	32146	9.3%
Q2 2025	0	0.0%	9022	2.6%	9663	2.8%	22915	6.6%	33567	9.7%
Q3 2025	0	0.0%	11273	3.3%	11914	3.4%	25618	7.4%	36270	10.5%
Q4 2025	0	0.0%	11273	3.3%	11914	3.4%	26206	7.6%	36858	10.6%
Q1 2026	0	0.0%	7011	2.0%	7652	2.2%	22563	6.5%	33215	9.6%
Q2 2026	0	0.0%	7011	2.0%	10405	3.0%	29088	8.4%	39740	11.5%
Q3 2026	0	0.0%	7011	2.0%	10405	3.0%	28636	8.3%	39288	11.3%
Q4 2026	0	0.0%	7011	2.0%	10405	3.0%	28636	8.3%	39288	11.3%
Q1 2027	3865	1.1%	13955	4.0%	20372	5.9%	32070	9.3%	42722	12.3%
Q2 2027	3865	1.1%	16631	4.8%	23048	6.6%	34746	10.0 %	45398	13.1%
Q3 2027	3865	1.1%	16631	4.8%	23048	6.6%	34746	10.0 %	45398	13.1%
Q4 2027	3865	1.1%	16631	4.8%	23048	6.6%	34746	10.0 %	45398	13.1%
Q1 2028	7031	2.0%	15995	4.6%	15995	4.6%	23575	6.8%	34227	9.9%
Q2 2028	7031	2.0%	13319	3.8%	13319	3.8%	20266	5.8%	30918	8.9%
Q3 2028	7031	2.0%	8320	2.4%	8320	2.4%	15267	4.4%	25919	7.5%
Q4 2028	7031	2.0%	7031	2.0%	7031	2.0%	12689	3.7%	23341	6.7%
Q1 2029	7031	2.0%	7031	2.0%	7031	2.0%	12689	3.7%	23341	6.7%
Q2 2029	7031	2.0%	7031	2.0%	7031	2.0%	12689	3.7%	23341	6.7%
Q3 2029	7031	2.0%	7031	2.0%	7031	2.0%	12689	3.7%	23341	6.7%
Q4 2029	7031	2.0%	7031	2.0%	7031	2.0%	12689	3.7%	23341	6.7%
Q1 2030	7031	2.0%	7031	2.0%	7031	2.0%	12689	3.7%	23341	6.7%
Q2 2030	7031	2.0%	7031	2.0%	7031	2.0%	12689	3.7%	23341	6.7%
Q3 2030	7031	2.0%	7031	2.0%	7031	2.0%	12689	3.7%	23341	6.7%
Q4 2030	7031	2.0%	7031	2.0%	7031	2.0%	12689	3.7%	23341	6.7%
Max 2024-30	**7031**	**2.0%**	**20452**	**5.9%**	**23048**	**6.6%**	**34746**	**10.0 %**	**45398**	**13.1%**
Max 2028-30	**7031**	**2.0%**	**15995**	**4.6%**	**15995**	**4.6%**	**23575**	**6.8%**	**34227**	**9.9%**

