FIVE ESTUARIES OFFSHORE WIND FARM

ENVIRONMENTAL STATEMENT

VOLUME 6, PART 2, CHAPTER 7: MARINE MAMMAL ECOLOGY

Application Reference	EN010115
Application Document Number	6.2.7
Revision	A
APFP Regulation	5(2)(a)
Date	March 2024

Project	Five Estuaries Offshore Wind Farm
Sub-Project or Package	Environmental Statement
Document Title	Volume 6, Part 2, Chapter 7: Marine Mammal Ecology
Application Document Number	6.2.7
Revision	A
APFP Regulation	5(2)(a)
Document Reference	005024202-01

Revision	Date	Status/Reason for Issue	Originator	Checked	Approved
A	Mar-24	ES	GoBe & SMRU Consulting	GoBe	VE OWFL

TABLES

FIGURES

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
WCS	Worst Case Scenario
WTG	Wind Turbine Generator
ZOI	Zone of Influence

GLOSSARY OF TERMS

Term	Definition
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.
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.
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.
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

Term	Definition
	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 Environmental Statement (ES) chapters and technical reports:

> Volume 6, Part 2, Chapter 1: Offshore Project Description;
> Volume 6, Part 2, Chapter 2: Marine Geology, Oceanography and Physical Processes;
> Volume 6, Part 2, Chapter 3: Marine Water and Sediment Quality;
> Volume 6, Part 2, Chapter 5: Benthic Ecology;
> Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology;
> Volume 6, Part 2, Chapter 8: Commercial Fisheries;
> Volume 6, Part 5, Annex 7.1: Marine Mammal Baseline Characterisation;
> Volume 9, Report 14.1: Outline Marine Mammal Mitigation Protocol (MMMP) - Piling;
> Volume 9, Report 14.2: Outline MMMP for Unexploded Ordnance - UXO;
> Volume 9, Report 15: Outline Southern North Sea Special Area of Conservation Site Integrity Plan (Outline SNS SAC SIP);
> Volume 9, Report 18.1: Working in Proximity to Marine Wildlife
> Volume 6, Part 5, Annex 6.2: Underwater Noise Technical Report;
> Volume 6, Part 5, Annex 6.2.1: Landfall Impact Piling Technical Report
> Volume 5, Report 4: Report to Inform Appropriate Assessment (RIAA);
> Volume 6, Part 5, Annex 4.10: 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
> Volume 6, Part 5, Annex 4.11: 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 the assessment of potential impacts on marine mammals associated with the construction, operation and maintenance (O&M), and decommissioning of VE. The Planning Act 2008 and Marine Works (Environmental Impact Assessment; EIA) 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 mammals.

7.2.2 The following section provides information regarding the legislative context surrounding the assessment of potential effects in relation to marine mammals. Full details of all policy and legislation relevant to the VE application are provided within Volume 6, Part 1, Chapter 2: Policy and Legislation. A summary of the current policy and legislation specifically relevant to marine mammals is provided below. Five Estuaries Offshore Wind Farm Limited (hereafter the Applicant) 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 Planning Act 2008;
- The Marine Works (Environmental Impact Assessment) Regulations 2007 (as amended);
- The Convention on the Conservation of European Wildlife and Natural Habitats (the Bern Convention; 1979);
- EU Council Directive 92/43/EEC on the conservation of natural habitats and of wild flora and fauna (the 'Habitats Directive');
- EU Directive 2008/56/EC Marine Strategy Framework Directive;
- The Conservation of Offshore Marine Habitats and Species Regulations 2017 (as amended);
- The Conservation of Habitats and Species Regulations 2017;
- Marine and Coastal Access Act 2009;
- The Wildlife and Countryside Act 1981 (as amended);
- 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;
- East Inshore and Offshore Coast Marine Plans; and
- The Conservation of Seals Act 1970.

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

7.2.5 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).

7.2.6 The approach to this ES chapter will follow the approach outlined in Volume 6, Part 1, Chapter 3: EIA Methodology. In addition to the guidance outlined Volume 6, Part 1, Chapter 3, the assessment of marine mammals will also comply with the following guidance documents where they are specific to the topic:

- Offshore Wind Marine Environmental Assessments: Best Practice Advice for Evidence and Data Standards. Phase I: Expectations for pre-application baseline data for designated nature conservation and landscape receptors to support offshore wind applications (Natural England, 2021);
- Offshore Wind Marine Environmental Assessments: Best Practice Advice for Evidence and Data Standards. Phase III: Expectations for data analysis and presentation at examination for offshore wind applications (Natural England, 2022);
- Marine environment: UXO clearance joint interim position statement[1] compiled by Defra, the Department for Business, Energy and Industrial Strategy (BEIS, now DESNZ), the MMO, the JNCC, Natural England, the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED), the Department of Agriculture, Environment and Rural Affairs (DAERA), NatureScot and Marine Scotland (Defra *et al*., 2021);
- Marine Mammal Noise Exposure Criteria: Assessing the severity of marine mammal behavioural responses to human noise (Southall *et al*., 2021);
- Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects (Southall *et al*., 2019);
- The protection of marine European Protected Species from injury and disturbance. Guidance for the marine area in England and Wales and the UK offshore marine area (JNCC *et al*., 2010);
- The Planning Inspectorate (hereafter referred to as the Inspectorate) Advice Note 7: EIA: Process, Preliminary Environmental Information and Environmental Statements (The Inspectorate, 2020);
- Updated cumulative effects assessment tier system (Natural England, 2022);
- Chartered Institute of Ecology and Environmental Management (CIEEM) Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater, Coastal and Marine (CIEEM, 2019);
- Oslo Paris Convention (OSPAR) Guidance on Environmental Considerations for OWF Development (OSPAR, 2008);
- Environmental Impact Assessment for offshore renewable energy projects – guide (British Standards Institute, 2015);
- Approaches to Marine Mammal Monitoring at Marine Renewable Energy Developments (Macleod *et al*., 2010);

[1] https://www.gov.uk/government/publications/marine-environment-unexploded-ordnance-clearance-joint-interim-position-statement

- Guidelines for Data Acquisition to Support Marine Environmental Assessments of Offshore Renewable Energy Projects (Judd, 2012);
- Guidance for assessing the significance of noise disturbance against Conservation Objectives of harbour porpoise SACs (JNCC, 2020);
- JNCC guidelines for minimising the risk of injury to marine mammals from using explosives (JNCC, 2010a);
- Statutory Nature Conservation Agency Protocol for Minimising the Risk of Injury to Marine Mammals from Piling Noise (JNCC, 2010b);
- Marine mammal observations and compliance with JNCC guidelines during pile driving operations from 2010–2021 (Stone, 2023);
- An exploration of time-area thresholds for noise management in harbour porpoise SACs literature review and population modelling (Brown *et al.,* 2023);
- An approach to impulsive noise mitigation in English waters (Defra *et al.*, 2022); and
- An approach to impulsive noise mitigation in English waters - Appendix A (Defra *et al.*, 2022).

Table 7.1: Legislation and policy context.

Legislation/Policy	Key Provisions	Section Where Comment Addressed
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 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*"	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 7.10, 7.11, 7.12 and 7.13.
Overarching National Policy Statement for Energy NPS EN-1 (DESNZ, 2023a)	Paragraph 5.4.17 and 5.4.18 of 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*	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) (Volume 5, Report 4.2) and where relevant will be

Legislation/Policy	Key Provisions	Section Where Comment Addressed
	environmental information proportionate to the infrastructure where EIA is not required to help the Infrastructure Planning Commission (IPC) consider thoroughly the potential effects of a proposed project."	included in the RIAA (Volume 5, Report 4.2).
	Paragraph 5.4.4 and 5.4.5 of NPS EN-1 state: *"The highest level of biodiversity protection is afforded to sites identified through international conventions. 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 (HRA) Screening Report (RIAA) (Volume 5, Report 4.2) and where relevant will be included in the RIAA (Volume 5, Report 4).
	Paragraph 5.4.7 and 5.4.8 of 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 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*	There are no marine mammal SSSIs which are considered to be at risk of effect from the construction, operation and decommissioning of VE, and as such no further consideration of SSSIs has been given.

Legislation/Policy	Key Provisions	Section Where Comment Addressed
	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."	
	Paragraph 5.4.16 of NPS EN-1 state: *"Many individual species receive statutory protection under a range of legislative provisions.184 Other species and habitats have been identified as being of principal importance for the conservation of biodiversity in England and Wales, as well as for their continued benefit for climate mitigation and adaptation and thereby requiring conservation action."*	All species receptors, including those of conservation importance are summarised in Section 7.4.3.
National Policy Statement for Renewable Energy Infrastructure (EN-3) (DESNZ, 2023b)	Paragraph 2.8.127 of the 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*	Injury and disturbance from piling and UXO clearance has been assessed in section 7.10 as part of the assessment of construction impacts on marine mammals. The

Legislation/Policy	Key Provisions	Section Where Comment Addressed
	levels which are high enough to cause disturbance, injury, or even death to marine mammals."	Applicant are not seeking to licence UXO in the DCO however, a Volume 9, Report 14.2: Outline MMMP - UXO is submitted at ES. All appropriate licencing requirements will be met post-consent. European Protected Species (EPS) wildlife licences to disturb and injure are required for piling and UXO clearance and an application will be made prior to start of construction.
	Paragraph 2.8.128 of the NPS EN-3 states: *"All marine mammals are protected under Part 3 of the Habitats Regulations."*	
	Paragraph 2.8.129 of the NPS EN-3 states: *"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), applicants will need to apply for a wildlife licence to allow the activity to take place."*	
	Paragraph 2.8.130 of the NPS EN-3 states: *"The development of offshore wind farms can also impact fish species (see paragraphs 2.8.129 – 2.8.133), which can have indirect impacts on marine mammals if those fish are prey species."*	The potential impacts to prey availability from construction are assessed in Section 7.10.
	Paragraph 2.8.131 of the NPS EN-3 states: *"Where necessary, assessment of the effects on marine mammals should include details of:* > *likely feeding areas and impacts on prey species and prey habitat;*	The ES has considered the effects from all development stages on marine mammals. These assessments are provided from Sections 7.10 to 7.13.

Legislation/Policy	Key Provisions	Section Where Comment Addressed
	> *known birthing areas / haul out sites for breeding and pupping;* > *migration routes;* > *protected sites;* > *baseline noise levels;* > *predicted construction and soft start noise levels in relation to mortality, permanent threshold shift (PTS), temporary threshold (TTS) and disturbance;* > *operational noise;* > *duration and spatial extent of the impacting activities including cumulative/incombination effects with other plans or projects;* > *collision risk;* > *entanglement risk; and* > *barrier risk"*	
	Paragraph 2.8.132 of the NPS EN-3 states: *"The scope, effort and methods required for marine mammal surveys should be discussed with the relevant SNCB."*	The scope, effort and methods for marine mammal surveys were discussed throughout Volume 5, Report 5.2.1: Evidence Plan Process.
	Paragraph 2.8.133 of the NPS EN-3 states: *"The applicant should discuss any proposed noisy activities with the relevant body and must reference*	The impacts of the Proposed Development on designated sites are assessed in Volume 5, Report

Legislation/Policy	Key Provisions	Section Where Comment Addressed
	the joint JNCC and SNCB underwater noise guidance in relation to noisy activities (alone and in-combination with other plans or projects) within HRA sites, in addition to the JNCC mitigation guidelines to piling, explosive use, and geophysical surveys."	5.4: RIAA. The mitigation measures for underwater noise are specified in Table 7.16 and further detail can be found in the Volume 9, Report 14.1: Outline MMMP - Piling.
	Paragraph 2.8.134 of the NPS EN-3 states: *"Where the assessment identifies that noise from construction and UXO clearance may reach noise levels likely to lead to noise thresholds being exceeded (as detailed in the JNCC guidance) or an offence as described in paragraph 2.8.138 above, the applicant will be expected to look at possible alternatives or appropriate mitigation"*	The mitigation measures for underwater noise are specified in and further detail can be found in Volume 9, Report 9.14.1: Outline MMMP - Piling and Volume 9, Report 9.14.2: Outline MMMP - UXO.
	Paragraph 2.8.135of the NPS EN-3 states: *"The applicant should develop a Site Integrity Plan (SIP) to allow the cumulative impacts of underwater noise to be reviewed closer to the construction date, when there is more certainty in other plans and projects."*	Volume 9, Report 9.15: Outline Southern North Sea Special Area of Conservation Site Integrity Plan details the mitigation methods that could be used to reduce the impacts of underwater noise has been provided. A final SIP will be produced for piling and UXO in the post-consent stage when there is more certainty on project timescales and an in-combination assessment will be presented taking into account projects that are

Legislation/Policy	Key Provisions	Section Where Comment Addressed
		confirmed to be undertaking works in the same seasons as VE.
	Paragraph 2.8.237 of the 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. Active displacement of marine mammals outside potential injury zones can be undertaken using equipment such as acoustic deterrent devices. 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"*	The details of marine mammal mitigation is presented within Volume 9, Report 14.1: Outline MMMP - Piling. See Table 7.16 for more information. Monitoring of marine mammals has been detailed within Volume 9, Report 9.32: Offshore In Principle Monitoring Plan (IPMP).
	Paragraph 2.8.238 & 2.8.239 of the NPS EN-3 states: *"Where noise impacts cannot be avoided, other mitigation should be considered, including alternative installation methods and noise abatement technology, spatial/temporal restrictions on noisy activities, alternative foundation types. Applicants should undertake a review of up-to-date research should be undertaken and all potential mitigationoptions presented as part of the application, having consulted the relevant JNCC mitigation guidelines."*	The details of marine mammal mitigation options for piling and UXO clearance, including at-source noise abatement methods, are presented within Volume 9, Report 9.14.1: Outline MMMP - Piling and Volume 9, Report 9.14.2: Outline MMMP - UXO. Where practicable the use of low order methods to dispose of UXOs using deflagration will be implemented.

7.3 CONSULTATION

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 (PINS), 2020) was issued in November 2021 by PINS. VE's PEIR consultation ran from 14 March to 12 May 2023.

7.3.2 A record of key areas of consultation specific to marine mammals 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 Volume 5, Report 1: Consultation report, is submitted 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 were 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 7.1 and Volume 6, Part 5, Annex 7.1: Marine Mammal Baseline Characterisation). Harbour porpoise, grey seal and harbour seal remain scoped into the ES chapter.
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 7.10, however it does not include an assessment of significance, as agreed.
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 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	The CEA assesses the worst case scenario, see section 7.13. Barrier effects have been included within the assessment of disturbance, as both behavioural disturbance and displacement together are assessed within the dose-response function therefore there is no separate assessment of barrier effects (Section 7.10). TTS has been scoped in for construction impacts, see section 7.10.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	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 6, Part 5, 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 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.	At PEIR, and now at ES, the three species included in assessment are the harbour porpoise, grey seal and harbour seal based on VE site-specific surveys (see Section 7.7). No other species were identified in the two years of site specific surveys at VE, see Volume 6, Part 5, Annex 7.1: Marine Mammal Baseline Characterisation.
Scoping Opinion	Table 11.2 Natural England agrees that all relevant marine mammal protected areas have	Updates to Figure 11.5 of the Scoping Report reflects the

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
(Natural England, 2021)	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.	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 7.7.
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 included within the assessment of disturbance, as both behavioural disturbance and displacement together are assessed within the dose-response function therefore there is no separate assessment of barrier effects, see section 7.10.
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 6, Part 5, Appendix 6.2: Underwater Noise Technical Report and presented in section 7.11. 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 provided as to not undertaking a meaningful assessment of impact significance.	TTS impact ranges have been presented in Table 7.28 and Table 7.30. There is no assessment of magnitude, sensitivity or significance as previously agreed with Natural England.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
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 included within the assessment of disturbance, as both behavioural disturbance and displacement together are assessed within the dose-response function therefore there is no separate assessment of barrier effects, see section 7.10.
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 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.	No action required as this is an observation only.
Scoping Opinion	We understand that the applicant has also relied on the Project Environmental	Volume 9, Report 9.18: Outline Project

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
(Natural England, 2021)	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.	Environmental Management Plan (PEMP) is submitted at ES and has been added to the mitigation list in Section 7.9 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 7.13 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 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.	The data sources identified in section 7.4.4 below have not recorded the presence of any other relevant marine mammals.
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	Further justification has been provided in section 7.4.2 as to the scoping out of

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	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 consultation bodies and the absence of LSE on the environment.	accidental pollution, this has been agreed with SNCBs.
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	TTS impact ranges have been presented in section 7.10, there has been no assessment of magnitude, sensitivity or significance as previously agreed with Natural England.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	report on TTS ranges and areas, this matter can be scoped out of further assessment.	
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 7.10.
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 included within the assessment of disturbance for the construction phase, as both behavioural disturbance and displacement together are assessed within the dose-response function therefore there is no separate assessment of barrier effects see section 7.10.
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 colonies in relation to VE are in Essex and Kent (SCOS, 2022). Information on