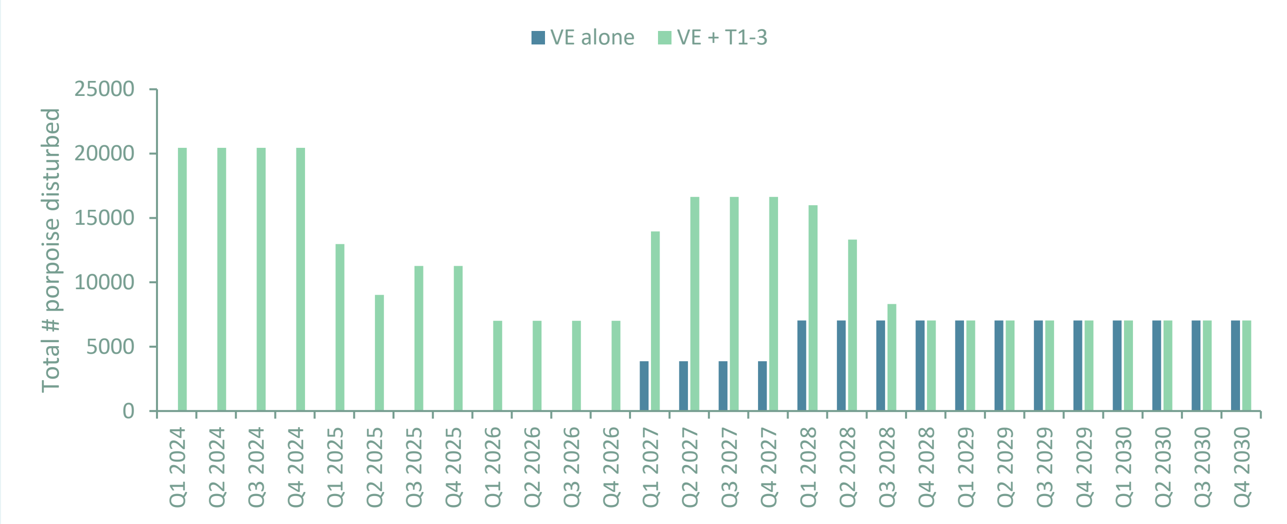

Figure 7.22: Cumulative underwater noise disturbance estimates to harbour porpoise for VE alone and VE in addition to Tier 1-3 projects.

7.14.29 There are significant 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, plus those specific to harbour porpoise:

- The number of developments active at the same time (clearing UXOs, piling or surveying). In order for 41,533 porpoise to be disturbed across all Tier 1-6 projects in 2027, this would require that 36 offshore wind farm developments, 1 tidal energy development and 4 seismic surveys are all active at the same time. This is considered to be extremely unrealistic.
- The assumption that all porpoise within a 26 km range are disturbed. Pile driving activities at other offshore wind farms have shown that this assumption of total displacement within 26 km of pile driving is a significant over-estimate. At Beatrice, there was only a 50% response at 7.4 km and a 28% response within 26 km for the first location piled, with decreasing response levels over the construction period to 50% response at only 1.3 km by the final location (Figure 7.20) (Graham *et al.,* 2019). Likewise, pile driving at the first 7 large scale offshore windfarms in the German Bight (including unmitigated piling) found declines in porpoise out to only 17 km, with unmitigated piling in isolation also illustrating only weak declines beyond approximately 17 km (Brandt *et al.,* 2018).

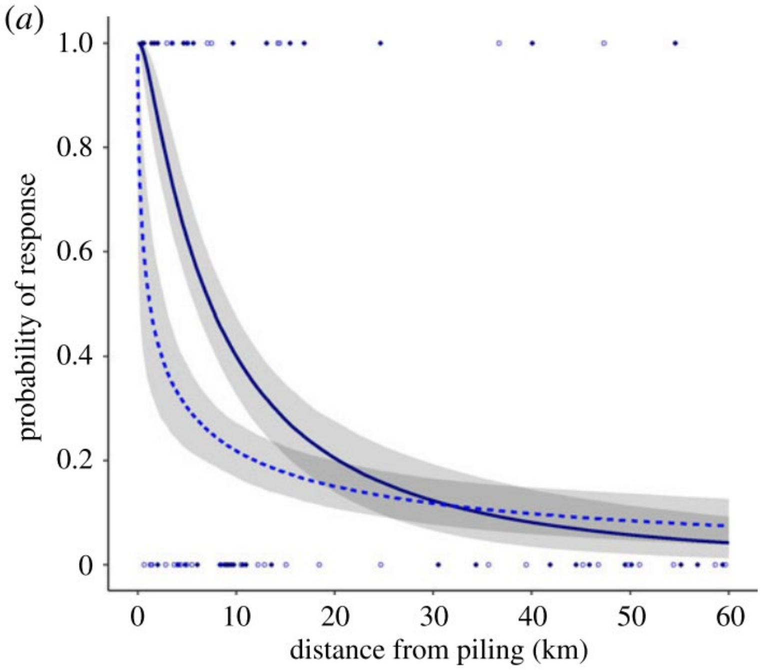

Figure 7.23: The probability of harbour porpoise response (24 h) in relation to the partial contribution of distance from piling for the first location piled (solid navy line) and the final location piled (dashed blue line) (Graham *et al*., 2019).

7.14.30 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).

7.14.31 The number of animals predicted to be impacted in this CEA (though acknowledging that this is a vast over-estimate) could potentially result in 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 likely not enough to affect the population trajectory over a generational scale. For example, previous population modelling (using iPCoD) of offshore wind farms 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).

7.14.32 Similarly, the DEPONS model found that the North Sea porpoise population was unlikely to be significantly impacted by construction of 65 wind farms, unless impact ranges were assumed to be much larger (exceeding 50 km) than that indicated by existing studies (Nabe-Nielsen *et al*., 2018). Therefore, given that impacts are likely not enough to affect the population trajectory over a generational scale, the magnitude of the cumulative increase in disturbance from underwater noise is **Medium**.

7.14.33 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.

7.14.34 Therefore, the effect significance of disturbance to harbour porpoise from the cumulative impact of underwater noise is **Minor**, which is not significant in EIA terms.

HARBOUR SEAL

7.14.35 The potential number of harbour seals disturbed per day by project is provided in Table 7.35.

7.14.36 A summary of the total disturbance impact to harbour seals per day by Tier, is provided in Table 7.36.

7.14.37 A summary of the total disturbance impact to harbour seals per day across all projects in Tiers 1-3 is provided in Figure 7.21.

7.14.38 Across all years considered in the CEA (2024-2030 inclusive), the periods with highest levels of predicted disturbance to harbour seals are in the years preceding the piling window for VE.

7.14.39 When considering the potential impact from VE 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 Southeast England MU is in 2024 and 2025, when several central/southern North Sea projects are constructing (Dogger Bank projects, Hornsea 3, Norfolk Vanguard, East Anglia projects). At this time, a maximum of 230 harbour seals (4.4% 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).

7.14.40 By comparison, the total impact to the Southeast England MU is expected to be much lower throughout the VE construction window (2028-2030). At this time, a maximum of 9 harbour seals (0.2% MU) may be disturbed per day in 2028 (assuming all Tier 1-3 projects are constructing at the same time, and that disturbance is additive across projects), reducing to only 2 harbour seals (0.0% MU) in 2029 and 2030 (as no T1-3 projects are due to be piling then).

7.14.41 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. The number of animals predicted to be impacted in this CEA across Tiers 1-4 (up to 4.4% MU) could potentially result in 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 likely not enough to affect the population trajectory over a generational scale. Therefore, the magnitude of the cumulative increase in disturbance from underwater noise is **Medium**.

7.14.42 The sensitivity of harbour seals to disturbance from both piling and UXO clearance has been assessed as **Low**.

7.14.43 Therefore, the effect significance of disturbance to harbour seals from the cumulative impact of underwater noise is **Minor**, which is not significant in EIA terms.

Table 7.35: Number of harbour seals potentially disturbed by underwater noise by project.

Project	VE	Dogger Bank A	Dogger Bank B	Sofia	Dogger Bank C	Hornsea 3	Norfolk Vanguard	Norfolk Boreas	East Anglia 1 N	East Anglia 2	Hornsea 4	Outer Dowsing	Dudgeon Extension	Sherringham Extension	North Falls	Dogger Bank South W	Dogger Bank South E	Seismic Survey 1	Seismic Survey 2
Tier		**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**4**	**5**	**5**	**5**	**5**	**5**	**5**	**6**	**6**
Q1 2024		0	0	0	0	3	212			15								364	364
Q2 2024		0	0	0	0	3	1			15								364	364
Q3 2024		0	0	0	0	3	1			15								364	364
Q4 2024		0	0	0	0	3	1			15								364	364
Q1 2025					0	3	1		17	2								364	364
Q2 2025					0	3			17	2			302	264				364	364
Q3 2025					0	3		208	17	2			302	264				364	364
Q4 2025					0	3		208	17	2			302	264				364	364
Q1 2026					0			208	1	2			302	264	3			364	364
Q2 2026					0			1	1	2	11		1	1	3	2	4	364	364
Q3 2026					0			1	1	2	11		1	1	3	2	4	364	364
Q4 2026					0			1	1	2	11		1	1	3	2	4	364	364
Q1 2027	38					5		1	1	2	5	94			3	2	4	364	364
Q2 2027	38					5	1	1	1	2	5	94			3	2	4	364	364
Q3 2027	38					5	1	1	1	2	5	94			3	2	4	364	364
Q4 2027	38					5	1	1	1	2	5	94			3	2	4	364	364
Q1 2028	2					5	1		1			94			3	2	4	364	364
Q2 2028	2					5			1			94			3	2	4	364	364
Q3 2028	2								1			94			3	2	4	364	364
Q4 2028	2											94				2	4	364	364
Q1 2029	2											94				2	4	364	364
Q2 2029	2											94				2	4	364	364
Q3 2029	2											94				2	4	364	364
Q4 2029	2											94				2	4	364	364
Q1 2030	2											94				2	4	364	364
Q2 2030	2											94				2	4	364	364
Q3 2030	2											94				2	4	364	364
Q4 2030	2											94				2	4	364	364

Table 7.36: Total number of harbour seals disturbed by underwater noise across the Tiers. Results including lower Tier projects, and thus with lower data confidence, are denoted by grey text.