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
		harbour seal breeding colonies have been included in Section 7.7.
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.	Volume 9, Report 9.14.1: Outline MMMP - Piling and Volume 9, Report 9.14.2: Outline MMMP - UXO is submitted at ES which establishes the mitigation. Volume 9, Report 18.1: Working in Proximity to Wildlife and Volume 9, Report 9.15: Outline SNS SAC SIP will also be provided as part of the DCO application
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 MDS for VE has been included in the CEA, see section 7.13.
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 7.4 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*., 2006a; Teilmann *et al*., 2006b; Cefas, 2010; Brasseur *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
	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 7.10. 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 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.	Underwater noise from other (non-piling) construction activities is assessed in section 7.10.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
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 7.10.
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 Section 7.6.
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 9, Report 9.14.1: Outline MMMP - Piling is submitted alongside this ES chapter which discusses the potential mitigation used to reduce PTS, TTS and 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 CEA, see section 7.13 for details.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
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 included as part of the disturbance assessment, as both behavioural disturbance and displacement together are assessed within the dose-response function therefore there is no separate assessment of barrier effects, see section 7.10.
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 7.10, there has been no assessment of magnitude, sensitivity or significance as previously agreed. This agrees 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 7.11.
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 6, Part 5, Annex 6.2: Underwater Noise Technical Report and assessed in Section 7.10.
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 6. Part 5, Annex 7.1: Marine Mammal Baseline Characterisation with the requested literature included.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
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.
Pre PEIR ETG (November 2022)	Essex Wildlife Trust highlighted the Thames Estuary Harbour Porpoise Report (ZSL and MCR, 2022) for inclusion in the marine mammal baseline.	The data from ZSL and MCR (2022) has been included in Table 7.3 and has been referenced in Volume 6, Part 5, Annex 7.1: Marine Mammal Baseline Characterisation.
Section 42 responses (Natural England, 2023)	Natural England does not agree with the assigned sensitivity and magnitude for harbour porpoise throughout the assessment of underwater noise impacts. They advise that these assignments should be revised particularly due to the sensitivity of UXO clearance and piling. They believe other impacts have been downplayed as well e.g. PTS, prey, disturbance due to operational noise and changes in fish abundance/distribution during operation.	Sensitivity is defined by the biology of the species and the Applicant is not aware of any additional literature to support a change in the sensitivity of harbour porpoise from underwater noise. The sensitivity definitions align with those presented in other projects' EIAs. The four levels of sensitivity have been changed from: Negligible/Low/Medium/High to Low/Medium/High/Very High in line with Natural England's recommendations.
Section 42 responses (Natural England, 2023)	NE's mains concern is related to the assigned magnitude and sensitivity for harbour porpoise throughout the assessment of underwater noise impacts. The current assessment with assigned 'negligible' or 'low' sensitivity/magnitude does not fully reflect the sensitivity of this species to underwater noise. Additionally, there does not seem to be a 'hierarchy' of assigned scores between high and low impact activities. For example, sensitivity score 'Low' is assigned both for PTS from UXO clearance and piling as well as for disturbance from other construction activities. There are other examples (see detailed	The four levels of sensitivity have been changed from: Negligible/Low/Medium/High to Low/Medium/High/Very High in line with Natural England's recommendations. With regards to magnitude, the assessment now differentiates between magnitude pre- and post-mitigation.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	comments) where we feel that the assigned scores should be amended. NE recommend that the assigned sensitivity/magnitude scores are revised to take into account the sensitivity of harbour porpoise to underwater noise, especially when it comes to impacts of UXO clearance and piling.	
Section 42 responses (Natural England, 2023)	Natural England provided detailed comments on the Survey Reports on 12 November 2021 and 01 February 2023. The comments provided remain relevant.	This is noted by the Applicant.
Section 42 responses (Natural England, 2023)	The survey methodology is appropriate, and it follows the standard practice for digital aerial surveys for seabirds and marine mammals, occurring every month over a period of two years.	This is noted by the Applicant. The marine mammal survey is detailed in the Volume 6, Part 5, Annex 4.11: Digital Video Aerial Surveys of Seabirds and Marine Mammals at Five Estuaries: Two-year Report for March 2019 to February 2021 and summarised in Paragraph 7.4.3.
Section 42 responses (Natural England, 2023)	Natural England agrees with the Management Units (MUs) for three key marine mammal species as a basis for the appropriate reference populations for the assessment.	This is noted by the Applicant. The baseline assessment is detailed in the Volume 6, Part 5, Annex 7.1: Marine Mammals Baseline Characterisation and summarised in Paragraph 7.4.3.
Section 42 responses (Natural England, 2023)	Natural England agrees that the adjusted average density estimate for harbour porpoises derived from the site-specific surveys is suitable density for further quantities impact assessment and that Carter et al, 2020,2022 are the appropriate references for estimating grid-cell specific seal densities.	This is noted by the Applicant. This baseline assessment is detailed in the Volume 6, Part 5, Annex 7.1: Marine Mammals Baseline Characterisation (and the density estimates have been used in the quantitative assessments in Section 7.10.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
Section 42 responses (Natural England, 2023)	NE state that the data sources used to characterise the baseline are appropriate and up to date.	The baseline has been updated at the ES stage based on the publication of SCANS IV (Gilles et al. 2023) and SCOS (2023).
Section 42 responses (Natural England, 2023)	The data analysis and rational provided are satisfactory and in line with Natural England's Best Practice Guidelines.	This is noted by the Applicant. The background to the data analysis is presented in Sections 7.5 and 7.6.
Section 42 responses (Natural England, 2023)	Natural England is satisfied that all the key potential pressures/impacts and receptors have been identified.	This is noted by the Applicant.
Section 42 responses (Natural England, 2023)	Natural England notes that an indicative assessment has been provided for UXO clearance within this document and that a separate Marine Licence will be submitted when more information on the number and size of UXOs in the area become available.	The assessment for UXO clearances is presented in Section 7.10. As agreed, a separate assessment of UXO will be undertaken at the post-consent stage when more information is known and geophysical surveys have taken place. As part of the post-consent Marine Licence (ML) application for UXO clearance works, an EPS licence will be applied for, MMMP submitted, and an assessment of impacts on the Southern North Sea SAC (site code: UK0030395) will be presented in the post-consent SIP and RIAA. An initial in-combination assessment of UXO clearance has been presented in Volume 5, Report 5.4: RIAA and mitigation detailed in the Volume 9, Report 15: Outline SNS SAC SIP.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
Section 42 responses (Natural England, 2023)	Natural England broadly agrees with the approach taken for the underwater noise modelling and the assessment.	This is noted by the Applicant.
Section 42 responses (Natural England, 2023)	Table 7.6 - Table 7.8 refers to 'Neutral' magnitude, but this is not defined within Table 7.6.	The methodology language has been amended to 'Negligible' in line with the definitions in Table 7.6.
Section 42 responses (Natural England, 2023)	Natural England notes that the newest version of INSPIRE programme has been used to reduce 'unnecessary conservatism' in modelling. This being the case, we do not agree with the conclusion that the SEL_{cum} PTS predictions are 'highly precautionary' and 'very unlikely'. NE note that this comment is for awareness.	This is noted by the Applicant.
Section 42 responses (Natural England, 2023)	Natural England does not agree with the assigned 'Low' magnitude for Permanent Threshold Shift (PTS) from UXO clearance. Considering that the PTS constitutes irreversible hearing damage, more appropriate magnitude would be 'Medium', as per the definition provided in Table 7.6: "Permanent effects on individuals that may influence individual survival but not at a level that would alter population trajectory over a generational scale (Negative)." With the implementation of appropriate mitigation measures the magnitude could be reduced to Low.	The magnitude scores presented in PEIR were assigned after the consideration of a UXO MMMP which will reduce the risk to negligible levels. Section 7.10 has been amended to state the magnitude score for UXO clearance before and after mitigation. This approach was discussed in the ETG dated 5 September 2023.
Section 42 responses (Natural England, 2023)	In general NE feel that the assigned magnitude and sensitivity has been downplayed throughout the assessment, particularly for harbour porpoise. NE recommend that the assigned scores are revised to take into account the sensitivity of harbour porpoise to UWN, especially concerning UXO. Also, there does not seem to be a 'hierarchy' of assigned scores between high and low impact activities. For example, sensitivity score 'Low' is assigned for PTS from UXO clearance and	The magnitude scores have been revisited in Sections 7.10, 7.11 and 7.12 to present scores both before and after the application of mitigation measures (see Table 7.16). The four levels of sensitivity have been changed from:

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	piling as well as for disturbance from other construction activities. This requires revisiting.	Negligible/Low/Medium/High to Low/Medium/High/Very High in line with Natural England's recommendations
Section 42 responses (Natural England, 2023)	There seems to be an error in paragraph 7.11.107 whereby a sentence from the Section 7.11.102 is copied here, while there is a missing information on the assigned magnitude.	The text has been amended to detail the impacts on magnitude.
Section 42 responses (Natural England, 2023)	The statement in this paragraph on the presence of the novel vessels on site ("The introduction of additional vessels during construction of VE is not a novel impact for marine mammals present in the area") contradicts the statement made in paragraph 7.11.51. This states that "In addition to this mitigation, it is also likely that the presence of novel vessels and associated construction activity will ensure that the vicinity of the pile is free of harbour porpoise by the time that piling begins". Thus, the former statement suggests that harbour porpoises are habituated to the presence of vessels, while the latter suggests that the vessels on site do disturb and deter the animals prior to the construction activities.	The text has been revised for better clarification.
Section 42 responses (Natural England, 2023)	It is unclear whether the documents mentioned here (i.e., the Codes of Conduct provided by the WiSe Scheme, Scottish Marine Wildlife Watching Code or Guide to Best Practice for Watching Marine Wildlife) be included within the Vessel Management Plan.	Volume 9, Report 18.1: Working in Proximity to Wildlife is submitted at ES. This document will be developed during the pre-construction phase and will determine vessel routing to minimise, as far as possible, encounters with marine mammals. It will also consider codes of conduct provided by WiSe, Marine Wildlife Watching Code and Guide to Best Practice.
Section 42 responses	NE believe the assigned magnitude of 'Negligible' is not sufficiently precautionary	The magnitude text has not been amended and is

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
(Natural England, 2023)	given the importance of prey to marine mammals, thus they advise that this is revised to 'Low'.	assigned Negligible. This does not impact the significance under the EIA Regulations 2017 therefore the conclusion for change in fish abundance/distribution (prey) from decommissioning activities remains not significant.
Section 42 responses (Natural England, 2023)	NE believe given the uncertainty around the noise emitted by larger turbines, it would be more precautionary to assign "Low" magnitude for disturbance instead of "Negligible."	As outlined in section 7.11 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. It is unlikely that operational noise is expected to be of a level that would result in any disturbance effect. Therefore, the magnitude remains Negligible (Section 7.11).
Section 42 responses (Natural England, 2023)	It is stated in paragraph 7.12.10 that the total number of vessels and peak number of vessels on site will be 25 while the Volume 6, Part 2, Chapter 1: Offshore Project Description (Table 1.40) states that there will be 27 vessels. Please clarify which number of vessels is correct.	The total number of vessels throughout per year throughout operation phase is 27. This has been amended throughout Section 7.10.
Section 42 responses (Natural England, 2023)	This paragraph states that the change in fish abundance/distribution from operation will be "highly localised". We disagree that the effects will be 'highly localised' as there is no evidence to support this. The spatial extent of changes to fish abundance/distribution due to increased fishing pressure outside of the array area is unknown. Therefore, when we combine the spatial footprint of the OWF and unknown spatial extent of this impact around the OWF, the resulting effect cannot be 'highly localised.	The magnitude text has not been amended and is assigned Negligible. This does not impact the significance under the EIA Regulations 2017 therefore the conclusion for change in fish abundance/distribution (prey) from decommissioning activities remains not significant.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	Thus, it would be precautionary to amend the assigned magnitude from 'Negligible' to 'Low'.	
Section 42 responses (Natural England, 2023)	Natural England broadly agrees with the cumulative assessment methodology. Any changes in the assessment score for individual activities (as per the above comments) should be reflected in cumulative assessment and amended accordingly.	The CEA presented in section 7.13 includes any new projects in the marine mammal study area that are planning to construct in the same time period as VE, . The information presented regarding timelines and development stages of projects included at PEIR was based on publicly available knowledge and will be reviewed an updated as necessary.
Section 42 responses (Natural England, 2023)	There is an error in this sentence: "The following Section provides information regarding the legislative context surrounding the assessment of potential effects in relation to fish and shellfish ecology.". The sentence should refer to marine mammals not fish and shellfish.	The text in this sentence has been amended to reflect that the assessment is on marine mammals.
Section 42 responses (Natural England, 2023)	Table 7.1 - Please note that Special Protection Areas (SPA) are not relevant to marine mammals.	The text in this table has been amended to reflect that SPAs are not designated for marine mammals but that SACs are.
Section 42 responses (Natural England, 2023)	NE advise that habitat loss needs to be included as an impact pathway for all relevant sites. There is a clear overlap with the Southern North Sea Special Area of Conservation (SNS SAC). Habitat loss should be taken through to the Appropriate Assessment stage unless a clear justification can be made that there would be no Likely Significant Effect (LSE) either alone, or in-combination with other projects with footprints within the SNS SAC.	Habitat loss has been screened into the Volume 5, Report 5.4: RIAA for the SNS SAC. On a precautionary basis habitat loss has been scoped in and assessed in Sections 7.10, 7.11 and 7.12 for harbour porpoise to align the assessments for marine mammals in the HRA and EIA.
Section 42 responses (MMO, 2023)	The MMO provides a breakdown of the sites which could be affected by VEs and any associated management measures within them	EPS licences will be applied for at the post-consent stage for cetaceans for piling and

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	and what species are legally protected such as harbour porpoise and seals. The MMO consider that a wildlife licence is likely to be required for these works for potential disturbance and injury to cetaceans, and injury to seals for reasons provided above. Early engagement is recommended with the MMO on this matter.	UXO clearance. Marine wildlife licences will be applied for pinnipeds.
Section 42 responses (MMO, 2023)	Continuous (non-piling sources): Small effect ranges (largely < 100m) have been predicted for other sources of noise including the operational noise from wind turbines, and various construction activities (i.e., cable laying, suction dredging, trenching, rock placement and vessel noise). A fleeing animal receptor has been assumed for all marine mammals, and therefore the predicted effect ranges are minimal.	This is noted by the Applicant.
Section 42 responses (MMO, 2023)	UXO Clearance: The MMO have provided a breakdown of the assessment of UXOs and the predications. The MMO consider the predictions look reasonable. The MMO welcome that the final MMMP will be updated post-consent to take into account the most suitable mitigation measures. For UXO clearance, a Marine License will be applied for post-consent and included in that application will be a UXO MMMP. The MMO consider the current approach to mitigation outlined within the MMMP is appropriate.	The applicant has produced an Outline MMMP for UXO clearance (Volume 9, Report 14.2) submitted with this ES to provide examples of potential mitigation measures that could be implemented by VE. A final UXO MMMP will be produced post-consent as part of the UXO clearance marine licence application.
Section 42 responses (MMO, 2023)	The MMO do not agree that it would be inappropriate to assess the significance of TTS, and believe an assessment of TTS should be included in underwater noise impact assessments, in addition to the assessment of the risk of PTS and disturbance. However, it was agreed that, as a minimum, the predicted TTS effect ranges along with the number of animals at risk should be present in the ES.	TTS impact ranges have been presented in Section 7.10, 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 December 2021.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
Section 42 responses (MMO, 2023)	Chapter 7 Marine Mammals, Section 7.5.18 - A 5 km Effective Deterrence Range (EDR) for low order detonations has been assumed, which was suggested by Sofia Offshore Wind Farm. The MMO requested further evidence to support this EDR, and it was noted that Sofia Offshore Wind Farm would be undertaking underwater noise monitoring for low order clearance to provide empirical data to evidence the 5 km EDR. The MMO are yet to see empirical evidence to support the 5 km EDR.	The Applicant recognises that the Sofia Offshore Wind Farm UXO clearance campaign (MLA/2020/00489) had unsuccessful low order clearance attempts and therefore there is no empirical data to support the 5 km EDR (SOWFL, 2023). However, the Applicant is also aware that Moray West Offshore Wind Fam UXO (MS- 00010483) were cleared using EODEX method with 100% success rate. Underwater noise monitoring was conducted for the first 30 detonations, the data has not been analysed as of the time of ES submission, but indications show that low order resulted in noise levels lower that what was modelled. Additionally, the JNCC (2023) Marine Noise Registry recognises the 5 km EDR for low order clearance. The Applicant therefore has presented the following assessment: a 26 km EDR for high order clearance, a 5 km EDR for low order clearance, and TTS as a proxy for both high and low order clearance. See Section 7.1 for methodology approach and Section 7.10 for UXO clearance impact assessment.
Section 42 responses (MMO, 2023)	The MMO consider that the claims made throughout the report, particularly in Section 7.7.11 of Chapter 7 (that the SEL_{cum} PTS predictions are 'highly precautionary' and 'very	The Applicant maintains that the assessment of cumulative PTS (SEL_{cum}) is highly precautionary given

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	unlikely to be realised') are unsubstantiated. "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". The MMO would argue how 'uncertainties' can be 'highly conservative'. Although it is reasonable to assume that a marine mammal will swim away from the source, the actual concept of fleeing, specifically swimming away from the pile at a constant speed for a sustained period of time (over several hours), is not precautionary. The primary aim of the underwater noise modelling is to present the realistic worst-case scenario. While the MMO acknowledge that there may be conservative assumptions made (for instance, that pulsed sound does not lose its impulsive characteristics while propagating away from the source), these conservatisms may be offset by uncertainties surrounding the predicted source levels and fleeing speeds.	the information presented in Section 7.6. The modelling does not account for recovery in threshold shift in between pulses or the loss of impulsive characteristics with distance. With regards to the fleeing model, the model uses typical swimming speeds rather than fleeing speeds which is considered to be conservative.
Section 42 responses (MMO, 2023)	*"Overall, non-piling construction noise sources [cable laying, suction dredging etc.] 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".* Please note that this statement is true for a stationary/static receptor but not for a fleeing receptor (fleeing has been assumed in the underwater noise modelling). There are also other similar statements throughout Chapter 7 which need amending. As explained in Annex 6.2 (Section 1.3.28), when an SEL_{cum} impact range is presented for a fleeing animal, this range can essentially be considered a starting position for the fleeing animal receptor. If a receptor began to flee in a straight line away	The Applicant agrees with the MMO and has removed this sentence.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	from the noise source starting at the position (distance from the source) denoted by a modelled PTS or TTS contour, the receptor would receive exactly that noise exposure as per the PTS criterion under consideration. We acknowledge that the assessment presented is conservative as 24-hour continuous exposure has been assumed.	
Post-ETG response letter (Natural England, 17th October 2023)	Disturbance from UXO clearance: 5km EDR Natural England is in discussion with Cefas and other relevant bodies regarding EDR for low order detonations. A joint statement is yet to be produced, but we will issue this to VE OWF as soon as it is finalised.	The Applicant acknowledges the Natural England and Cefas joint statement and will continue to engage on this matter once the statement is published. At present the JNCC (2023) Marine Noise Registry recognises the 5 km EDR for low order clearance and as such this has been assessed in Section 7.10 alongside a 26 km EDR for high order clearance and TTS as a proxy for PTS.
Post-ETG response letter (Natural England, 17th October 2023)	PTS from UXO clearance Natural England note the Project's explanation that the magnitude scores presented in the assessment are assigned after the consideration of mitigation. However, as Natural England have not had sight of the mitigation plan for UXO clearance, we cannot agree that the magnitude score would be reduced to the levels the Project is suggesting. Therefore, we would like to see the magnitude presented before the measures and after the mitigation measures, as suggested by VE.	The impacts from UXO clearance have been assessed in Section 7.10 as it is an impact that is scoped in for the construction phase however, UXO clearance will not be licenced in the DCO but through a separate ML application. Volume 9, Report 14.2: Outline MMMP - UXO is submitted as part of the DCO application to detail the mitigation measures referenced in Section 7.10 that are considered in the magnitude scoring. A final UXO MMMP will be submitted in the post-consent stage as part of the ML application. Potential

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
		mitigation measures to reduce the impacts from piling an UXO clearance on the SNS SAC are detailed in Volume 9, Report 9.15: Outline SNS SAC SIP. In Section 7.10 the magnitude and significance for UXO clearance has been presented both pre- and post-mitigation.
Post-ETG response letter (Natural England, 17th October 2023)	Magnitude and sensitivity scores We note there is an action on Natural England to respond to comments made during the ETG meeting dated 29th September 2023. Natural England assess each project on a case-by-case basis, using the information provided by the Project, alongside current evidence and understanding. Therefore, we believe it is not appropriate to compare projects like for like. However, in this instance and for illustrative purposes, we have compared the two projects. With regards to the sensitivity scores used in Hornsea 4 (HOW4), Natural England notes that HOW4 used a 4 level scale: very high, high, medium and low. VE also uses a 4-level scale but with different definitions: high, medium, low and negligible. Consequently, Medium in HOW4 is equivalent to Low in VE. Regardless of whether the definitions are the same or not, the terminology is different, and this appears to lead to a downplaying of the impact. Having looked into this comparison further, our main concern is how sensitivity and magnitude are taken forward to the impact matrix. For example, in the HOW4 impact matrix, a combination of a moderate magnitude and a medium sensitivity determines the impact to be significant. In the VE impact matrix, however, the equivalent combination (low sensitivity and medium magnitude) determines that the impact is not significant. Consequently, we advise that	The magnitude scores have been revisited in Sections 7.10, 7.11 and 7.12 to present scores both before and after the application of mitigation measures (see Table 7.16). The Applicant highlights that sensitivity is based on species biology and there has been no additional published literature that would alter the sensitivity of harbour porpoise or any other species for this assessment. However, based on Natural England's recommendations the four levels of sensitivity have been changed from: Negligible/Low/Medium/High to Low/Medium/High/Very High.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	this 'pick and choose' comparison of one project with another, is not appropriate. Regardless of the comparison with HOW4, Natural England still has concerns regarding the downplaying of impacts within the assessment. We would also like to reiterate our comments on the Preliminary Environmental Information Report (PEIR) regarding the lack of a hierarchy between high and low impact activities with regards to the sensitivity scores. Thus, we continue to advise that the assigned sensitivity/magnitude and significance matrices scores, should be revised.	