	VE alone		VE + T1-3		VE + T1-4		VE + T1-5		VE + T1-6	
	#	% MU	#	% MU	#	% MU	#	% MU	#	% MU
Q1 2024	0	0.0%	230	4.4%	230	4.4%	230	4.4%	958	18.3%
Q2 2024	0	0.0%	19	0.4%	19	0.4%	19	0.4%	747	14.3%
Q3 2024	0	0.0%	19	0.4%	19	0.4%	19	0.4%	747	14.3%
Q4 2024	0	0.0%	19	0.4%	19	0.4%	19	0.4%	747	14.3%
Q1 2025	0	0.0%	23	0.4%	23	0.4%	23	0.4%	751	14.4%
Q2 2025	0	0.0%	22	0.4%	22	0.4%	588	11.3%	1316	25.2%
Q3 2025	0	0.0%	230	4.4%	230	4.4%	796	15.2%	1524	29.2%
Q4 2025	0	0.0%	230	4.4%	230	4.4%	796	15.2%	1524	29.2%
Q1 2026	0	0.0%	211	4.0%	211	4.0%	780	14.9%	1508	28.9%
Q2 2026	0	0.0%	4	0.1%	15	0.3%	26	0.5%	754	14.4%
Q3 2026	0	0.0%	4	0.1%	15	0.3%	26	0.5%	754	14.4%
Q4 2026	0	0.0%	4	0.1%	15	0.3%	26	0.5%	754	14.4%
Q1 2027	38	0.7%	47	0.9%	52	1.0%	155	3.0%	883	16.9%
Q2 2027	38	0.7%	48	0.9%	53	1.0%	156	3.0%	884	16.9%
Q3 2027	38	0.7%	48	0.9%	53	1.0%	156	3.0%	884	16.9%
Q4 2027	38	0.7%	48	0.9%	53	1.0%	156	3.0%	884	16.9%
Q1 2028	2	0.0%	9	0.2%	9	0.2%	112	2.1%	840	16.1%
Q2 2028	2	0.0%	8	0.2%	8	0.2%	111	2.1%	839	16.1%
Q3 2028	2	0.0%	3	0.1%	3	0.1%	106	2.0%	834	16.0%
Q4 2028	2	0.0%	2	0.0%	2	0.0%	102	2.0%	830	15.9%

	VE alone		VE + T1-3		VE + T1-4		VE + T1-5		VE + T1-6	
Q1 2029	2	0.0%	2	0.0%	2	0.0%	102	2.0%	830	15.9%
Q2 2029	2	0.0%	2	0.0%	2	0.0%	102	2.0%	830	15.9%
Q3 2029	2	0.0%	2	0.0%	2	0.0%	102	2.0%	830	15.9%
Q4 2029	2	0.0%	2	0.0%	2	0.0%	102	2.0%	830	15.9%
Q1 2030	2	0.0%	2	0.0%	2	0.0%	102	2.0%	830	15.9%
Q2 2030	2	0.0%	2	0.0%	2	0.0%	102	2.0%	830	15.9%
Q3 2030	2	0.0%	2	0.0%	2	0.0%	102	2.0%	830	15.9%
Q4 2030	2	0.0%	2	0.0%	2	0.0%	102	2.0%	830	15.9%
Max 2024-30	**38**	**0.7%**	**230**	**4.4%**	**230**	**4.4%**	**796**	**15.2%**	**1524**	**29.2%**
Max 2028-30	**2**	**0.0%**	**9**	**0.2%**	**9**	**0.2%**	**112**	**2.1%**	**840**	**16.1%**

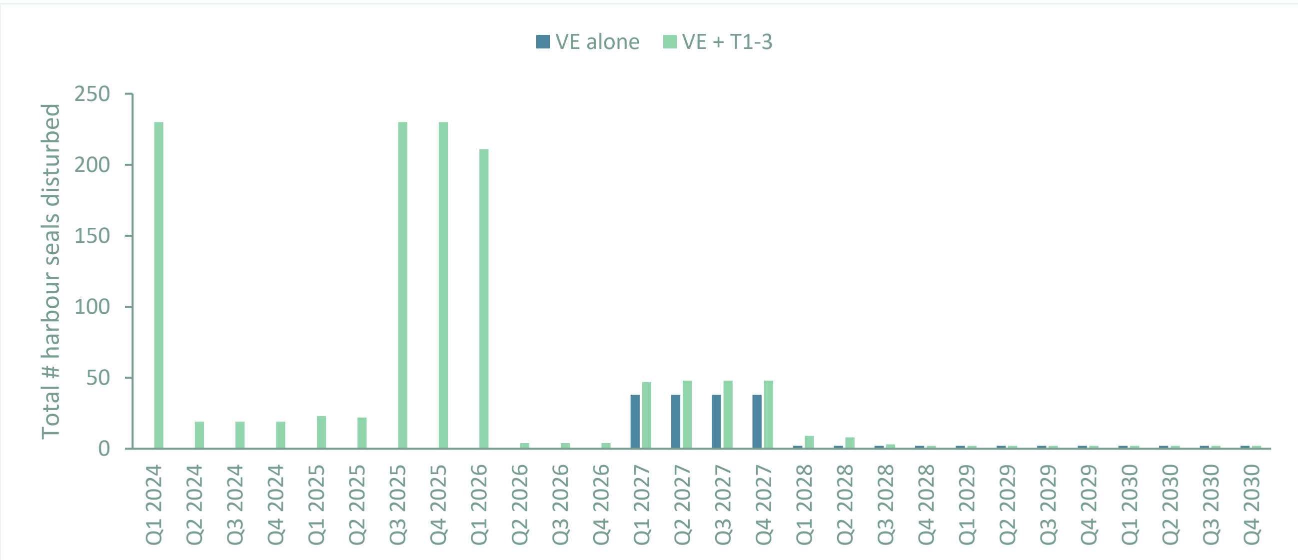

Figure 7.24: Cumulative underwater noise disturbance estimates to harbour seals for VE alone and VE in addition to Tier 1-3 projects.

GREY SEAL

7.14.44 The potential number of grey seals disturbed per day by project is provided in Table 7.37.

7.14.45 A summary of the total disturbance impact to grey seals per day by Tier, is provided in Table 7.38.

7.14.46 A summary of the total disturbance impact to grey seals per day across all projects in Tier 1-3 is provided in Table 7.22.

7.14.47 Across all years considered in the CEA (2024-2030 inclusive), the periods with highest levels of predicted disturbance to grey seals are in the years preceding the piling window for VE.

7.14.48 When considering the potential impact from VE 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 combined Southeast and Northeast England MUs is in 2024, when several central/southern North Sea projects are in construction (Dogger Bank projects, Hornsea 3, Norfolk Vanguard, East Anglia projects). At this time, a maximum of 2,097 grey seals (3.3% 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).

7.14.49 By comparison, the total impact to the Southeast and Northeast England MUs is expected to be much lower throughout the VE construction window (2028-2030). At this time, a maximum of 167 grey seals (0.3% MU) may be disturbed per day in 2028 (assuming all Tier 1-3 projects are constructing at the same time, and that disturbance is additive across projects), reducing to only 112 grey seals (0.2% MU) in 2029 and 2030 (as no T1-3 projects are due to be piling then).

7.14.50 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. The number of animals predicted to be impacted in this CEA across Tiers 1-4 (up to 3.3% MU) could potentially result in 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 likely not enough to affect the population trajectory over a generational scale. Therefore, the magnitude of the cumulative increase in disturbance from underwater noise is **Medium**.

7.14.51 The sensitivity of grey seals to disturbance from both UXO clearance has been assessed as **Low** and as **Negligible** for disturbance from piling.

7.14.52 Therefore, the effect significance of disturbance to grey seals from the cumulative impact of underwater noise is **minor (adverse)**, which is not significant in EIA terms.

Table 7.37: Number of grey seals potentially disturbed by underwater noise by project.

Project	VE	Dogger Bank A	Dogger Bank B	Sofia	Dogger Bank C	Hornsea 3	Norfolk Vanguard	Norfolk Boreas	East Anglia 1 N	East Anglia 2	Blyth Demo	Hornsea 4	Outer Dowsing	Dudgeon Extension	Sherringham Extension	North Falls	Dogger Bank South W	Dogger Bank South E	Seagreen C	Seismic Survey 1	Seismic Survey 2
Tier		**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**4**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**6**	**6**
Q1 2024		9	9	2	1	98	340			85	1553								2122	1548	1548
Q2 2024		9	9	2	1	98	4			85	1553								2122	1548	1548
Q3 2024		9	9	2	1	98	4			85	1553								2122	1548	1548
Q4 2024		9	9	2	1	98	4			85	1553								2122	1548	1548
Q1 2025					1	98	4		64	43	1553								2122	1548	1548
Q2 2025					1	98			64	43				114	591				2122	1548	1548
Q3 2025					1	98		344	64	43				114	591				2122	1548	1548
Q4 2025					1	98		344	64	43				114	591				2122	1548	1548
Q1 2026					1			344	2	43				114	591	219				1548	1548
Q2 2026					1			2	2	43		2028		1	1	219	535	369		1548	1548
Q3 2026					1			2	2	43		2028		1	1	219	535	369		1548	1548
Q4 2026					1			2	2	43		2028		1	1	219	535	369		1548	1548
Q1 2027	225					49		2	2	43		1489	1648			219	535	369		1548	1548
Q2 2027	225					49	4	2	2	43		1489	1648			219	535	369		1548	1548
Q3 2027	225					49	4	2	2	43		1489	1648			219	535	369		1548	1548
Q4 2027	225					49	4	2	2	43		1489	1648			219	535	369		1548	1548
Q1 2028	112					49	4		2				1648			219	535	369		1548	1548
Q2 2028	112					49			2				1648			219	535	369		1548	1548
Q3 2028	112								2				1648			219	535	369		1548	1548
Q4 2028	112												1648				535	369		1548	1548
Q1 2029	112												1648				535	369		1548	1548
Q2 2029	112												1648				535	369		1548	1548
Q3 2029	112												1648				535	369		1548	1548
Q4 2029	112												1648				535	369		1548	1548
Q1 2030	112												1648				535	369		1548	1548
Q2 2030	112												1648				535	369		1548	1548
Q3 2030	112												1648				535	369		1548	1548
Q4 2030	112												1648				535	369		1548	1548