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[2] detonation arising from underwater noise during clearance activities;
  - Impact 2: Disturbance from UXO[2] 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;
  - Impact 10: Change in fish abundance/distribution due to disturbance impacts on fish;
  - Impact 11: Habitat loss; and
  - Impact 12: Disturbance at seal haul out sites.
- Operation and maintenance:
  - Impact 13: Operational noise from turbines;
  - Impact 14: Collision risk from operation vessels;
  - Impact 15: Disturbance from operation vessels;
  - Impact 16: Change in fish abundance/distribution due to disturbance impacts on fish;
  - Impact 17: Habitat loss; and
  - Impact 18: Disturbance at seal haul out sites.
- Decommissioning:
  - Impact 19: PTS and disturbance from decommissioning activities.

[2] 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 ES.

- Impact 20: Collision risk from decommissioning vessels;
- Impact 21: Disturbance from decommissioning vessels;
- Impact 22: Change in fish abundance/distribution due to disturbance impacts on fish;
- Impact 23: Habitat loss; and
- Impact 24: Disturbance at seal haul out sites.

IMPACTS SCOPED OUT FOR ASSESSMENT

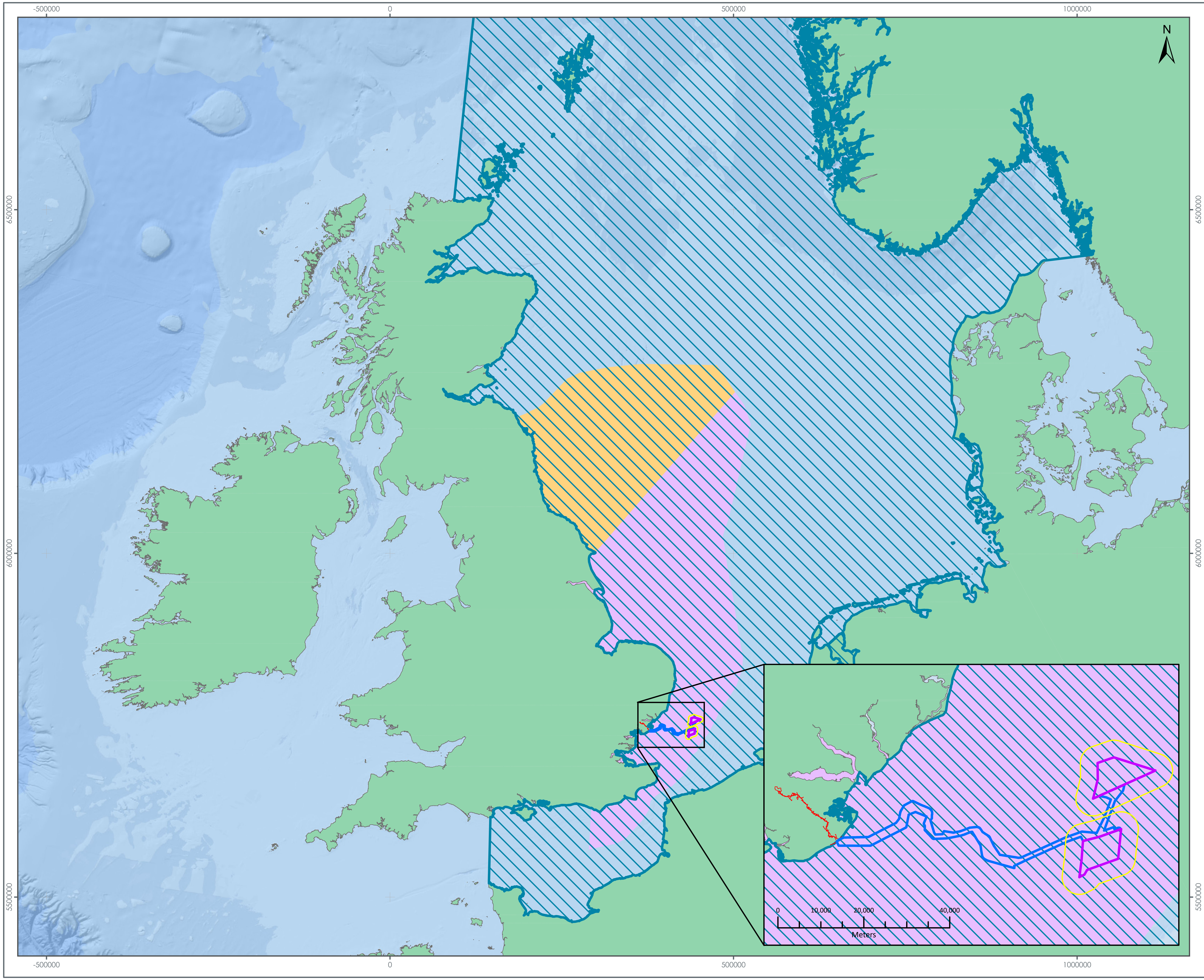
7.4.2 On the basis of the baseline environment, the project description outlined in Volume 6, Part 2, Chapter 1: Project Description, in accordance with the Scoping Opinion (PINS, 2021) and through agreements reached under the EPP, a number of impacts have been scoped out (see Table 7.2), these include:

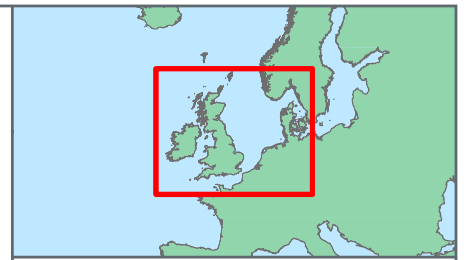
- Construction:
  - Impact 14: Accidental pollution has been scoped out due to the implementation of PEMP. This has been agreed with SNCBs.
- Operation and maintenance:
  - Impact 13: Electro-magnetic fields have been scoped out as there is no likely significant effect (LSE) on the species identified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

STUDY AREA

7.4.3 The VE marine 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 6, Part 5, 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 6, Part 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 Order Limits
- Study Area

Management Units, Species:

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

0 50 100 200
Kilometers

Data Source:
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	26/01/2024	For Issue	BPHB	MB

DRAWING NUMBER: 7.1

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

FIVE ESTUARIES
OFFSHORE WIND FARM

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 6, Part 5, 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.
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).
SCANS IV (Gilles *et al*. 2023)	Combination of vessel and aerial surveys of the North Sea and European Atlantic continental shelf waters conducted in July 2022.
SCANS III (Hammond *et al.*, 2021 ; Lacey *et al.*, 2022)	Combination of vessel and aerial surveys of the North Sea and European Atlantic continental shelf waters conducted in July 2016.
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.
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.
MERP (Waggitt *et al.*, 2020)	Species distribution maps available at monthly and 10 km^2 density scale.
SCOS reports (SCOS 2021, SCOS 2022, SCOS 2023)	Scientific Advice on Matters Related to the Management of Seal Populations. This outlines the current status of both harbour and grey seals in the UK.

SOURCE	DESCRIPTION
Seal haul-out data (provided by SMRU)	August haul-out surveys of harbour and grey seals.
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.
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.
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.
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.
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 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.
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.
Seawatch Foundation Sightings	Sightings recorded from the Eastern England region.
Harbour porpoise citizen science data UK (Nielsen *et al*. 2021)	Harbour porpoise density data collected by citizen science and assessment of spatio-temporal patterns.

SOURCE	DESCRIPTION
Thames Estuary Harbour Porpoise Survey Report (ZSL and MCR., 2022)	Sightings of harbour porpoise recorded in the Thames Estuary in April 2022.

ASSESSMENT METHODOLOGY

7.4.5 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 (as recommended in JNCC *et al.,* 2023).
- Disturbance from piling: quantitative assessment using dose-response functions:
  - Harbour porpoise dose-response function (Graham *et al.,* 2017)
  - Harbour seal dose-response function (Whyte *et al.,* 2020) (also applied to grey seals)
- Disturbance from other construction activities: qualitative assessment based on limited evidence in literature.

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

ASSESSMENT OF PTS

7.4.7 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 6, Part 5, Annex 6.2: Underwater 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 carnivore in water (PCW)	Grey seal Harbour seal	185	218

7.4.8 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.

7.4.9 Southall *et al*. (2019) propose the SPL_{peak} metric is 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).

7.4.10 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).

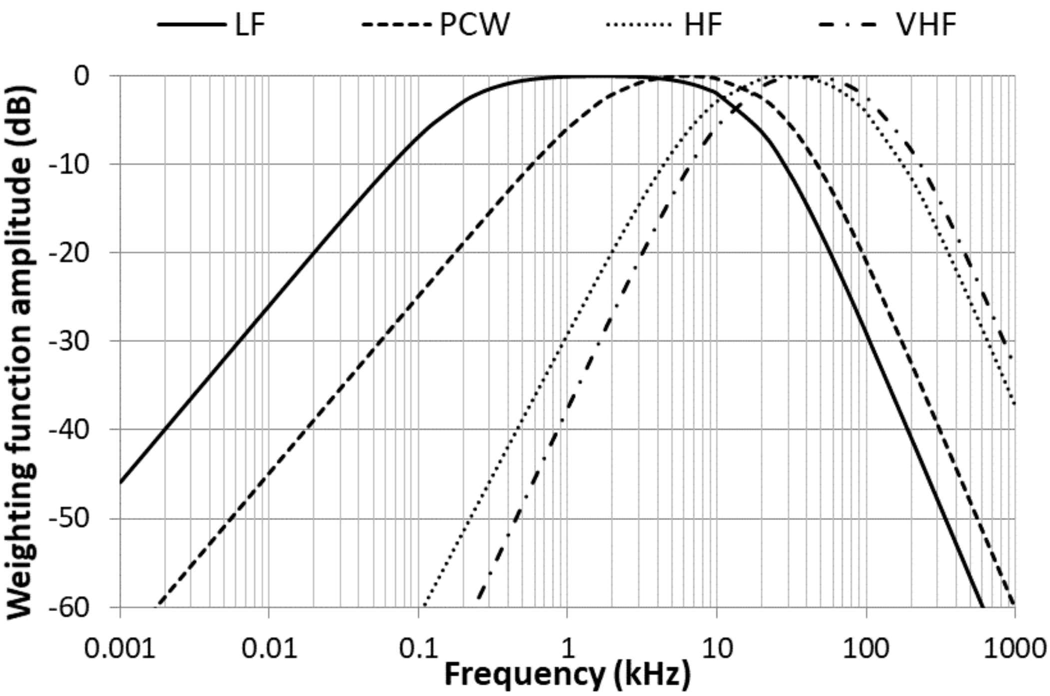


Figure 7.2 Auditory weighting functions for low frequency (LF), high frequency (HF) and very high frequency (VHF) cetaceans as well as phocid carnivores in water (PCW) (from Southall et al., 2019).

ASSESSMENT OF TTS

7.4.11 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 7.6), 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 7.6.40 - 7.6.48.

7.4.12 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 Assessments (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 and Harbour seal	170	212

ASSESSMENT OF PTS FROM UXO CLEARANCE

7.4.13 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

7.4.14 While there is 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.

7.4.15 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

7.4.16 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 behavioural responses to single pulses, other than those that may secondarily result in injury or death (e.g., stampeding), are expected to dissipate rapidly enough as to have limited long-term consequence. Consequently, upon exposure to a single pulse, the onset of significant behavioural disturbance is

proposed to occur at the lowest level of noise exposure that has a measurable transient effect on hearing (i.e., TTS-onset). We recognize that this is not a behavioural effect per se, but we use this auditory effect as a de facto behavioural threshold until better measures are identified. Lesser exposures to a single pulse are not expected to cause significant disturbance, whereas any compromise, even temporarily, to hearing functions has the potential to affect vital rates through altered behaviour.

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

7.4.17 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

7.4.18 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.

7.4.19 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.

7.4.20 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."*

7.4.21 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

7.4.22 There are no empirical data upon which to set a threshold for disturbance from low-order UXO clearance. Data have shown that low-order deflagration detonations produce underwater noise that is over 20 dB lower than high-order detonation of charges of 5-10 kg (Robinson *et al.*, 2020) which highlights that the EDR for low-order UXO clearance should be significantly lower than that assumed for high-order clearance methods. The JNCC MNR disturbance tool (JNCC, 2023) provides default and worst-case EDRs for various noise sources, and lists the default low-order UXO clearance EDR as 5 km. In the absence of any further data, this 5 km EDR for low-order UXO clearance will be assumed here.

SUMMARY

7.4.23 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).

7.4.24 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.

7.4.25 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

7.4.26 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 6, Part 5, 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.

7.4.27 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

7.4.28 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"*.

7.4.29 Noise contours at 5 dB intervals were generated by noise modelling (see Volume 6, Part 5, Annex 6.2: Underwater 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.

7.4.30 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

7.4.31 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) (Table 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

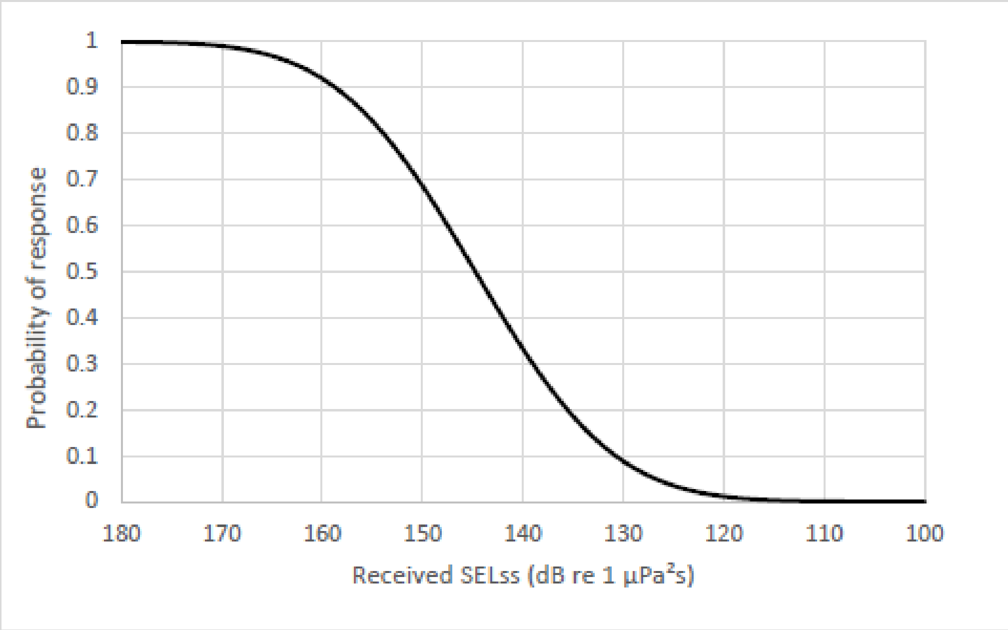


Figure 7.3 Relationship between the proportion of animals responding and the received single strike SEL (SELss) (not weighted to porpoise hearing), based on passive acoustic monitoring results obtained during Phase 1 of the Beatrice Offshore Wind Farm monitoring program (Graham *et al.,* 2017).

7.4.32 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.

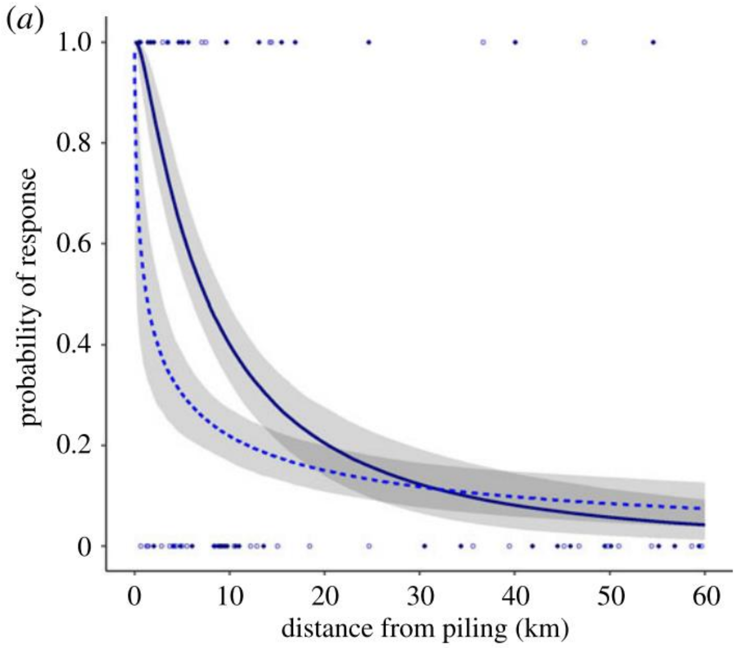


Figure 7.4 The probability of a harbour porpoise response (24 h) in relation to the partial contribution of distance from piling for the first location piled (solid navy line) and the final location piled (dashed blue line). Obtained from Graham et al. (2019)

SEAL DOSE-RESPONSE FUNCTION

7.4.33 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[4] 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.

7.4.34 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.

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

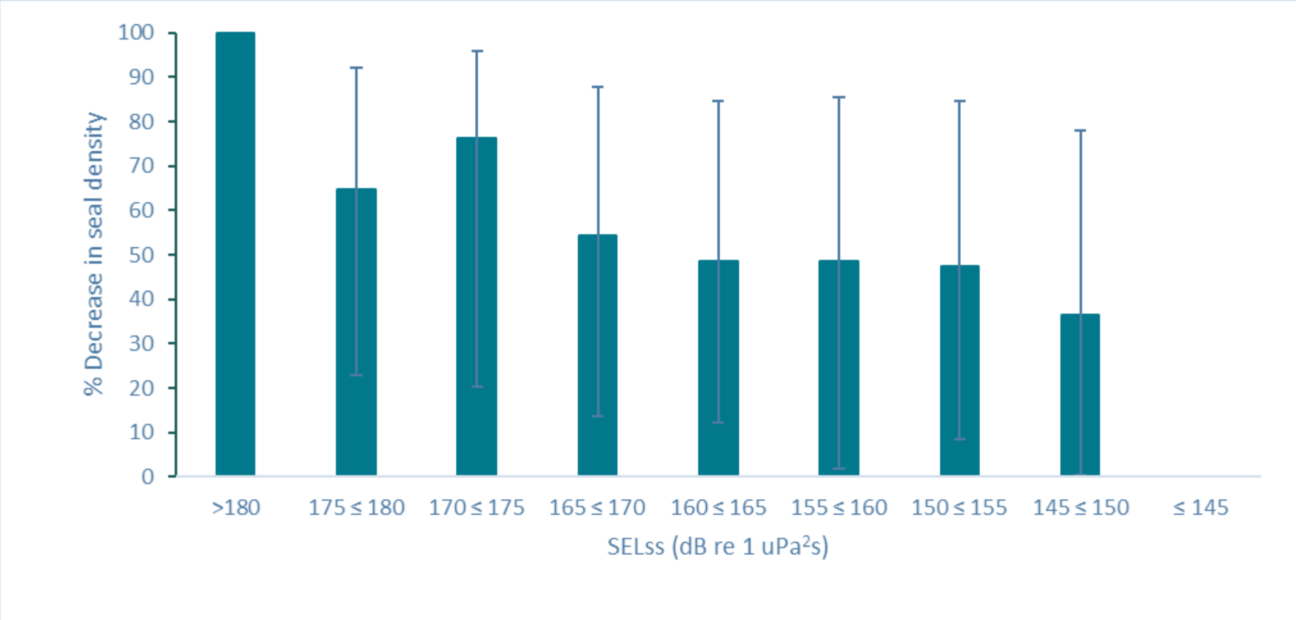


Figure 7.5 Predicted decrease in seal density as a function of estimated sound exposure level, error bars show 95% CI (Whyte et al., 2020).