Table 7.38: Total number of grey seals disturbed by underwater noise across the Tiers. Results including lower Tier projects, and thus with lower data confidence, are denoted by grey text.

	VE alone		VE + T1-3		VE + T1-4		VE + T1-5		VE + T1-6	
	#	% MU	#	% MU	#	% MU	#	% MU	#	% MU
Q1 2024	0	0.0%	2097	3.3%	2097	3.3%	4219	6.6%	7315	11.5%
Q2 2024	0	0.0%	1761	2.8%	1761	2.8%	3883	6.1%	6979	11.0%
Q3 2024	0	0.0%	1761	2.8%	1761	2.8%	3883	6.1%	6979	11.0%
Q4 2024	0	0.0%	1761	2.8%	1761	2.8%	3883	6.1%	6979	11.0%
Q1 2025	0	0.0%	1763	2.8%	1763	2.8%	3885	6.1%	6981	11.0%
Q2 2025	0	0.0%	206	0.3%	206	0.3%	3033	4.8%	6129	9.7%
Q3 2025	0	0.0%	550	0.9%	550	0.9%	3377	5.3%	6473	10.2%
Q4 2025	0	0.0%	550	0.9%	550	0.9%	3377	5.3%	6473	10.2%
Q1 2026	0	0.0%	390	0.6%	390	0.6%	1314	2.1%	4410	6.9%
Q2 2026	0	0.0%	48	0.1%	2076	3.3%	3201	5.0%	6297	9.9%
Q3 2026	0	0.0%	48	0.1%	2076	3.3%	3201	5.0%	6297	9.9%
Q4 2026	0	0.0%	48	0.1%	2076	3.3%	3201	5.0%	6297	9.9%
Q1 2027	225	0.4%	321	0.5%	1810	2.9%	4581	7.2%	7677	12.1%
Q2 2027	225	0.4%	325	0.5%	1814	2.9%	4585	7.2%	7681	12.1%
Q3 2027	225	0.4%	325	0.5%	1814	2.9%	4585	7.2%	7681	12.1%
Q4 2027	225	0.4%	325	0.5%	1814	2.9%	4585	7.2%	7681	12.1%
Q1 2028	112	0.2%	167	0.3%	167	0.3%	2938	4.6%	6034	9.5%
Q2 2028	112	0.2%	163	0.3%	163	0.3%	2934	4.6%	6030	9.5%
Q3 2028	112	0.2%	114	0.2%	114	0.2%	2885	4.5%	5981	9.4%
Q4 2028	112	0.2%	112	0.2%	112	0.2%	2664	4.2%	5760	9.1%

	VE alone		VE + T1-3		VE + T1-4		VE + T1-5		VE + T1-6	
Q1 2029	112	0.2%	112	0.2%	112	0.2%	2664	4.2%	5760	9.1%
Q2 2029	112	0.2%	112	0.2%	112	0.2%	2664	4.2%	5760	9.1%
Q3 2029	112	0.2%	112	0.2%	112	0.2%	2664	4.2%	5760	9.1%
Q4 2029	112	0.2%	112	0.2%	112	0.2%	2664	4.2%	5760	9.1%
Q1 2030	112	0.2%	112	0.2%	112	0.2%	2664	4.2%	5760	9.1%
Q2 2030	112	0.2%	112	0.2%	112	0.2%	2664	4.2%	5760	9.1%
Q3 2030	112	0.2%	112	0.2%	112	0.2%	2664	4.2%	5760	9.1%
Q4 2030	112	0.2%	112	0.2%	112	0.2%	2664	4.2%	5760	9.1%
Max 2024-30	**225**	**0.4%**	**2097**	**3.3%**	**2097**	**3.3%**	**4585**	**7.2%**	**7681**	**12.1%**
Max 2028-30	**112**	**0.2%**	**167**	**0.3%**	**167**	**0.3%**	**2938**	**4.6%**	**6034**	**9.5%**

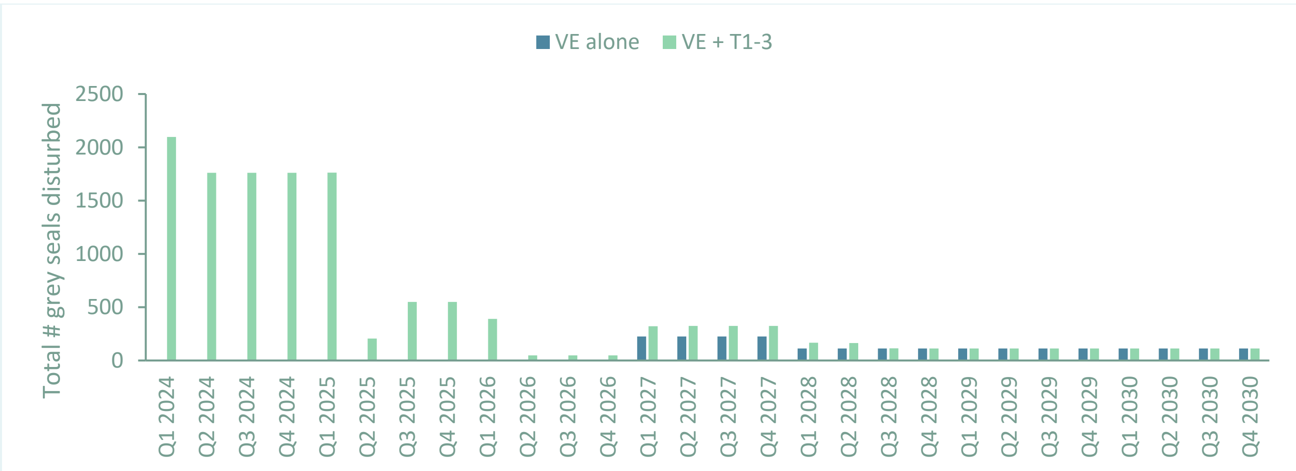

Figure 7.7.25: Cumulative underwater noise disturbance estimates to grey seals for VE alone and VE in addition to Tier 1-3 project.

DISTURBANCE FROM VESSEL ACTIVITY

7.14.53 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.

7.14.54 Although some OWF vessels (such as crew transport and supply vessels) may transit the wind farm 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 wind farm 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.

7.14.55 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 confined predominantly to construction sites. The vessel movements for offshore wind farms 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 vessel management plans (or comply with exiting Marine Wildlife Watching Codes) in order to minimise any potential effects on marine mammals.

7.14.56 Seismic surveys vessels may risk adding vessel presence to novel areas; however, these 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.

7.14.57 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.

7.14.58 The sensitivity of both porpoise and seal species to vessel disturbance has been assessed as **Negligible**.

7.14.59 Therefore, the effect significance of vessel disturbance to marine mammals from the cumulative impact of underwater noise is **Negligible**, which is not significant in EIA terms.

7.15 INTER-RELATIONSHIPS

7.15.1 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 (e.g. subsea noise effects from piling, operational WTGs, vessels and decommissioning); 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.

7.15.2 A description of the likely inter-related effects arising from VE on marine mammal ecology is provided in Volume 2, Chapter 14: Inter-relationships, with a summary of assessed inter-relationships provided below:

- Collision risk from vessel activity in the area (impact 7);
- Disturbance from vessel activity (impact 8);
- Changes to water quality (impact 9); and
- Changes to marine mammal prey species (impact 10).

7.15.3 The impact of inter-relationships between marine mammals and vessel disturbance has been assessed as **negligible** (adverse) significance to **minor** (adverse) significance. The impact of inter-relationships between marine mammals and collision risk, changes to water quality and prey species has been assessed as **not significant** in terms of EIA regulations 2017. 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 and applied mitigation already considered.

7.16 TRANSBOUNDARY EFFECTS

7.16.1 Transboundary effects are defined as those effects upon the receiving environment of other European Economic Area (EEA) states, whether occurring from VE alone, or cumulatively with other projects in the wider area. Transboundary effects have been screened in by PINS for marine mammals, see Volume 1, Appendix 3.2: Transboundary Screening for additional details on the screening process.

7.16.2 There may be behavioural disturbance or displacement of marine mammals from the VE suite 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 VE could extend into waters of other EEA states. VE OWF is located in close proximity to other states (e.g., French, German waters) and therefore there is the potential for transit of certain species between areas.