7.4.35 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

7.4.36 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 6, Part 5, Annex 6.2: Underwater 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

7.4.37 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

7.4.38 The assessment of barrier effects has been included within the impacts of disturbance to marine mammals from construction impacts and is based on the results presented in Volume 6, Part 5, Annex 6.2: Underwater Noise Technical Report. The assessment of disturbance includes displacement of animals within the dose-response function.

ASSESSMENT ON CHANGES OF FISH ABUNDANCE/DISTRIBUTION

7.4.39 The assessment for changes of fish abundance and distribution is based on the assessments of fish prey species presented in Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology, Volume 6, Part 2, 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 6, Part 5, Annex 6.2: Underwater 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*).

ASSESSMENT ON HABITAT LOSS

7.4.40 The assessment of habitat loss is based on the assessments of seabed habitat change from the placement of structures, scour protection, cable protection and cable crossings presented in Volume 6, Part 2, Chapter 5: Benthic Ecology and Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology.

ASSESSMENT ON DISTURBANCE AT SEAL HAUL OUT SITES

7.4.41 The assessment to disturbance at seal haul outs is based on the potential for the Green Port Hull on the Humber being considered for VE during the construction phase and Great Yarmouth, Felixstowe or Harwich being considered for VE during the operational phase.

7.4.42 Disturbance at haul out sites results in increased vigilance and 'flushing' behaviour which can have energetic consequences. During construction and operation vessel disturbance would likely be the cause of any disturbance at seal haul out sites.

7.5 ASSESSMENT CRITERIA AND ASSIGNMENT OF SIGNIFICANCE

7.5.1 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 6, Part 1, Chapter 3: Environmental Impact Assessment Methodology).

7.5.2 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 VE 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.

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

7.5.4 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.

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

7.5.6 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.

7.5.7 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			
			Very High	High	Medium	Low
	Adverse	High	Major	Major	Moderate	Minor
		Medium	Major	Moderate	Minor	Negligible
		Low	Moderate	Minor	Minor	Negligible
Magnitude	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[5].

7.6 UNCERTAINTY AND TECHNICAL DIFFICULTIES ENCOUNTERED

7.6.1 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

7.6.2 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

7.6.3 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.

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

EXPOSURE TO NOISE

7.6.4 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.

7.6.5 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

7.6.6 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.

7.6.7 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.

7.6.8 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.

7.6.9 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.

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

7.6.11 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

7.6.12 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 gunfire of the same SEL_{cum} exposed to human, where 30 impulses with an SPL_{peak} of 150 dBre1mPa result in a TTS of 20 dB, while 300 impulses of a respectively lower SPL_{peak} did not result in any TTS.

7.6.13 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.

7.6.14 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).

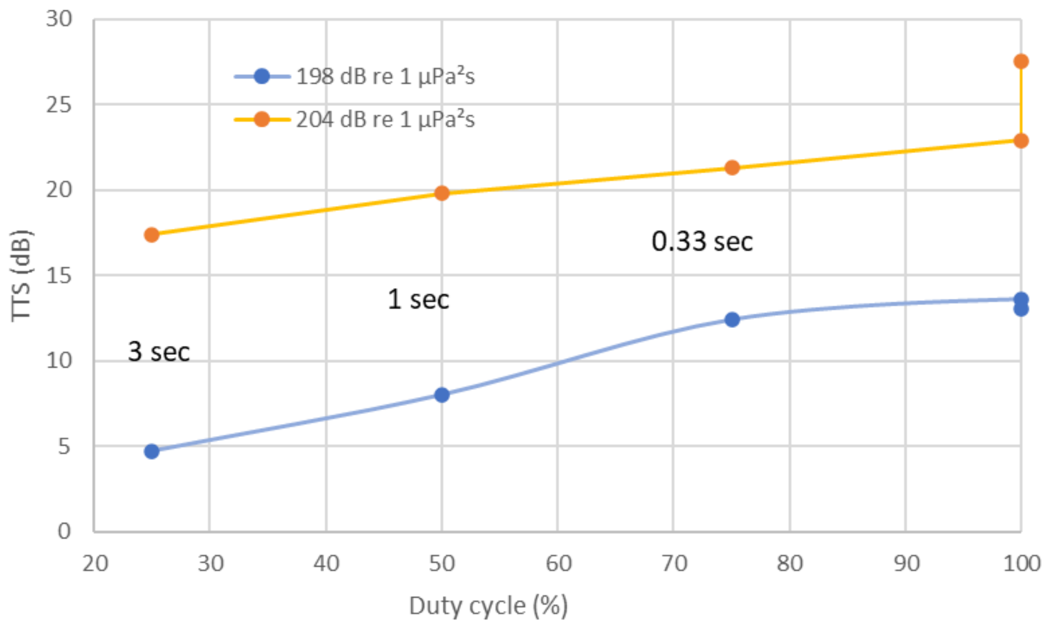


Figure 7.6 Temporary threshold shift (TTS) elicited in a harbour porpoise by a series of 1-2 kHz sonar down-sweeps of 1 second duration with varying duty cycle and constant SELcum of 198 and 204 dB re1 µPa²s, respectively. Also labelled are the corresponding 'silent period' in-between pulses. Data from Katelein et al., 2014.

7.6.15 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^{2}s, 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^{2}s (thus resulting in a 10 dB re 1 µPa^{2}s difference in the threshold).

7.6.16 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.

7.6.17 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).

7.6.18 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.

7.6.19 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-N decrease from 8.6 km for harbour porpoise to 6.5 km (+2 dB) or 5.5 km (+3 dB).

7.6.20 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}	8.6	-
PTS + 2 dB	157 SEL_{cum}	6.5	2.1 km
PTS + 3 dB	158 SEL_{cum}	5.5	3.1 km

IMPULSIVE CHARACTERISTICS

7.6.21 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.

7.6.22 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).

7.6.23 Using the criteria of signal duration[6], rise time[7], crest factor[8] and peak pressure[9] divided by signal duration[10], 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.

7.6.24 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.

7.6.25 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.

[6] Time interval between the arrival of 5% and 95% of total energy in the signal.
[7] Measured time between the onset (defined as the 5th percentile of the cumulative pulse energy) and the peak pressure in the signal.
[8] 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.
[9] The greatest absolute instantaneous sound pressure within a specified time interval.
[10] Time interval between the arrival of 5% and 95% of total energy in the signal.

7.6.26 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[11] 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.

7.6.27 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.

[11] Kurtosis is a measure of the asymmetry of a probability distribution of a real-valued variable.

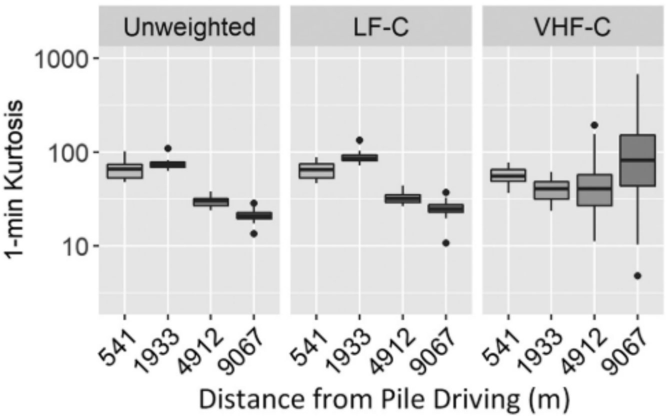


Figure 7.7 The range of kurtosis weighted by LF-C and VHF-C Southall et al. (2019) auditory frequency weighting functions for 30 min of impact pile driving data measured in 25 m of water at the Block Island Wind Farm. Boxplots show the median value (horizontal lines), interquartile range (boxes) and outer values (dots). Boxplots reproduced from Martin et al. (2020).

7.6.28 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.

7.6.29 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.

7.6.30 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"*.

7.6.31 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.

7.6.32 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

7.6.33 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[12] (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).

[12] 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

CUMULATIVE PTS SUMMARY

7.6.34 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

7.6.35 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 6, Part 5, Annex 7.1: Marine Mammal Baseline Characterisation.

PREDICTED RESPONSE

7.6.36 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.

7.6.37 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

7.6.38 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).

7.6.39 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

7.6.40 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.

7.6.41 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.

7.6.42 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.

7.6.43 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.

7.6.44 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.

7.6.45 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 7.6.6 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.

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

7.6.47 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.

7.6.48 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, 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.

7.7 EXISTING ENVIRONMENT

THE ARRAY AREAS

7.7.1 The existing environment in the array area for marine mammals is detailed in Volume 6, Part 5: Annex 7.1: Marine Mammal Baseline Characterisation and Volume 6, Part 5, Annex 4.11: 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 with a summary provided here. This ES chapter should therefore be read alongside the Volume 6, Part 5, Annex 7.1: Marine Mammal Baseline Characterisation and Volume 6, Part 5, Annex 4.11: 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 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.

7.7.2 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, (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 (#/km^2)	Density ref
Harbour porpoise	North Sea	346,601	IAMMWG (2023)	1.82	HiDef Aerial Surveying Ltd (2020, 2021)
				Grid cell specific	SCANS III density surface (Lacey *et al*., 2022)
				0.3096	SCANS IV block NS-B (Gilles *et al*., 2023)
Harbour seal	Southeast England	4,868	SCOS (2023) counts scaled using Lonergan et al. (2013)	Grid cell specific, average 0.018	Carter *et al*., (2020, 2022)
Grey seal	Southeast MU and Northeast MU	65,505	SCOS (2023) counts scaled using SCOS (2022) BP 21/03	Grid cell specific, average 0.106	Carter *et al*., (2020, 2022)

7.7.3 Harbour porpoise within the North Sea MU have an estimated abundance of 346,601 (95% CI: 289,498 – 419,967, CV: 0.09) (IAMMWG 2023). The conservation status (JNCC, 2019a) concluded an overall assessment of 'Unknown'. Across the four SCANS abundance estimates of harbour porpoise in the North Sea MU (1994, 2005, 2016 and 2022) there is no evidence of a trend in abundance (Gilles *et al.,* 2023; Hammond *et al.,* 2021). 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). The site-specific average density estimate is used in the quantitative impact assessment as it is significantly higher than the summer SCANS III and IV survey estimates. In addition to the site-specific survey estimates, SCANS IV uniform density estimate for the NS-B block (Gilles et al., 2023) is presented as it covers a wider area than the site-specific survey and, to reflect that harbour porpoise density in the wider area is not uniform, the SCANS III density surface (Lacey et al., 2022) is also presented.

7.7.4 The latest August haul-out data for harbour seals within the Southeast England MU is the 2021 August haul-out count where 3,505 individuals were counted (SCOS, 2023). In Volume 6, Part 5, Annex 7.1: Marine Mammal Baseline Characterisation the 2021 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 4,868 harbour seals in the Southeast England MU in 2021 (95% CI: 3,980 - 6,490). The count was 50% lower in 1989 compared to 1988 as a result of the phocine distemper virus epizootic (PDV). The counts then increased by 6.6% p.a. between 1989 and 2002; however, another PDV epizootic outbreak meant that the 2003 count was 30% lower than the 2002 count. Between 2003 and 2017 the counts increased then levelled off. However, in 2019 the count for the Southeast England MU was 27.6% lower than the mean count between 2012-2018, which was thought to be the first indication of a declining population (SCOS, 2021). Counts for 2020 and 2021 have since confirmed that the population has declined (SCOS, 2023). No harbour seals were identified in the site-specific survey. The quantitative impact assessment uses the best and most recent estimate of the distribution of seals at-sea from the seal habitat preference maps (Carter *et al.,* 2022) to estimate the number of harbour seals impacted.

7.7.5 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 6, Part 5, Annex 7.1: Marine Mammal Baseline Characterisation, the 2021 count data for the Southeast England MU (7,694) was combined with the Northeast England MU 2022 count data (6,517 total). This was then scaled by the estimated proportion hauled out (0.2515, 95% CI: 0.2145-0.2907) (SCOS, 2022) to produce an estimate of 65,505 grey seals in the Southeast and Northeast England MUs combined (95% CI: 48,885 – 66,252).

7.7.6 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, 2023). Grey seals were identified occasionally over the two years of site-specific surveys, with a total of 8 sighted in the 24 surveys. The quantitative impact assessment uses the best and most recent estimate of the distribution of seals at-sea from the seal habitat preference maps (Carter *et al.*, 2022) to estimate the number of harbour seals impacted.

DESIGNATED SITES

7.7.7 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).

7.7.8 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.

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

7.7.10 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

7.7.11 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 mammals.

7.7.12 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.

7.7.13 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. Harbour porpoise are considered to have an Unknown conservation status, however the UK harbour porpoise population has been assessed as having Favourable future prospects.

7.7.14 An assessment of the impacts of climate change on marine mammal baseline is presented in Section 7.14. The impacts of marine mammals are assessed quantitatively in Volume 6, Part 4, Chapter 1: Climate Change.

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 KEY PARAMETERS FOR ASSESSMENT

7.8.1 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.

<table>
<tr><th>Potential Effect</th><th>Maximum design scenario assessed</th><th>Justification</th></tr>
<tr><td>Construction</td><td></td><td></td></tr>
<tr><td>Impact 1: PTS from UXO Clearance</td><td rowspan="2">UXO clearance:
> 2000 expected potential UXO targets;
> 950 potential UXO predicted to require inspection;
> 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.
> UXO clearance campaign expected 2028</td><td rowspan="2">Estimated maximum design. A detailed UXO survey will be completed prior to construction. The type, size and number of possible detonations and duration of UXO clearance operations is not known at this stage. The Applicant is not seeking to licence the disposal of UXO in this application, but it is included in the impact assessment.</td></tr>
<tr><td>Impact 2: Disturbance from UXO Clearance</td></tr>
</table>

<table>
<tr><th>Potential Effect</th><th>Maximum design scenario assessed</th><th>Justification</th></tr>
<tr><td>Impact 3: PTS from piling</td><td rowspan="3">Monopile WTG:
> Max 79 WTGs
> Max 15 m pile diameter;
> Max hammer energy: 7,000 kJ;
> Max 7.5 hours per pile;
> Max 24 hours piling per day;
> Max 2 simultaneous piling events.
> Max total piling time (hours) = 592.5
> Number of piling days = 79 (assuming an MDS of 1 pile per day)
Monopile other structures:
> Max 2 Offshore Substation Platforms (OSP);
> Max pile diameter 15 m;
> Max hammer energy 7,000 kJ; and
> Max 7.5 hours piling per monopile.
> Max total piling time (hours) (2 OSP) = 15
> Number of piling days = 2
Mult-leg jacket WTG:
> Max 79 WTG;
> 4 legs per foundation;
> 1 pin-pile per leg;
> Max 316 pin-piles in total;</td><td rowspan="3">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.</td></tr>
<tr><td>Impact 4: TTS from piling</td></tr>
<tr><td>Impact 5: Disturbance from piling</td></tr>
</table>

Potential Effect	Maximum design scenario assessed	Justification
	> Max pin-pile diameter 3.5 m; > Max hammer energy 3,000 kJ; > Max 4 hours per pin pile; > Max 24 hours piling per day; > Max 2 simultaneous piling events; > Max total piling time (hours) = 1,264 > Number of piling days = 79 (assuming an MDS of 4 piles per day) **Multi-leg jacket OSP:** > Number of jacked foundations: 2 > Number of legs per foundation: 6 > Max 12 legs; > 2 pin piles per leg; > Max 24 pin piles in total; > Max 4 hours per pile; > Max pin-pile diameter 3.5 m; > Max hammer energy 3,000 kJ; and > Maximum total piling time (hours) (2 OSP) = 96 > Number of piling days = 6 Foundation installation: 2029-2030	

Potential Effect	Maximum design scenario assessed	Justification
	Piling construction duration: 1 year Total monopiles (WTG + OSPs): 85 Total pin-piles (WTG + OSPs): 340	
Impacts 6: PTS and disturbance from other construction activities	**Seabed preparation spoil volume for all 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/or post-lay ploughing; > simultaneous lay and plough (such as burial sledge); > mechanical trenching; > dredging (typically Trailer suction hopper dredger or water injection dredger); > max flow excavation; and > rock cutting. **Offshore construction indicative dates:** 2027-2030	Maximum potential for underwater noise impacts from pre-construction works.

Potential Effect	Maximum design scenario assessed	Justification
Impact 7: Collision risk from construction vessels	Max total construction vessels: 96 Max total round trips: 4,311 Indicative peak vessels on-site simultaneously: 35 Offshore construction indicative dates: 2027-2030	The maximum numbers of vessels and associated vessel movements represents the maximum potential for collision risk and disturbance
Impact 8: Disturbance from construction vessels		
Impact 9: Change in water quality from construction activities	Maximum amount of suspended sediment released during construction activities and associated duration - see Volume 6, Part 2, Chapter 2: Marine Geology, Oceanography and Physical Processes and Volume 6, Part 2, Chapter 3: Marine Water and Sediment Quality.	
Impact 10: Change in fish abundance/distribution from construction activities	Assessment is based on the MDS presented in Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology.	
Impact 11: Habitat loss	Total temporary habitat disturbance within Order Limits is 36,513,188 m^2 **Array areas:** Total temporary habitat disturbance within array areas is 21,771,734 m^2 **Offshore ECC:** Total temporary habitat disturbance within Offshore ECC is 14,739,204 m^2	The temporary disturbance relates to seabed preparation for foundations and cables, jack up and anchoring operations, and cable installation.
Impact 12: Disturbance at seal haul out sites	Assessment is based on potential ports, distances to vessel transit routes and landfall.	
Operation		
Impact 13: 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.	
Impact 14: Collision risk from O&M vessels	Maximum total operation vessels: 27	The maximum numbers of vessels and associated

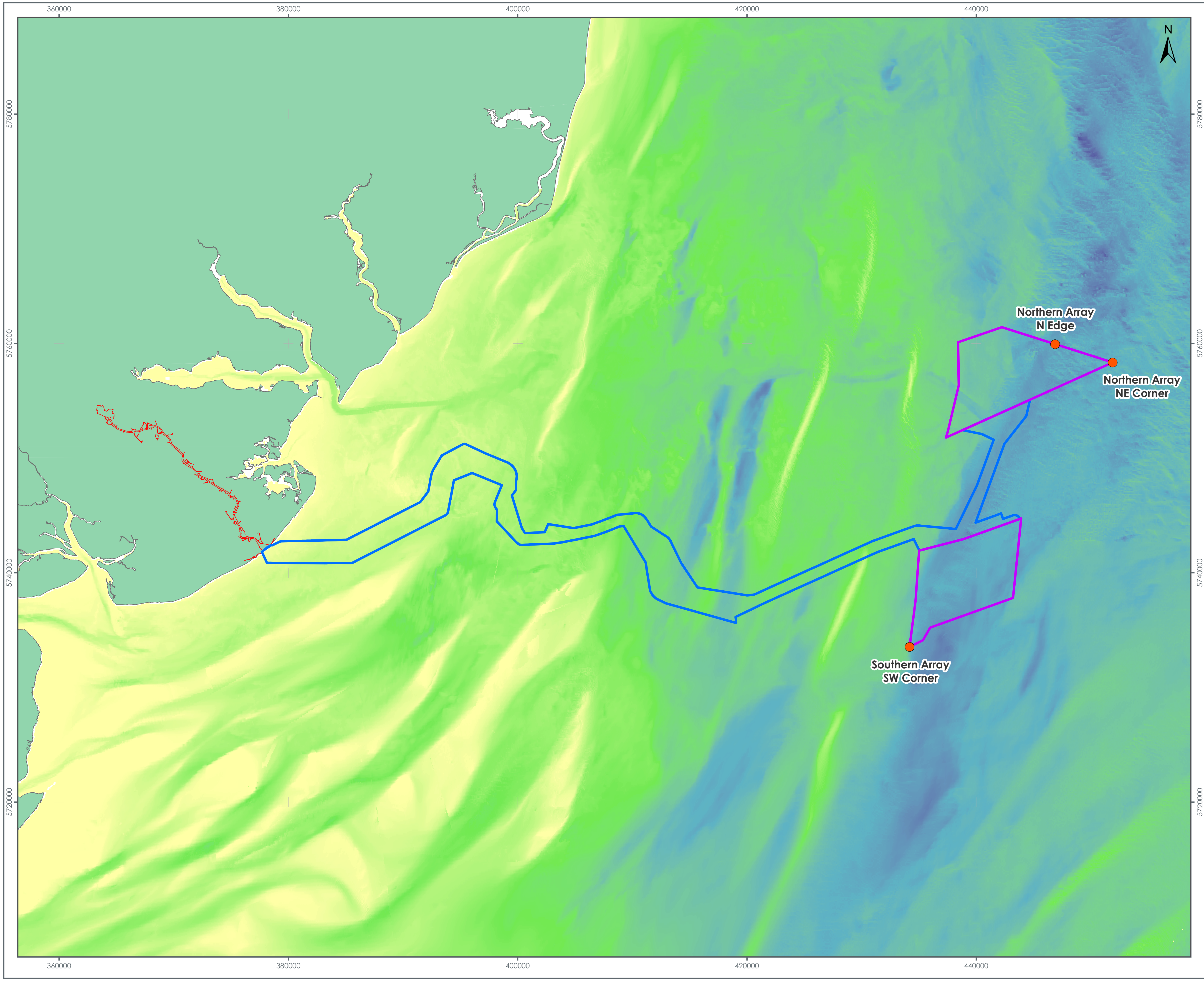
Potential Effect	Maximum design scenario assessed	Justification
Impact 15: Disturbance from O&M vessels	Maximum total annual round trips: 1,776 Indictive peak vessels on-site simultaneously: 27	vessel movements represents the maximum potential for collision risk and disturbance.
Impact 16: Change in fish abundance/ distribution	Assessment is based on the MDS presented in Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology.	
Impact 17: Habitat loss	Total permanent habitat lost within Order Limits is 3,415,083 m^2 **Array areas:** Total habitat lost within array areas is 3,112,079 m^2 **Offshore ECC:** Total habitat lost within Offshore ECC is 303,004 m^2 Total temporary habitat loss within Order Limits is 734,894 m^2 **Array areas:** Total temporary habitat disturbance within array areas is 589,052 m^2 **Offshore ECC:** Total temporary habitat disturbance within the Offshore ECC is 145,842 m^2	Permanent habitat loss defined by maximum area of seabed lost as a result of the placement of structures, scour protection, cable protection and cable crossings. Temporary habitat loss defined by maximum number of jack-up vessel operations and total cable replacement throughout the maintenance activities that could have an interaction with the seabed.
Impact 18: Disturbance at seal haul out sites	Assessment is based on potential ports, distances to vessel transit routes and landfall.	
Decommissioning		
Impact 19: 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 20: Collision risk from decommissioning vessels	Assumed to be similar vessel types, numbers and movements to construction	The maximum numbers of vessels and associated vessel movements represents

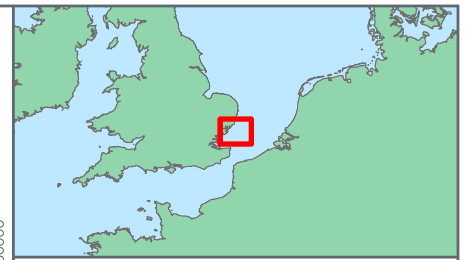
Potential Effect	Maximum design scenario assessed	Justification
Impact 21: Disturbance from decommissioning vessels	phase (or less) therefore maximum: > Maximum total decommissioning vessels: 96 > Maximum total annual round trips: 4,311 > Indicative peak vessels on-site simultaneously: 35	the maximum potential for collision risk and disturbance.
Impact 22: Change in fish abundance/distribution	Assessment is based on the MDS presented in Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology.	
Impact 23: Habitat loss	Assumed to be similar level (or less) to the construction phase.	
Impact 24: Disturbance at haul out sites	Assessment is based on potential ports, distances to vessel transit routes and landfall.	

PILING PARAMETERS

WTGS

7.8.2 The potential underwater noise impacts from pile driving of WTGs has been assessed at three locations within the array area: Northern Array northern edge (N) (53.9 m depth), Northern Array northeast corner (NE) (48.2 m depth) and the Southern Array southwest corner (SW) (44.7 m depth) (Figure 7.8).





LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Order Limits
- Modelling Locations

Depth (m)

High : 0

Low : -70

0 2.5 5 10

Kilometers

Data Source:

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

WTG Underwater Noise Modelling Locations

VER	DATE	REMARKS	Drawn	Checked
1	26/01/2024	For Issue	BPHB	MB

DRAWING NUMBER: 7.8

SCALE: 1:300,000 | PLOT SIZE: A3 | DATUM: WGS84 | PROJECTION: UTM31N

FIVE ESTUARIES
OFFSHORE WIND FARM

7.8.3 Two foundation scenarios have been assumed in the underwater noise modelling for WTGs:

- Monopile scenario: installation of a 15 m monopile with a maximum of 7,000 kJ hammer energy
- Pin pile (jacket) scenario: installation of 3.5 m pin pile with a maximum of 3,000 kJ hammer energy.

7.8.4 The WTG piling parameters for each scenario are detailed in Table 7.14.

7.8.5 In addition to this, mitigated piling was modelled at the Northern Array northern edge (N) modelling location and for each piling scenario, assuming a 10 dB reduction in source level. See Volume 6, Part 5, Annex 6.2: Underwater Noise Technical Report for full details.

Table 7.14 Piling parameters used in the underwater noise modelling for WTGs.

Monopile								
	Soft-start & Ramp-up						**Full energy**	**Total**
Energy (kJ)	1,050	1,050	1,400	2,800	4,200	5,600	7,000	1 pile: 16,563 strikes, 7 hours 30 minutes duration
# Strikes	100	100	200	200	200	200	15,563	
Duration (s)	600	300	300	300	300	300	24,900	
Strike rate (blows/min)	10	Burst*	40	40	40	40	37.5	
Pin pile (single)								
	Soft-start & Ramp-up						**Full energy**	**Total**
Energy (kJ)	450	450	600	1,200	1,800	2,400	3,000	1 pile: 8,688 strikes, 4 hours duration 4 piles: 34,752 strikes, 16 hours duration
# Strikes	100	100	200	200	200	200	7,688	
Duration (s)	600	300	300	300	300	300	12,300	
Strike rate (blows/min)	10	Burst*	40	40	40	40	37.5	
*the “Burst” stages represent 30 seconds of piling at 40 bl/min followed by a 30 second pause in piling, repeated for 5 minutes								

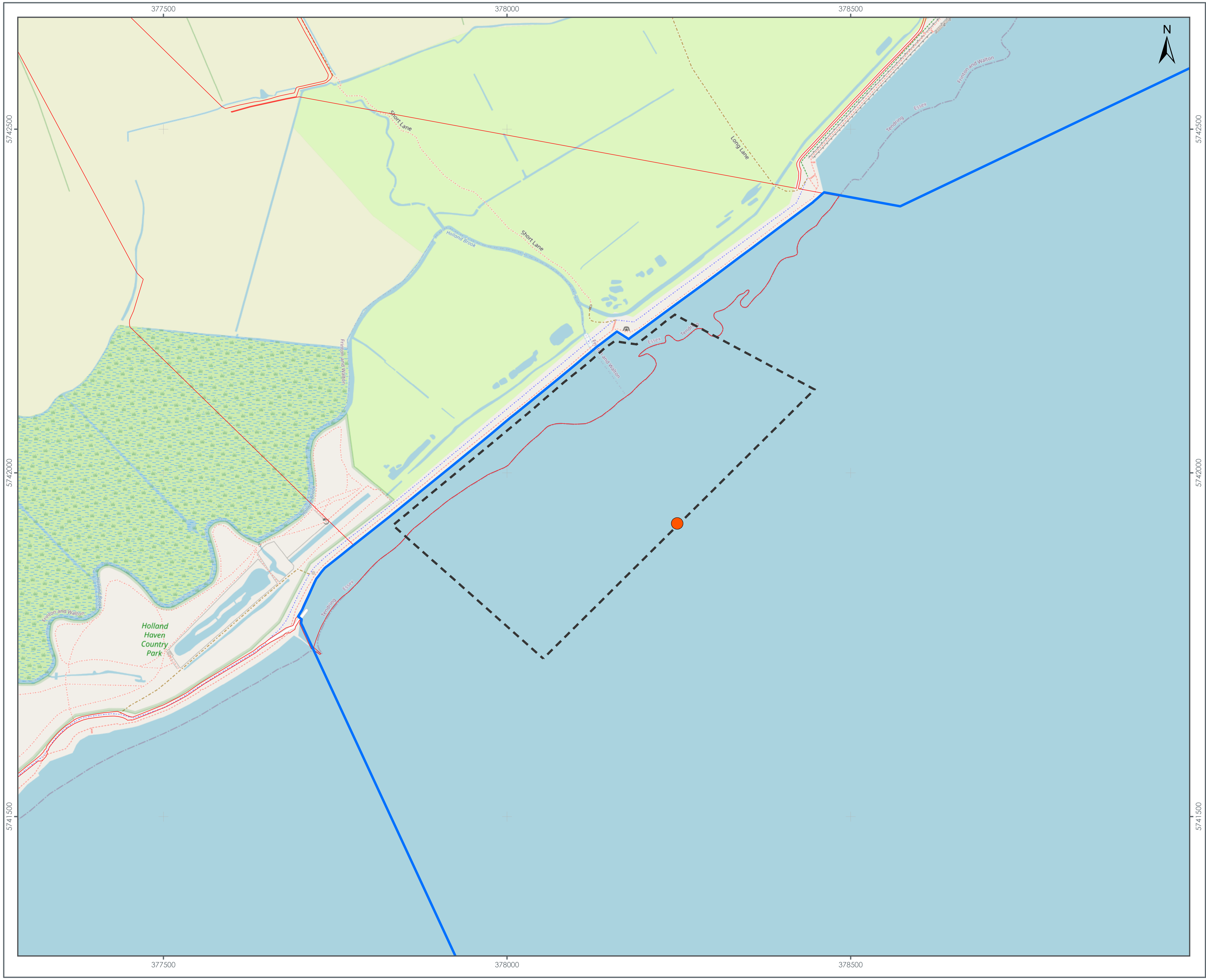
7.8.6 Further scenarios were conducted to explore piling with 2 vessels, one vessel at the Southern Array – SW corner location and one vessel at the Northern Array – N corner. Within this, difference sequential and concurrent scenarios were explored:

- Monopiles sequential (30 hours piling) – alternate staggered installation at N and SW, with two monopiles installed at each location (total four piles);
- Monopiles sequential (24 hours piling) – alternate staggered installation at N and SW, with two monopiles installed at each location (total four piles);
- Monopile concurrent (15 hours piling) – simultaneous installation at N and SW, with two piles installed sequentially at each location (four total piles);
- Pin piles sequential (32 hours piling) – installation of four piles (sequentially) at N, followed on completion by the installation of four piles (sequentially) at SW (eight total piles); and

- Pin piles concurrent (16 hours piling) – simultaneous installation at N and SW, with four piles installed sequentially at each location (eight total piles).

LANDFALL

7.8.7 In addition to piling of WTGs within the array area, there could be impact piling for the construction of a sheet piled enclosure at the landfall location on the Essex coast between Holland-on-Sea and Frinton-on-Sea (Figure 7.9). Sheet piled enclosure construction assumes the installation of 750 mm wide Larssen sheet piles, measuring 20 m in length with up to 8 piles installed per day, at both Mean High Water Springs (MHWS) and Mean Low Water Springs (MLWS). The piling parameters are detailed in Table 7.15. See Volume 6, Part 5, Annex 6.2.1: Landfall Impact Piling Modelling for full details.



LEGEND

- Offshore Export Cable Corridor
- Onshore Order Limits
- Indicative Landfall Area
- Cofferdam Modelling Location

0 50 100 200
Meters

Data Source:
© OpenStreetMap (and) contributors, CC-BY-SA

PROJECT TITLE:
FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:
Landfall Cofferdam Piling Underwater Noise Modelling Location

VER	DATE	REMARKS	Drawn	Checked
1	19/01/2024	For Information	BPHB	AL

DRAWING NUMBER: 7.9

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

FIVE ESTUARIES
OFFSHORE WIND FARM

Table 7.15 Piling parameters used in the underwater noise modelling for landfall sheet piling.

Sheet piles				Total (1/day)	Total (8/day)
Energy (kJ)	60	Ramp-up	300	**-**	**-**
# Strikes	100	800	1,200	**2,100**	**16,800**
Duration (min)	10	20	30	**1 hr**	**8 hr**
Strike rate (blows/min)	10	40	40	**-**	**-**

7.9 MITIGATION

7.9.1 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 7.16. 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).

Table 7.16: Mitigation relating to marine mammals

Mitigation	Mitigation measures
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) (Volume 9, Report 18) has been 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

Mitigation	Mitigation measures
	controlled and provides protection to marine life across all phases of the life of the wind farm.
Pollution prevention	The Applicant 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.[13]
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), secured in the dML. 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)
Piling MMMP	Volume 9, Report 14.1: Outline Marine Mammal Mitigation Protocol - Piling will be implemented as a condition in the dML. The MMMP will be secured as a condition within the dML. The purpose of the MMMP will be to reduce the impact of auditory injury (PTS) to negligible levels. A final MMMP will be produced in the post-consent phase.
UXO MMMP	Volume 9, Report 14.2: Outline Marine Mammal Mitigation Protocol - UXO is submitted alongside the application. Implementation of a UXO Marine MMMP subject to a separate Marine Licence application should UXO clearance be required in the post-consent phase. The purpose of the MMMP will be to reduce the impact of auditory injury (PTS) to negligible levels. UXO clearance will not be licenced as part of the DCO.
Working in Proximity to Wildlife	Volume 9, Report 18.1: Working in Proximity to Wildlife will reduce the risk of vessel disturbance and collision risk which will consider the mitigation listed in the Working in Proximity to Wildlife in the Marine Environment Code of Conduct document. The Working in Proximity to Wildlife will be secured as a condition within the dML.

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

Mitigation	Mitigation measures
Southern North Sea SAC Site Integrity Plan (SIP)	Volume 9, Report 15: Outline SNS SAC SIP to reduce the impact of underwater noise disturbance on the harbour porpoise feature of the Southern North Sea SAC as a condition withing the dML.
Operation	
Working in Proximity to Wildlife	Volume 9, Report 18.1: Working in Proximity to Wildlife will reduce the risk of vessel disturbance and collision risk which will consider the mitigation listed in the Working in Proximity to Wildlife in the Marine Environment Code of Conduct document. The Working in Proximity to Wildlife will be secured as a condition within the dML.
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 mitigation measure will be similar to those for the construction phase. The Decommissioning Programme will be secured as a condition in the dML.
Working in Proximity to Wildlife	Volume 9, Report 18.1: Working in Proximity to Wildlife will reduce the risk of vessel disturbance and collision risk which will consider the mitigation listed in the Working in Proximity to Wildlife in the Marine Environment Code of Conduct document. The Working in Proximity to Wildlife will be secured as a condition within the dML.
Decommissioning MMMP	Implementation of a decommissioning MMMP subject to a separate Marine Licence application prior to decommissioning should this be required. The purpose of the MMMP will be to reduce the impact of auditory injury (PTS) to negligible levels.

7.10 ENVIRONMENTAL ASSESSMENT: CONSTRUCTION PHASE

7.10.1 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 receptors caused by each identified impact is given below.

7.10.2 The current project design includes an ECC to shore to facilitate power export from the Array Areas to the national electricity grid. Under the Offshore Transmissions Network Review (OTNR) options, work to consider the potential for an offshore connection has been commenced but is not well advanced. An offshore connection is not a viable or deliverable alternative at this time. However, in order to allow the identification of impacts that be relevant were this to become an option, the assessment for each potential impact has been split into “Array Area Impacts” and“Offshore Export Cable Corridor Impacts.” Further details on the OTNR process are outlined in Volume 9, Report 29: Offshore Connection Scenario.

IMPACT 1: PTS FROM UXO CLEARANCE

ARRAY AREA IMPACTS

7.10.3 If UXO are found in the array area, 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.

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

7.10.5 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 in the array area. 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.

7.10.6 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.

7.10.7 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 array area 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.

7.10.8 Full details of the underwater noise modelling and the resulting PTS-onset impact areas and ranges are detailed in Volume 6, Part 5, Annex 6.2: Underwater 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.

7.10.9 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 7.17.

7.10.10 The results for the impact of low-order UXO with a charge size of 0.5 kg are presented in Table 7.30.

Table 7.17: PTS-onset impact ranges, number of animals and percentage of MU predicted to experience PTS-onset for high-order UXO detonation.

Species	Threshold		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)	Range (km)	4.6	6.0	7.8	9.8	12	13
		# porpoise	121	206	348	549	823	966
		% MU	0.03	0.06	0.10	0.16	0.24	0.28
Harbour (HS) & grey seal (GS)	218 dB (PCW)	Range (km)	0.91	1.1	1.5	1.9	2.5	2.7
		# HS	0	<1	<1	<1	<1	<1
		% MU	<0.01	<0.02	<0.02	<0.02	<0.02	<0.02
		# GS	<1	<1	<1	1	2	2
		% MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Weighted SEL_{ss} (dB re 1µPa²s)								
Harbour porpoise	155 dB (VHF)	Range (km)	0.57	0.74	0.95	1.1	1.4	1.5
		# porpoise	2	3	5	7	11	13
		% MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Harbour (HS) & grey seal (GS)	185 dB (PCW)	Range (km)	0.39	0.57	0.83	1.1	1.6	1.9
		# HS	0	0	0	<1	<1	<1
		% MU	<0.01	<0.01	<0.01	<0.02	<0.02	<0.02
		# GS	<1	<1	<1	<1	<1	1
		% MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table 7.18 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	<0.01%
Harbour seal & grey seal	218 dB (PCW)	Impact range	240 m
		# harbour seals	<1
		% MU	<0.02%
		# grey seals	<1
		% MU	<0.01%
Weighted SEL_{ss} (dB re 1µPa^{2}s)			
Harbour porpoise	155 dB (VHF)	Impact range	110 m
		# porpoise	<1
		% MU	<0.01%
Harbour seal & grey seal	185 dB (PCW)	Impact range	60 m
		# harbour seals	<1
		% MU	<0.02%
		# grey seals	<1
		% MU	<0.01%

SENSITIVITY

7.10.11 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 medium sensitivity for harbour porpoise, harbour seals and grey seals is deemed appropriate.