7.16.3 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 VE 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

7.16.4 Any transboundary impacts that do occur as a result of VE are predicted to be short-term and intermittent, with the recovery of marine mammal populations to affected areas following the completion of construction activities.

7.16.5 The magnitude of the impact has been assessed as **negligible** (adverse) to **low** (adverse) 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** (adverse) significance, which is **not significant** in terms of the EIA regulations 2017.

7.17 SUMMARY OF EFFECTS

7.17.1 This chapter has assessed the potential effects on marine mammal receptors arising from VE. The impacts considered include direct impacts (e.g. disturbance from piling), as well as indirect impacts (e.g. change in prey species abundance), alongside cumulative impacts (e.g. underwater noise from various offshore energy developments within the species MU). Potential impacts considered in this chapter, alongside any mitigation and residual effects are summarised in Table 7.39.

7.17.2 Throughout the construction, operation and decommissioning phases of VE, all impacts assessed were found to have either negligible, or minor effects on all marine mammal receptors and thus no impact pathway was considered to be significant in terms of the EIA Regulations.

7.17.3 The assessment of cumulative impacts from VE and other developments and activities concluded that the effects of any cumulative impacts would be of minor significance at the most, and thus no cumulative impact pathway was considered to be significant in regard of the EIA Regulations. The CEA will be reviewed at ES stage and the assessment will be updated to reflect any changes to project time scales or tiers based on new publicly available information.

Table 7.39: Summary of effects.

Description of impact	Effect	Additional mitigation measures	Residual impact
Construction			
Impact 1: PTS from UXO clearance	Negligible significance of effect for all species	MMMP for UXO	No significant adverse residual effects
Impact 2: Disturbance from UXO clearance	Minor significance of effect for harbour porpoise Negligible significance for grey and harbour seals		No significant adverse residual effects
Impact 3: PTS from piling	Negligible significance of effect for all species	MMMP (piling specific)	No significant adverse residual effects
Impact 4: TTS from piling	No assessment of significance		No significant adverse residual effects
Impact 5: Disturbance from piling	Minor significance of effect for harbour porpoise Negligible significance for grey and harbour seals		No significant adverse residual effects
Impact 6: PTS from other construction activities	Negligible significance of effect for all species	No mitigation required	No significant adverse residual effects
Impact 7: TTS from other construction activities	No assessment of significance	No mitigation required	No significant adverse residual effects
Impact 8: Disturbance from other construction activities	Minor significance of effect for harbour porpoise	No mitigation required	No significant adverse residual effects

Description of impact	Effect	Additional mitigation measures	Residual impact
	Negligible significance for grey and harbour seals		
Impact 9: Collision risk with vessels	Minor significance of effect for all species	VMP	No significant adverse residual effects
Impact 10: Disturbance with vessels	Minor significance of effect for all species		No significant adverse residual effects
Impact 11: Change in water quality	Negligible significance of effect for all species	No mitigation required	No significant adverse residual effects
Impact 12: Change in fish abundance/distribution	Negligible significance of effect for all species	No mitigation required	No significant adverse residual effects
Operation			
Impact 13: Operational noise	Negligible significance of effect for all species	No mitigation required	No significant adverse residual effects
Impact 9: Collision risk from vessels	Minor significance of effect for all species	VMP	No significant adverse residual effects
Impact 10: Disturbance from vessels	Negligible significance of effect for all species		No significant adverse residual effects
Impact 12: Change in fish abundance/distribution	Negligible significance of effect for all species	No mitigation required	No significant adverse residual effects
Decommissioning			
Impact 14: PTS and disturbance	Minor significance of effect for all species	Decommissioning MMMP	No significant adverse residual effects

Description of impact	Effect	Additional mitigation measures	Residual impact
Impact 9: Collision risk from vessels	Minor significance of effect for all species	VMP	No significant adverse residual effects
Impact 10: Disturbance from vessels	Minor significance of effect for all species		No significant adverse residual effects
Impact 12: Change in fish abundance/distribution	Negligible significance of effect for all species	No mitigation required	No significant adverse residual effects
Cumulative effects			
Disturbance from underwater noise	Minor significance of effect for all species	No mitigation required	No significant adverse residual effects
Disturbance from vessels	Negligible significance of effect for all species	No mitigation required	No significant adverse residual effects

7.18 NEXT STEPS

7.18.1 The following steps will be undertaken in order to progress the marine mammal ecology assessment from PEIR stage to DCO application stage:

- All feedback post-PEIR will be used to inform and update the marine mammal assessment and presented within the ES, where necessary.
- The latest references, positions and/ or guidance will be worked into the assessment and presented within the ES, where necessary.
- Further consultation and engagement will be undertaken through the Marine Mammal ETG.

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FIVE ESTUARIES
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