HARBOUR PORPOISE

MAGNITUDE

7.10.12 **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 7.17), 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 <0.01% of the MU population (Table 7.17).

7.10.13 **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 eight harbour porpoise being impacted, equating to <0.01% of the MU population (Table 7.18). Using weighted SEL_{ss}, <1 harbour porpoise was predicted to be impacted, equating to <0.01% of the MU population, with an impact range of 110 m (Table 7.18).

7.10.14 The impact of PTS-onset from high-order and low-order UXO clearance 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 unmitigated magnitude of the impact to harbour porpoise is considered to be low negative).

SIGNIFICANCE

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

ADDITIONAL MITIGATION

7.10.16 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 final 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 mitigated magnitude of this impact is therefore considered to be reduced to Negligible for harbour porpoise with the implementation of the UXO MMMP. An Outline UXO MMMP is submitted with the application for information at this point (Volume 9, Report 14.2: Outline Marine Mammal Mitigation Protocol – UXO).

RESIDUAL IMPACT

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

HARBOUR SEAL

MAGNITUDE

7.10.18 **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 7.17) and <0.02% 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 7.17) and <0.02% of the MU population.

7.10.19 **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 7.18), equating to <0.02% of the MU population.

7.10.20 The impact of PTS-onset from both high-order and low-order UXO clearance is predicted to be 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 over a maximum of 2.7 km, which is considered to be of Negligible magnitude without mitigation.

SIGNIFICANCE

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

GREY SEAL

MAGNITUDE

7.10.22 **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 <0.01% of the MU population (Table 7.17). Using weighted SEL_{ss}, the maximum impact range calculated was 1.9 km, equating to 1 grey seal and <0.01% of the MU population (Table 7.17).

7.10.23 **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 7.18) and <0.01% of the MU population.

7.10.24 The impact of PTS-onset from both high-order and low-order UXO clearance 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 magnitude without mitigation.

SIGNIFICANCE

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

OFFSHORE EXPORT CABLE CORRIDOR IMPACTS

7.10.26 If UXO are found in the Offshore ECC, a risk assessment will be undertaken and items of UXO will either be avoided, removed or detonated in situ. The pre-construction surveys have not yet been completed and it is not possible at this time to determine how many items of UXO will require clearance in the Offshore ECC. A separate Marine Licence will be applied for post-consent for the clearance (where required) of any UXO identified.

7.10.27 The impact of UXO clearance in the ECC is predicted to be the same as UXO clearance in the array area.

HARBOUR PORPOISE

SENSITIVITY

7.10.28 The overview of sensitivity is the same as described in the array area in paragraph 7.10.11 *et seq*.

MAGNITUDE

7.10.29 The overview of unmitigated and mitigated magnitude is the same as described for the array area in paragraphs 7.10.14 and 7.10.15 *et seq*.

SIGNIFICANCE

7.10.30 Harbour porpoise have been assessed as having a medium sensitivity to PTS from UXO clearance and the <u>unmitigated</u> magnitude is considered to be low. Therefore, the significance of PTS from <u>unmitigated</u> UXO clearance is concluded to be of **Minor** significance, which is not significant in terms of the EIA Regulations 2017.

7.10.31 Harbour porpoise have been assessed as having a medium sensitivity to PTS from UXO clearance and the <u>mitigated</u> magnitude is considered to be negligible. Therefore, the significance of PTS from <u>mitigated</u> UXO clearance is concluded to be of **Negligible** significance, which is not significant in terms of the EIA Regulations 2017.

HARBOUR SEAL

SENSITIVITY

7.10.32 The overview of sensitivity is the same as described in the array area in paragraph 7.10.11 *et seq*.

MAGNITUDE

7.10.33 The overview of unmitigated and mitigated magnitude is the same as described for the array area in paragraphs 7.10.20 and 7.10.21 *et seq*.

SIGNIFICANCE

7.10.34 Harbour seals have been assessed as having a medium sensitivity to PTS from UXO clearance and the <u>unmitigated</u> magnitude is considered to be negligible. Therefore, the significance of PTS from <u>unmitigated</u> UXO clearance is concluded to be of **Negligible** significance, which is not significant in terms of the EIA Regulations 2017.

GREY SEAL

SENSITIVITY

7.10.35 The overview of sensitivity is the same as described in the array area in paragraph 7.10.11 *et seq*.

MAGNITUDE

7.10.36 The overview of unmitigated and mitigated magnitude is the same as described for the array area in paragraphs 7.10.24 and 7.10.26 *et seq*.

SIGNIFICANCE

7.10.37 Grey seals have been assessed as having a medium sensitivity to PTS from UXO clearance and the unmitigated magnitude is considered to be negligible. Therefore, the significance of PTS from unmitigated UXO clearance is concluded to be of **Negligible** significance, which is not significant in terms of the EIA Regulations 2017.

IMPACT 2: DISTURBANCE FROM UXO CLEARANCE

ARRAY AREA IMPACTS

7.10.38 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 in the array area, the VE impact assessment presents the results for the 26 km EDR (high-order; Table 7.19), 5 km EDR (low-order; Table 7.27) and TTS-onset thresholds (Table 7.21).

7.10.39 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 7.19 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	1.12%
Harbour seal	0.018	2,123.72	38	4,868	0.78%
Grey seal	0.106	2,123.72	225	65,505	0.34%

Table 7.20 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	4,868	0.02%
Grey seal	0.106	78.54	8	65,505	0.01%

Table 7.21 Disturbance from UXO clearance using TTS-onset as a proxy for disturbance. All charge sizes ≥25 kg also include a donor charge.

Species and 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	<0.02	<0.02	<0.02	<0.02	<0.02	0.02	0.02
		# GS	<1	<1	1	3	4	7	8

Species and Threshold		Metric	0.5 kg	25 kg	55 kg	120 kg	240 kg	525 kg	698 kg
		% 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	<0.02	0.04	0.06	0.12	0.23	0.41	0.55%
		# GS	<1	9	19	33	65	120	161
		% MU	<0.01	0.01	0.03	0.05	0.10	0.18	0.25

SENSITIVITY

7.10.40 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 Medium.

HARBOUR PORPOISE

MAGNITUDE

7.10.41 **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 7.19). Given the number and proportion of the MU expected to be disturbed by high-order UXO clearance, the impact is assessed as a Low magnitude to harbour porpoise.

7.10.42 **Using the 5 km EDR for disturbance from low-order detonations:** it is anticipated that 143 harbour porpoise would be disturbed by UXO clearance, equating to 0.04% of the MU population (Table 7.20). Given the number and proportion of the MU expected to be disturbed by low-order UXO clearance, the impact is assessed as a Low magnitude.

7.10.43 **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 7.21). Given the number and proportion of the MU expected to be disturbed by high-order UXO clearance, the impact is assessed as a Low magnitude.

SIGNIFICANCE

7.10.44 The magnitude of the impact has been assessed as low and the sensitivity of harbour porpoise as medium. 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

7.10.45 **Using the 26 km EDR for disturbance from high-order detonations:** it is anticipated that estimated 38 harbour seals will be disturbed, equating to 0.78% of the MU population (Table 7.19). Given the low number and proportion of the MU predicted to be impacted, harbour seals are assessed as Negligible (neutral) magnitude.

7.10.46 **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 7.20). 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.

7.10.47 **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 7.21). 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

7.10.48 The magnitude of the impact has been assessed as Negligible and the sensitivity of harbour seals as medium. 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

7.10.49 **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 7.19). Given the low number and proportion of the MU predicted to be impacted, grey seals are assessed as Negligible (neutral) magnitude.

7.10.50 **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 7.20). 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.

7.10.51 **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 7.21). 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

7.10.52 The magnitude of the impact has been assessed as Negligible and the sensitivity of grey seals as medium. 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.

OFFSHORE EXPORT CABLE CORRIDOR IMPACTS

7.10.53 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 in the Offshore ECC, the VE impact assessment presents the results for the 26 km EDR (high-order; Table 7.19), 5 km EDR (low-order; Table 7.20) and TTS-onset thresholds (Table 7.21).

HARBOUR PORPOISE

SENSITIVITY

7.10.54 The overview of sensitivity is the same as described in the array area in paragraph 7.10.40 *et seq*.

MAGNITUDE

7.10.55 The overview of magnitude for high order (26 km EDR), low order (5 km EDR) and using TTS-onset as a proxy is the same as described in the array area in paragraphs 7.10.41, 7.10.42 and 7.10.43 *et seq*.

SIGNIFICANCE

7.10.56 Harbour porpoise have been assessed as having a medium sensitivity to disturbance form UXO clearance and the magnitude for high order (26 km EDR), low order (5 km EDR) and TTS-onset thresholds are considered to be low. Therefore disturbance from UXO clearance is concluded to be of **Minor** significance, which is not significant in terms of the EIA Regulations 2017.

HARBOUR SEAL

SENSITIVITY

7.10.57 The overview of sensitivity is the same as described in the array area in paragraph 7.10.40 *et seq*.

MAGNITUDE

7.10.58 The overview of magnitude for high order (26 km EDR), low order (5 km EDR) and using TTS-onset as a proxy is the same as described in the array area in paragraphs 7.10.45, 7.10.46 and 7.10.47 *et seq*.

SIGNIFICANCE

7.10.59 Harbour seals have been assessed as having a medium sensitivity to disturbance form UXO clearance and the magnitude for high order (26 km EDR), low order (5 km EDR) and TTS-onset thresholds are considered to be negligible. Therefore, disturbance from UXO clearance is concluded to be of **Negligible** significance, which is not significant in terms of the EIA Regulations 2017.

GREY SEAL

SENSITIVITY

7.10.60 The overview of sensitivity is the same as described in the array area in paragraph 7.10.40 *et seq*.

MAGNITUDE

7.10.61 The overview of magnitude for high order (26 km EDR), low order (5 km EDR) and using TTS-onset as a proxy is the same as described in the array area in paragraphs 7.10.49, 7.10.50 and 7.10.51*et seq*.

SIGNIFICANCE

7.10.62 Grey seals have been assessed as having a medium sensitivity to disturbance from UXO clearance and the magnitude for high order (26 km EDR), low order (5 km EDR) and TTS-onset thresholds are considered to be negligible. Therefore, disturbance from UXO clearance is concluded to be of **Negligible** significance, which is not significant in terms of the EIA Regulations 2017.

IMPACT 3: PTS FROM PILING

ARRAY AREA IMPACTS

7.10.63 The following section provides the quantitative assessment of the impact of auditory injury (PTS) from pile driving of WTGs 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 at maximum hammer energy for both monopiles (7,000 kJ) and pin piles (3,000 kJ) (Table 7.22) and additional sequential and concurrent piling scenarios (Table 7.23).

Table 7.22 Unmitigated PTS-onset impact area, maximum range, number of harbour porpoise, harbour seal and grey seal and percentage of MU predicted to be impacted from piling of WTGs.

	Pile type	Monopile (7,000 kJ)			Pin pile (3,000 kJ)		
Species	**Location**	**SW**	**NE**	**N**	**SW**	**NE**	**N**
Instantaneous PTS (SPL_{peak})							
Harbour porpoise	Area (km²)	1.6	1.7	1.7	1	1	1.1
	Max range (m)	730	730	740	580	580	590
Digital Aerial Surey (DAS) density (1.82/km²)	# porpoise	3	3	3	2	2	2
	% MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lacey *et al.* (2022) density	# porpoise	<1	1	1	<1	<1	<1
	% MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
SCANS IV (0.3096/km)	# porpoise	<1	<1	<1	<1	<1	<1
	% MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Harbour (HS) & Grey seal (GS) (Carter et al. 2020, 2022 density)	Area (km²)	0.01	0.01	0.01	0.01	0.01	0.01
	Max range (m)	60	60	60	<50	<50	<50
	# HS	<1	<1	<1	<1	<1	<1
	% MU	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
	# GS	<1	<1	<1	<1	<1	<1
	% MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cumulative PTS (SEL_{cum}) (1 monopile/day) (4 pin piles/day)							
Harbour porpoise	Area (km²)	150	180	180	87	110	110
	Max range (m)	8,400	8,500	8,600	6,400	6,500	6,600
DAS density (1.82/km²)	# porpoise	273	340	334	160	201	198
	% MU	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Lacey *et al.* (2022) density	# porpoise	60	104	105	35	61	62
	% MU	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1
SCANS IV (0.3096/km)	# porpoise	46	58	57	27	34	34
	% MU	<0.1	<0.1	<0.1	<0.01	<0.01	<0.01

	Pile type	Monopile (7,000 kJ)			Pin pile (3,000 kJ)		
Harbour (HS) & Grey seal (GS) (Carter et al. 2020, 2022 density)	Area (km^2)	0.1	0.2	0.2	<0.1	<0.1	<0.1
	Max range (m)	300	280	330	<100	<100	<100
	# HS	<1	<1	<1	<1	<1	<1
	% MU	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	# GS	<1	<1	<1	<1	<1	<1
	% MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table 7.23 Unmitigated PTS-onset impact area, maximum range, number of harbour porpoise, harbour seal and grey seal and percentage of MU predicted to be impacted from sequential and concurrent piling of WTGs.

Species		Monopile Sequential (30 hrs)	Monopile Sequential (24 hrs)	Monopile Concurrent (15 hrs)	Pin Pile Sequential (32 hrs)	Pin Pile Concurrent (1 6hrs)
Harbour porpoise	Area (km^2)	190	190	800	110	640
	Max range (m)	8,800	8,800	-	6,700	-
DAS density (1.82/km^2)	# porpoise	344	344	1,467	202	1,167
	% MU	0.10	0.10	0.42	0.06	0.34
Lacey *et al.* (2022) density	# porpoise	108	108	411	63	324
	% MU	0.03	0.03	0.12	0.02	0.09
SCANS IV (0.3096/km^2)	# porpoise	59	59	250	34	198
	% MU	0.02	0.02	0.07	0.01	0.06
Harbour (HS) & Grey seal (GS) (Carter et al. 2020,	Area (km^2)	0.4	0.4	140	<0.1	
	Max range (m)	400	400	-	<100	-
	# HS	<1	<1	7	<1	6

Species		Monopile Sequential (30 hrs)	Monopile Sequential (24 hrs)	Monopile Concurrent (15 hrs)	Pin Pile Sequential (32 hrs)	Pin Pile Concurrent (1 6hrs)
2022 density)	% MU	<0.02	<0.02	0.14	<0.02	0.12
	# GS	<1	<1	<1	<1	<1
	% MU	<0.01	<0.01	<0.01	<0.01	<0.01

Table 7.24 Difference between the unmitigated and mitigated PTS-onset maximum range (assuming 10 dB reduction in source level).

Species	Modelling location	Unmitigated cumulative PTS Range	Mitigated cumulative PTS range
Harbour porpoise	N	8.6 km	0.68 km
Seals	N	0.33 km	<0.1 km

HARBOUR PORPOISE

SENSITIVITY TO PTS FROM PILING

7.10.64 The ecological consequences of PTS for marine mammals are uncertain. At an Department for Business, Energy & Industrial Strategy (BEIS) funded expert elicitation workshop held at the University of St Andrews in 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.

7.10.65 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."

7.10.66 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 7.25. 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).
- Experts estimated that the median decline in an individual mature female harbour porpoise's survival was 0.01% (due to a 6 dB PTS (a notch a few kHz wide and 6 dB high) occurring somewhere in the hearing between 2-10 kHz)
- Experts estimated that the median decline in an individual 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).

Table 7.25 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

7.10.67 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.

7.10.68 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, harbour porpoise have been assessed as having a medium sensitivity to PTS.

MAGNITUDE

7.10.69 Table 7.22 presents the unmitigated PTS-onset impact area, impact range and number of harbour porpoise within the PTS-onset impact area using the maximum hammer energy.

7.10.70 The instantaneous PTS-onset impact ranges are low, with a maximum of 0.74 km for a monopile, which equates to 3 harbour porpoise experiencing PTS-onset. This represents <0.01% of the MU population.

7.10.71 For the onset of cumulative PTS, the maximum predicted unmitigated impact range is 8.6 km for a monopile. Using a density of 1.82 harbour porpoise/km^2 estimate at VE from the sites-specific surveys, this equates to 340 harbour porpoise and 0.10% of the MU population.

7.10.72 Table 7.23 presents the unmitigated PTS-onset impact area, impact range and number of harbour porpoise within the PTS-onset impact area for various sequential and concurrent piling scenarios. For the onset of cumulative PTS from sequential piling, the maximum predicted impact is sequential piling of monopiles for 24 and/or 30 hours. Impact ranges reach 8.8 km. Using a density of 1.82 harbour porpoise/km^2 at VE from the sites-specific surveys, this equates to 344 harbour porpoise and 0.10% of the MU population.

7.10.73 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 7.7 km from the pile). 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, unmitigated PTS-onset is considered to be of Low magnitude.

SIGNIFICANCE

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

ADDITIONAL MITIGATION

7.10.75 Although the numbers and percentage of harbour porpoise predicted to be at risk from unmitigated 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.

7.10.76 If noise reduction methods are used (leading to a 10 dB reduction in source level), the maximum cumulative PTS-onset impact range for harbour porpoise at the N location is reduced from 8.6 km to 0.68 km (Table 7.24Table 7.24). Therefore, the impact of mitigated PTS-onset from piling for harbour porpoise is assessed as having a Negligible (neutral) magnitude given the piling MMMP.

RESIDUAL IMPACT

7.10.77 The mitigated magnitude of the impact has been assessed as Negligible (with the implementation of a Volume 9, Report 14.1: Outline Marine Mammal Mitigation Protocol- Piling, including the potential to use noise reduction methods) and the sensitivity of harbour porpoise as medium. Therefore, the significance of mitigated PTS from piling is concluded to be of **Negligible** significance, which is not significant in terms of the EIA Regulations.

HARBOUR SEAL

SENSITIVITY TO PTS FROM PILING

7.10.78 The expert elicitation workshop in March 2018 also included seal species (Booth and Heinis, 2018). 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 7.4. The data provided in Table 7.26 and Table 7.28 should be interpreted as:

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

7.10.79 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 medium sensitivity to PTS.

Table 7.26 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

MAGNITUDE

7.10.80 Table 7.22 presents the PTS-onset impact area, impact range and number of harbour seals within the PTS-onset impact area.

7.10.81 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.

7.10.82 For the onset of cumulative PTS, the maximum predicted impact range is 0.33 km at the N monopile location. This equates to <1 harbour seal and represents <0.02% of the MU population.

7.10.83 Table 7.23 presents the PTS-onset impact area, impact range and number of harbour seals within the PTS-onset impact area for various sequential and concurrent piling scenarios. The maximum predicted impact is for the monopile concurrent scenario where up to 7 harbour seals are predicted to experience PTS-onset (0.14% MU).

7.10.84 Due to the low number and percentage of harbour seals predicted to be impacted, alongside the small impact ranges, the unmitigated magnitude of PTS-onset has been assessed as Negligible (neutral).

SIGNIFICANCE

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

ADDITIONAL MITIGATION

7.10.86 The addition of mitigation through the implementation of a piling MMMP (Volume 9, Report 14.1: Outline Marine Mammal Mitigation Protocol – Piling) will ensure the effect significance of PTS remain negligible. If noise reduction methods are used (leading to a 10 dB reduction in source level), the maximum cumulative PTS-onset impact range for harbour seals at the N location is reduced from 0.33 km to 0.1 km (Table 7.24Table 7.24). The mitigated magnitude is therefore Negligible (neutral).

RESIDUAL IMPACT

7.10.87 The magnitude of the mitigated impact has been assessed as negligible and the sensitivity of harbour seals as medium. Therefore, the significance of PTS from mitigated 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

7.10.88 The sensitivity of grey seals to PTS form piling is considered to be the same as for harbour seals: medium. 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 7.10.79 for additional details).

MAGNITUDE

7.10.89 Table 7.22 presents the PTS-onset impact area, impact range and number of grey seals within the PTS-onset impact area.

7.10.90 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 <0.01% of the MU population.

7.10.91 For the onset of cumulative PTS, the maximum predicted impact range is 0.33 km at the N monopile location. This equates to <1 grey seal and represents <0.01% of the MU population.

7.10.92 Table 7.23 presents the PTS-onset impact area, impact range and number of harbour seals within the PTS-onset impact area for various sequential and concurrent piling scenarios. The maximum predicted impact is for <1 grey seal predicted to experience PTS-onset (<0.01% MU).

7.10.93 Due to the low number and percentage of grey seals predicted to be impacted, alongside the small impact ranges, the unmitigated magnitude of PTS-onset has been assessed as Negligible (Negative).

SIGNIFICANCE

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

ADDITIONAL MITIGATION

7.10.95 The addition of mitigation through the implementation of a piling MMMP will ensure the effect significance of PTS remain negligible.

7.10.96 If noise reduction methods are used (leading to a 10 dB reduction in source level), the maximum cumulative PTS-onset impact range for harbour seals at the N location is reduced from 0.33 km to 0.1 km (Table 7.24). The mitigated magnitude is therefore Negligible (neutral).

RESIDUAL IMPACT

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

OFFSHORE EXPORT CABLE CORRIDOR

7.10.98 As piling of structures are not planned for the Offshore ECC there is no pathway for effect on marine mammals and therefore no risk of PTS.

LANDFALL SHEET PILING

7.10.99 The following section provides the quantitative assessment of the impact of auditory injury (PTS) from sheet piling for the cofferdam 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 7.27.

7.10.100 The instantaneous PTS-onset impact ranges are negligible, with a maximum impact range of <50 m at both MHWS and MLWS for all species. For the onset of cumulative PTS, the maximum predicted impact range is <100 m at both MHWS and MLWS for all species (Table 7.27. Given the negligible impact ranges for all species, the magnitude of PTS-onset from sheet piling for the cofferdam has been assessed as Negligible.

7.10.101 The sensitivity of marine mammals to impact piling of sheet piles for the cofferdam is assumed to be the same as impact piling for the WTGs: medium (see paragraphs 7.10.68, 7.10.79 and 7.10.88).

7.10.102 The magnitude of the impact has been assessed as Negligible and the sensitivity of harbour porpoise, harbour seals and grey seals as medium. Therefore, the significance of PTS from sheet piling is concluded to be of **Negligible** significance, which is not significant in terms of the EIA regulations 2017.

Table 7.27 Unmitigated PTS-onset impact area, maximum range, number of harbour porpoise, harbour seal and grey seal and percentage of MU predicted to be impacted from sheet piling for the cofferdam.

Species	Location	MHWS	MLWS
Instantaneous PTS (SPL_{peak})			
Harbour porpoise	Area (km^2)	<0.01	<0.01
DAS density (1.82/km^2)	Max range (m)	<50	<50
Lacey *et al.* (2022) density	# porpoise	<1	<1
SCANS IV density (0.3096/km^2)	% MU	<0.01	<0.01
Harbour (HS) & Grey seal (GS) (Carter et al. 2020, 2022 density)	Area (km^2)	<0.01	<0.01
	Max range (m)	<50	<50
	# HS	<1	<1
	% MU	<0.02	<0.02
	# GS	<1	<1
	% MU	<0.01	<0.01
Cumulative PTS (SEL_{cum}) 8 sheet piles/day			
Harbour porpoise	Area (km^2)	<0.1	<0.1
DAS density (1.82/km^2)	Max range (m)	<100	<100
Lacey *et al.* (2022) density	# porpoise	<1	<1
SCANS IV density (0.3096/km^2)	% MU	<0.01	<0.01
Harbour (HS) & Grey seal (GS) (Carter et al. 2020, 2022 density)	Area (km^2)	<0.1	<0.1
	Max range (m)	<100	<100
	# HS	<1	<1
	% MU	<0.02	<0.02
	# GS	<1	<1
	% MU	<0.01	<0.01

IMPACT 4: TTS FROM PILING

ARRAY AREA IMPACTS

7.10.103 Full details of the underwater noise modelling and the resulting TTS-onset impact areas and ranges are detailed in Volume 6, Part 5, Annex 6.2: Underwater Noise Technical Report. As previously outlined (see paragraphs 7.6.40 - 7.6.48), 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).

7.10.104 The largest cumulative TTS-onset impact range for harbour porpoise for the installation of one monopile WTG is 31 km, potentially impacting up to 3,822 harbour porpoise (1.10% MU) using the site-specific DAS average density estimate (Table 7.28).

7.10.105 Under the monopile concurrent scenario, up to 6,623 harbour porpoise are predicted to be impacted (1.91% MU) (Table 7.29).

7.10.106 The largest cumulative TTS-onset impact range for seals for the installation of one monopile WTG is 15-16 km, potentially impacting up to <1 harbour seal (<0.02% MU) and up to 27 grey seals (0.04% MU) (Table 7.28).

7.10.107 Under the monopile concurrent scenario, <1 harbour seal (<0.02% MU) and up to 76 grey seals (1.91% MU) are predicted to be impacted (Table 7.29).

7.10.108 If a noise mitigation is assumed, then the cumulative TTS-onset impact range for harbour porpoise for the installation of one monopile WTG reduces from 31 km to 15 km, potentially impacting up to 965 harbour porpoise (0.28% MU) using the site-specific DAS average density estimate (Table 7.28).

7.10.109 If a noise mitigation is assumed, then the cumulative TTS-onset impact range for seals for the installation of one monopile WTG reduces from 16 km to 3.3 km, potentially impacting <1 harbour seal (<0.02% MU) and 1 grey seal (<0.01% MU) (Table 7.28).

Table 7.28: Impact area, maximum range, number of harbour porpoise, harbour seal and grey seal and percentage of MU predicted to experience TTS-onset from piling of WTGs. N mitigated is the TTS onset impact range assuming a 10 dB reduction in source level.

	Pile type	Monopile (7,000 kJ)				Pin pile (3,000 kJ)		
Species	**Location**	**SW**	**NE**	**N**	**N mitigated**	**SW**	**NE**	**N**
Instantaneous TTS (SPL_{peak})								
Harbour porpoise	Area (km^2)	9.2	9.7	10	0.5	5.9	6.2	6.5
	Max range (m)	1,800	1,800	1,800	400	1,400	14,000	1,400
DAS (1.82/km^2)	# porpoise	17	18	18	1	11	11	12
	% MU	<0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01
SCANS III surface	# porpoise	4	5	6	<1	2	4	4
	% MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
SCANS IV (0.3096/km^2)	# porpoise	3	3	3	<1	2	2	2
	% MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Harbour & Grey Seals	Area (km^2)	0.07	0.07	0.07	<0.01	0.04	0.04	0.05
	Max range (m)	150	150	160	<50	120	120	120
	# harbour seals	<1	<1	<1	<1	<1	<1	<1
	% MU	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
	# grey seals	<1	<1	<1	<1	<1	<1	<1
	% MU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cumulative TTS (SEL_{cum})								

	Pile type	Monopile (7,000 kJ)			Pin pile (3,000 kJ)			
Harbour porpoise	Area (km^2)	1,800	2,100	2,100	530	1,500	1,700	1,700
	Max range (m)	31,000	31,000	31,000	15,000	28,000	28,000	28,000
DAS (1.82/km^2)	# porpoise	3,276	3,822	3,822	965	2,730	3,094	3,094
	% MU	0.95	1.10	1.10	0.28	0.79	0.89	0.89
SCANS III surface	# porpoise	808	1,220	1,186	970	661	1,009	980
	% MU	0.23	0.35	0.35	0.28	0.19	0.29	0.28
SCANS IV (0.3096/km^2)	# porpoise	551	659	643	165	452	543	529
	% MU	0.16	0.19	0.19	0.05	0.13	0.16	0.15
Harbour & Grey Seals	Area (km^2)	460	570	560	26	380	470	406
	Max range (m)	15,000	16,000	15,000	3,300	14,000	14,000	14,000
	# harbour seals	<1	<1	<1	<1	<1	<1	<1
	% MU	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
	# grey seals	19	22	27	1	15	17	22
	% MU	0.03	0.03	0.04	0.00	0.02	0.03	0.03

Table 7.29 Unmitigated TTS-onset impact area, maximum range, number of harbour porpoise, harbour seal and grey seal and percentage of MU predicted to be impacted from sequential and concurrent piling of WTGs.

Species	Location	Monopile Sequential (30 hrs)	Monopile Sequential (24 hrs)	Monopile Concurrent (15 hrs)	Pin Pile Sequential (32 hrs)	Pin Pile Concurrent (16 hrs)
Harbour porpoise	Area (km^2)	2,100	2,100	3,600	1,700	3,155
	Max range (m)	31,000	31,000	-	28,000	-
DAS density (1.82/km^2)	# porpoise	3,821	3,821	6,623	3,127	5,743
	% MU	1.10	1.10	1.91	0.90	1.66
Lacey *et al.* (2022) density	# porpoise	1,197	1,197	1,895	987	1,644
	% MU	0.35	0.35	0.55	0.28	0.47
SCANS IV (0.3096/km^2)	# porpoise	650	650	1,107	532	970
	% MU	0.19	0.19	0.32	0.15	0.28
Harbour (HS) & Grey seal (GS) (Carter et al. 2020, 2022 density)	Area (km^2)	570	570	1,500	470	1,300
	Max range (m)	16,000	16,000	-	14,000	-
	# HS	<1	<1	<1	<1	<1
	% MU	<0.01	<0.01	<0.01	<0.01	<0.01
	# GS	28	28	76	22	67
	% MU	0.04	0.04	0.12	0.03	0.10

OFFSHORE EXPORT CABLE CORRIDOR

7.10.110 As piling of structures are not planned for the Offshore ECC there is no pathway for effect on marine mammals and therefore no risk of TTS.

LANDFALL SHEET PILING

7.10.111 TTS from impact piling of sheet piles at the landfall sheet piling site is expected to result in no impact to marine mammals due to the very low impact ranges predicted (Table 7.30).

Table 7.30 Number of marine mammals and percentage of the MU predicted to experience TTS from sheet piling for the cofferdam.

Species		MHWS	MLWS
Instantaneous TTS (SPL_{peak})			
Harbour porpoise	Area (km^2)	<0.01	<0.01
DAS density (1.82/km^2)	Max range (m)	<50	<50
Lacey *et al.* (2022) density	# porpoise	<1	<1
SCANS IV density (0.3096/km^2)	% MU	0.00	0.00
Harbour & Grey Seals (Carter et al. 2020, 2022 density)	Area (km^2)	<0.01	<0.01
	Max range (m)	<50	<50
	# harbour seals	<1	<1
	% MU	0.00	0.00
	# grey seals	<1	<1
	% MU	0.00	0.00
Cumulative TTS (SEL_{cum})			
Harbour porpoise	Area (km^2)	<0.1	<0.1
DAS density (1.82/km^2)	Max range (m)	<100	<100
Lacey *et al.* (2022) density	# porpoise	<1	<1
SCANS IV density (0.3096/km^2)	% MU	<0.02	<0.02
Harbour & Grey Seals (Carter et al. 2020, 2022 density)	Area (km^2)	<0.1	<0.1
	Max range (m)	<100	<100
	# harbour seals	<1	<1
	% MU	<0.02	<0.02
	# grey seals	<1	<1

Species		MHWS	MLWS
	% MU	0.00	0.00

IMPACT 5: DISTURBANCE FROM PILING

ARRAY AREA IMPACTS

UNMITIGATED

7.10.112 The following Section (paragraphs 7.10.113 to 7.10.145) provides the quantitative assessment of disturbance from unmitigated pile driving of WTGs 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 7.31).

Table 7.31: Number of marine mammals and percentage of the MU predicted to experience potential behavioural disturbance from piling of WTGs.

		Pile type	Monopile (7,000 kJ)					Pin pile (3,000 kJ)				
Species	Density	Modelling location	SW	NE	N	SW & NE	SW & N	SW	NE	N	SW & NE	SW & N
Harbour porpoise	DAS (1.82/km²)	# porpoise	5,560	6,583	6,466	8,953	8,835	4,797	5,677	5,589	7,859	7,762
		% MU	1.60	1.89	1.87	2.58	2.55	1.38	1.64	1.61	2.27	2.24
	SCANS III surface	# porpoise	1,396	2,068	2,018	2,559	2,511	1,201	1,782	1,744	2,242	2,203
		% MU	0.40	0.60	0.58	0.74	0.72	0.35	0.51	0.50	0.65	0.64
	SCANS IV (0.3096/km²)	# porpoise	946	1,120	1,100	1,523	1,503	816	966	951	1,320	1,337
		% MU	0.27	0.32	0.32	0.44	0.43	0.24	0.28	0.27	0.38	0.39
Harbour seal	Carter *et al.* (2020) (grid cell specific)	# seals (mean & 95% CI)	1 (<1 – 2)	1 (<1 – 1)	1 (<1 – 2)	2 (<1 – 3)	2 (<1 – 4)	1 (<1 – 2)	<1 (<1 – 1)	1 (<1 – 1)	1 (<1 – 2)	1 (<1 – 3)
		% MU (mean & 95% CI)	0.02 (0.00-0.04)	0.02 (0.00-0.02)	0.02 (0.00-0.04)	0.04 (0.00-0.06)	0.04 (0.00-0.08)	0.02 (0.00-0.04)	<0.02 (0.00-0.02)	0.02 (0.00-0.02)	0.02 (0.00-0.04)	0.02 (0.00-0.06)
Grey seal	Carter *et al.* (2020) (grid cell specific)	# seals (mean & 95% CI)	79 (9 – 150)	92 (10 – 175)	102 (11 – 192)	143 (16 – 268)	152 (17 – 284)	63 (7 – 119)	72 (7 – 138)	81 (11 – 192)	114 (12 – 215)	122 (13 – 229)
		% MU (mean & 95% CI)	0.12 (0.01-0.23)	0.04 (0.02-0.27)	0.06 (0.02-0.29)	0.22 (0.02-0.41)	0.23 (0.03-0.43)	0.10 (0.01-0.18)	0.11 (0.01-0.21)	0.12 (0.02-0.29)	0.17 (0.02-0.33)	0.19 (0.02-0.35)

HABOUR PORPOISE

SENSITIVITY

7.10.113 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.

7.10.114 Studies using Digital Acoustic Recording Tags (DTAGs) have shown that porpoise tagged after capture in pound nets foraged on small prey nearly continuously during both the day and the night on their release (Wisniewska *et al.*, 2016). The authors state that porpoise therefore "operate on an energetic knife edge" and that they have "low resilience to disturbance". However, there are concerns with the methodologies used in the Wisniewska *et al.* (2016) paper that bring these conclusions into question. These concerns are summarized in a rebuttal to the original paper by Hoekendijk *et al.* (2018) which call for "a cautious, critical, and rational assessment of the results and interpretations". One of the key issues highlighted is that the porpoise were trapped in a pound net for 24+ hours before tagging and were not allowed to recover from stress and starvation once released. The high levels of foraging observed don't necessarily represent the typical foraging – i.e. they are not necessarily indicative of vulnerability to disturbance. Foraging behaviour after release may in part be a response to being captured and held. It is typical for the initial data recorded from tags to be excluded from analysis as it is not expected to be representative of typical behaviour (e.g. Wright et al 2017). Given that the tags on the porpoise in Wisniewska *et al.* (2016) only recorded for 15-23 hours after tagging, it could be considered that all of the data are impacted by the response to being caught and tagged, and thus none of it is representative of typical behaviour.

7.10.115 Wisniewska *et al.* (2018) responded to the rebuttal by Hoekendijk *et al.* (2018) by highlighting that it was unknown whether or not the captured porpoise fed while in the pound nets or whether this would have led to elevated stress. They state that the hunger levels of the released porpoise were unknown and that there was no evidence of prolonged response to the tagging circumstances.

7.10.116 Further to this, a subsequent paper by Booth (2020) used the Wisniewska *et al.* (2016) data combined with additional information on porpoise diet and the energy derived from different prey to highlight that the tagged animals likely were able to consume significant amounts of energy (well in excess of energetic requirements – based on the data available). Booth (2020) disputes the conclusion that porpoise exist on an "energetic knife-edge" as Wisniewska *et al.* (2016) claim but do not justify in their paper.

7.10.117 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.

7.10.118 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.

7.10.119 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).

7.10.120 At an expert elicitation workshop held in 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 (DEB) model for harbour porpoise (based on the DEB model in Hin *et al*. (2019)) was used to aid discussions regarding the potential effects of missed foraging opportunities on survival and reproduction. The model described the way in which the life history processes (growth, reproduction and survival) of a female and her calf depend on the way in which assimilated energy is allocated between different processes and was used during the elicitation to model the effects of energy intake and reserves following simulated disturbance.

7.10.121 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 7.10 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 7.10 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.

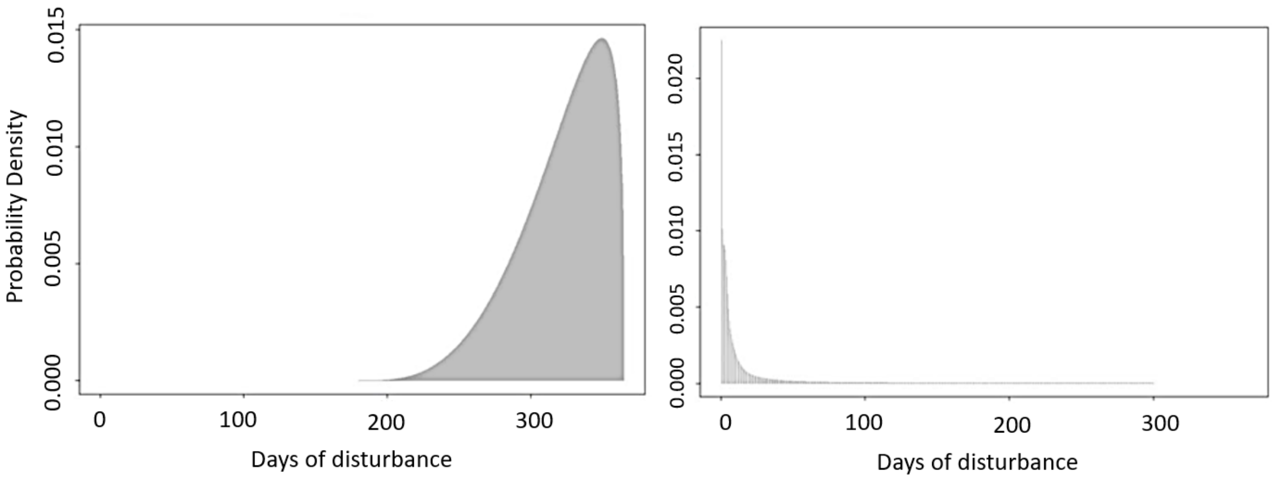


Figure 7.10 Probability distributions showing the consensus of the expert elicitation for harbour porpoise disturbance from piling (Booth et al., 2019). Left: the number of days of disturbance (i.e. days on which an animal does not feed for six hours) a pregnant female could 'tolerate' before it has any effect on fertility. Right: the number of days of disturbance a mother/calf pair could 'tolerate' before it has any effect on survival.

7.10.122 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 7.11). Therefore, porpoise that experience displacement are expected to be able to compensate for the lost foraging opportunities and increased energy expenditure of fleeing.

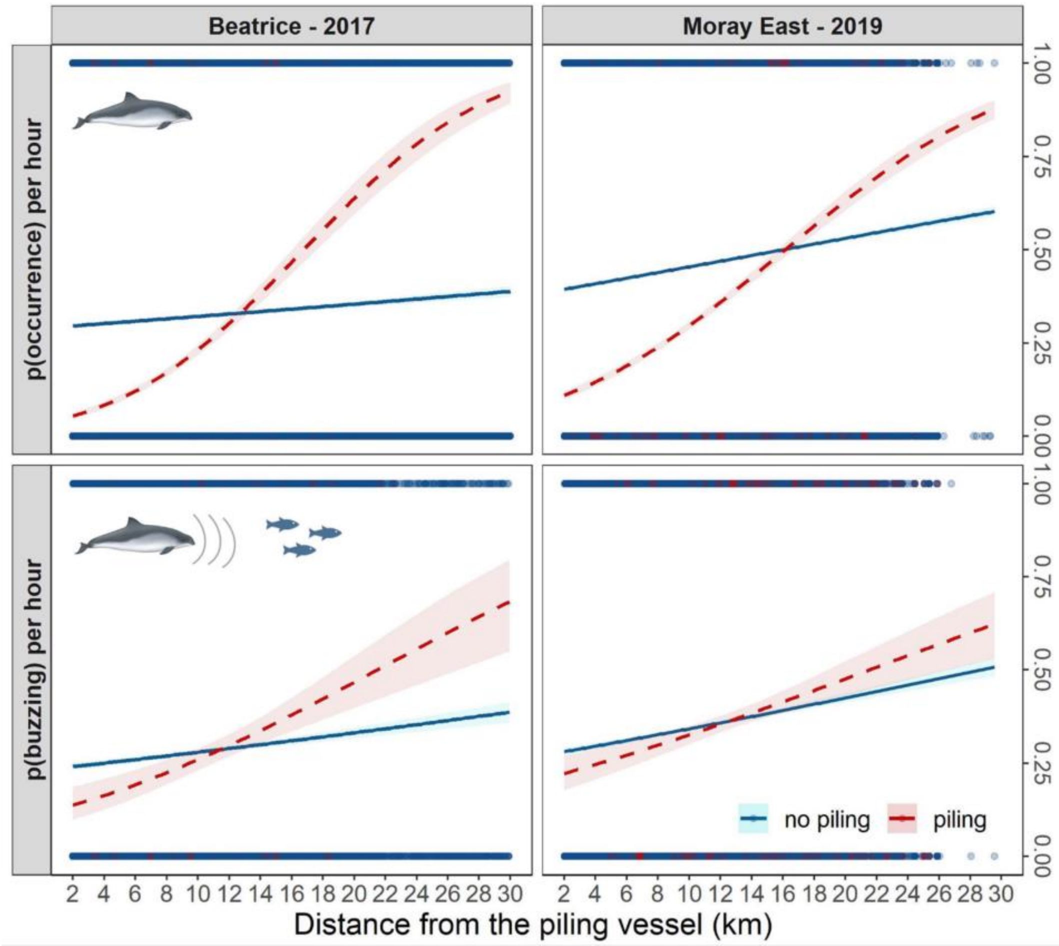


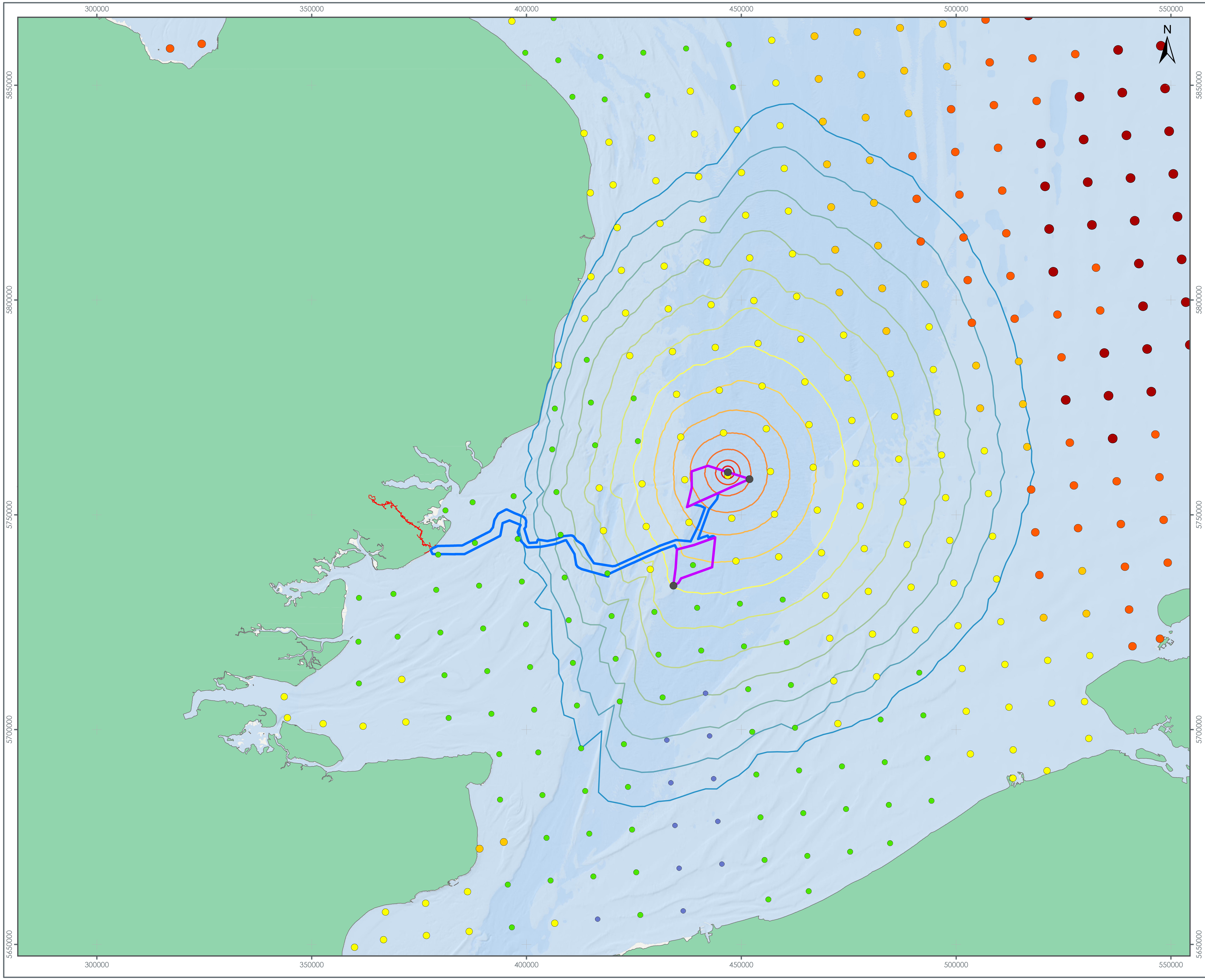
Figure 7.11: The probability of harbour porpoise occurrence and buzzing activity per hour during (dashed red line) and out with (blue line) pile-driving hours, in relation to distance from the pile-driving vessel at Beatrice (left) and Moray East (right). Obtained from Benhemma-Le Gall *et al*. (2021).

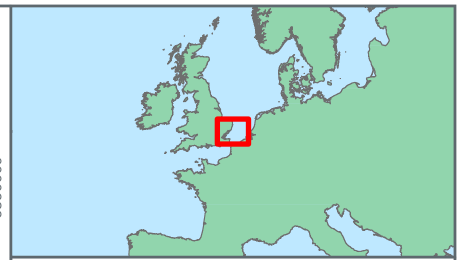
7.10.123 Given all the evidence summarised above, it is expected that harbour porpoise are somewhat resilient to and can compensate for temporary disturbance. Therefore, harbour porpoises have been assessed here as having a medium sensitivity to disturbance from pile driving activities.

MAGNITUDE

7.10.124 The results of disturbance to harbour porpoise from pile driving are presented in Table 7.31. From a single piling event, the maximum disturbance is predicted to occur at the NE monopile location, disturbing 6,583 harbour porpoise, which equates to 1.89% MU when using the site-specific DAS average density estimate (2,068 harbour porpoise, 0.6% of the MU population using the SCANS III density surface).

7.10.125 During concurrent piling, the maximum disturbance is predicted to occur during piling at the SW&NE monopile locations. This is predicted to disturb 8,953 harbour porpoise, which equates to 2.58% MU when using the site-specific DAS average density estimate (2,559 harbour porpoise, 0.74% of the MU using the SCANS III density surface).





LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Order Limits
- Modelling Locations

Noise contours, dB:

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

Harbour Porpoise Density (Animals per km²) (Lacey *et al.* 2022)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.25
- >1.25

0 10 20 40
Kilometers

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

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

Harbour Porpoise Behavioural Disturbance Contours from Worst Case Scenario

VER	DATE	REMARKS	Drawn	Checked
1	28/02/2024	For Issue	BPHB	JB

DRAWING NUMBER: 7.12

SCALE: 1:800,000 | PLOT SIZE: A3 | DATUM: WGS84 | PROJECTION: UTM31N

FIVE ESTUARIES
OFFSHORE WIND FARM

7.10.126 Given the results of the expert elicitation on the likely effects of behavioural disturbance on harbour porpoise vital rates (Booth et al. 2019), 85 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 short term duration, intermittent and is reversible. Given the number of porpoise predicted to be impacted and the proportion of the population this represents, (even under the worst-case scenario that the DAS density estimate is applicable throughout the entire disturbance range), this is considered to be a Low magnitude.

SIGNIFICANCE

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

HARBOUR SEAL

SENSITIVITY

7.10.128 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.

7.10.129 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.

7.10.130 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 7.13 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 7.13 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.

7.10.131 Given the evidence presented above, harbour seals have been assessed as having medium sensitivity to disturbance and resulting displacement from foraging grounds during impact piling events.

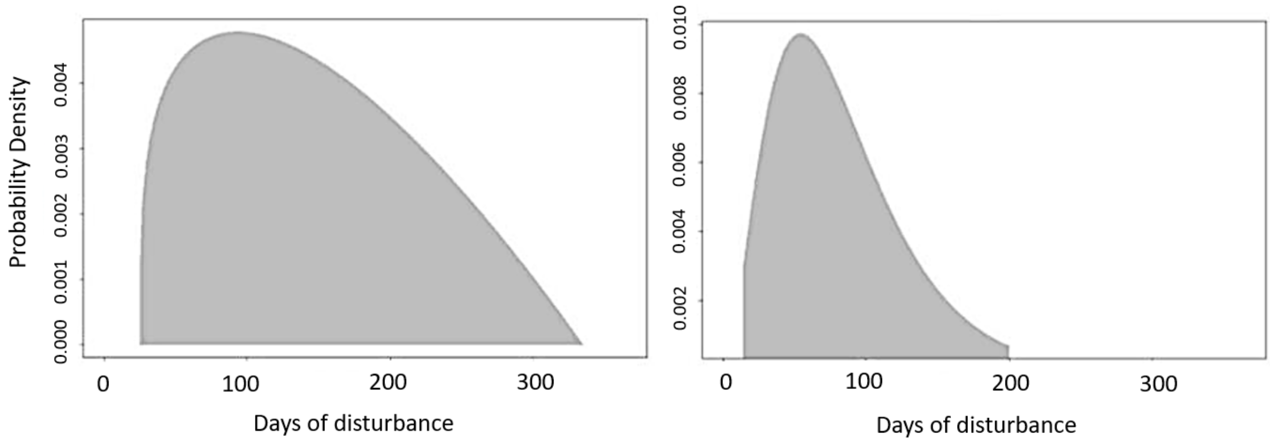
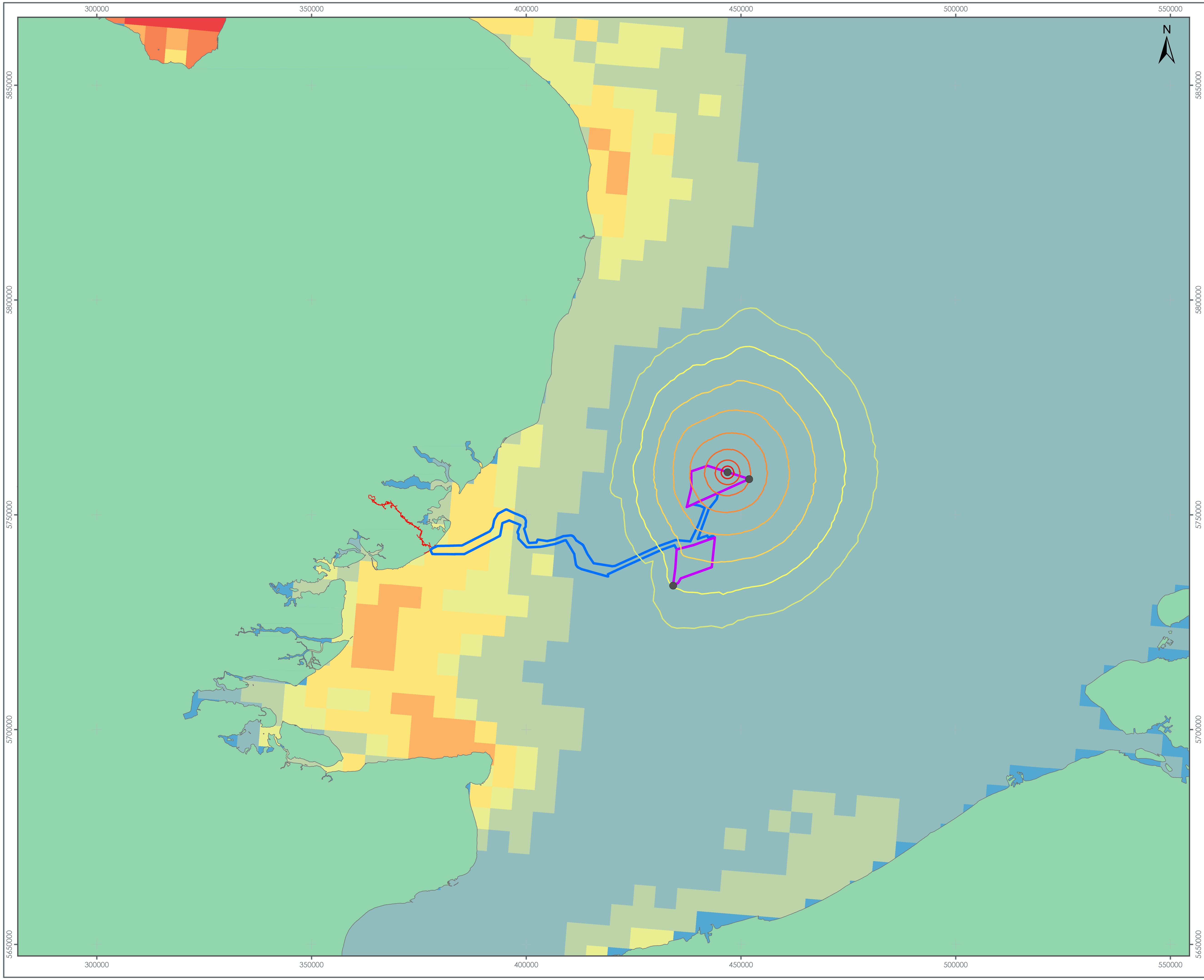


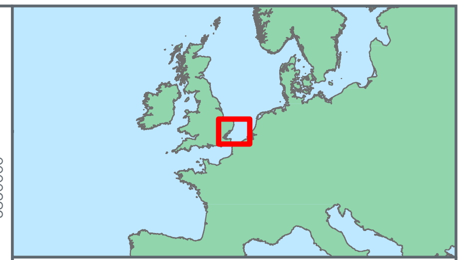
Figure 7.13: Probability distributions showing the consensus of the expert elicitation for harbour seal disturbance from piling. X-axis = days of disturbance; y-axis = probability density. Left: the number of days of disturbance (i.e. days on which an animal does not feed for six hours) a pregnant female 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

7.10.132 The results of disturbance to harbour seals from pile driving are presented in Table 7.31. 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 disturbance is predicted to occur to a maximum of only one harbour seal (95% CI: <1-2) which is equivalent to 0.02% (95% CI: <0.00-0.04%) of the MU population.

7.10.133 During concurrent piling, the maximum disturbance is predicted to occur during piling at the SW&N monopile locations. This is predicted to disturb two harbour seals (95% CI: <1-4), equivalent to 0.04% (95% CI: 0.00-0.08%) of the MU population.





LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Order Limits
- 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

0 5 10 20

Kilometers

Data Source:

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

Harbour Seal Behavioural Disturbance Contours from Worst Case Scenario

VER	DATE	REMARKS	Drawn	Checked
1	26/01/2024	For Issue	BPHB	JB

DRAWING NUMBER: 7.14

SCALE: 1:800,000 PLOT SIZE: A3 DATUM: WGS84 PROJECTION: UTM31N

FIVE ESTUARIES
OFFSHORE WIND FARM

7.10.134 The impact is predicted to be of local spatial extent, short term duration (up to 85 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

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

GREY SEAL

SENSITIVITY

7.10.136 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.

7.10.137 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.

7.10.138 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 7.15 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 7.15 right); however, there was a lot of uncertainty surrounding this estimate.

7.10.139 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.

7.10.140 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.

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

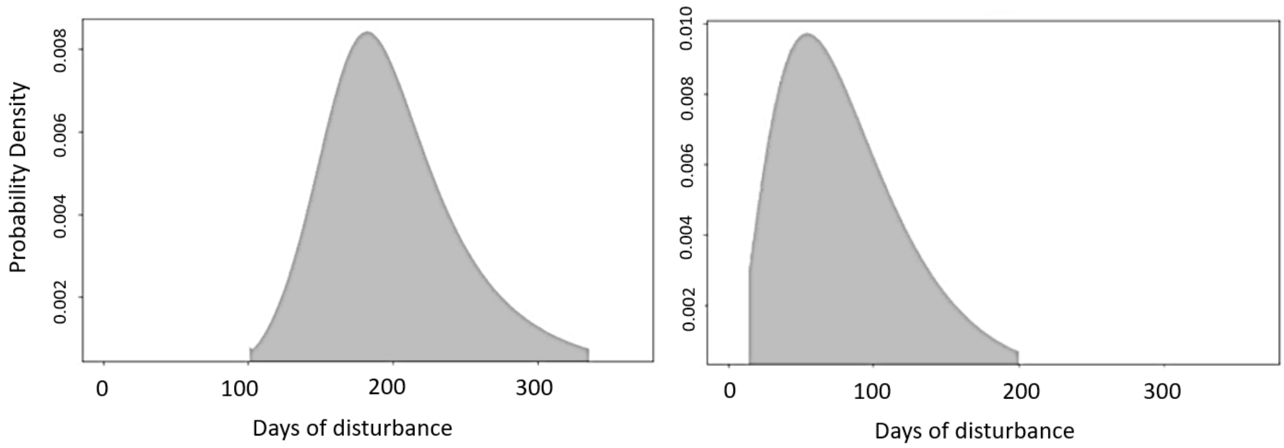
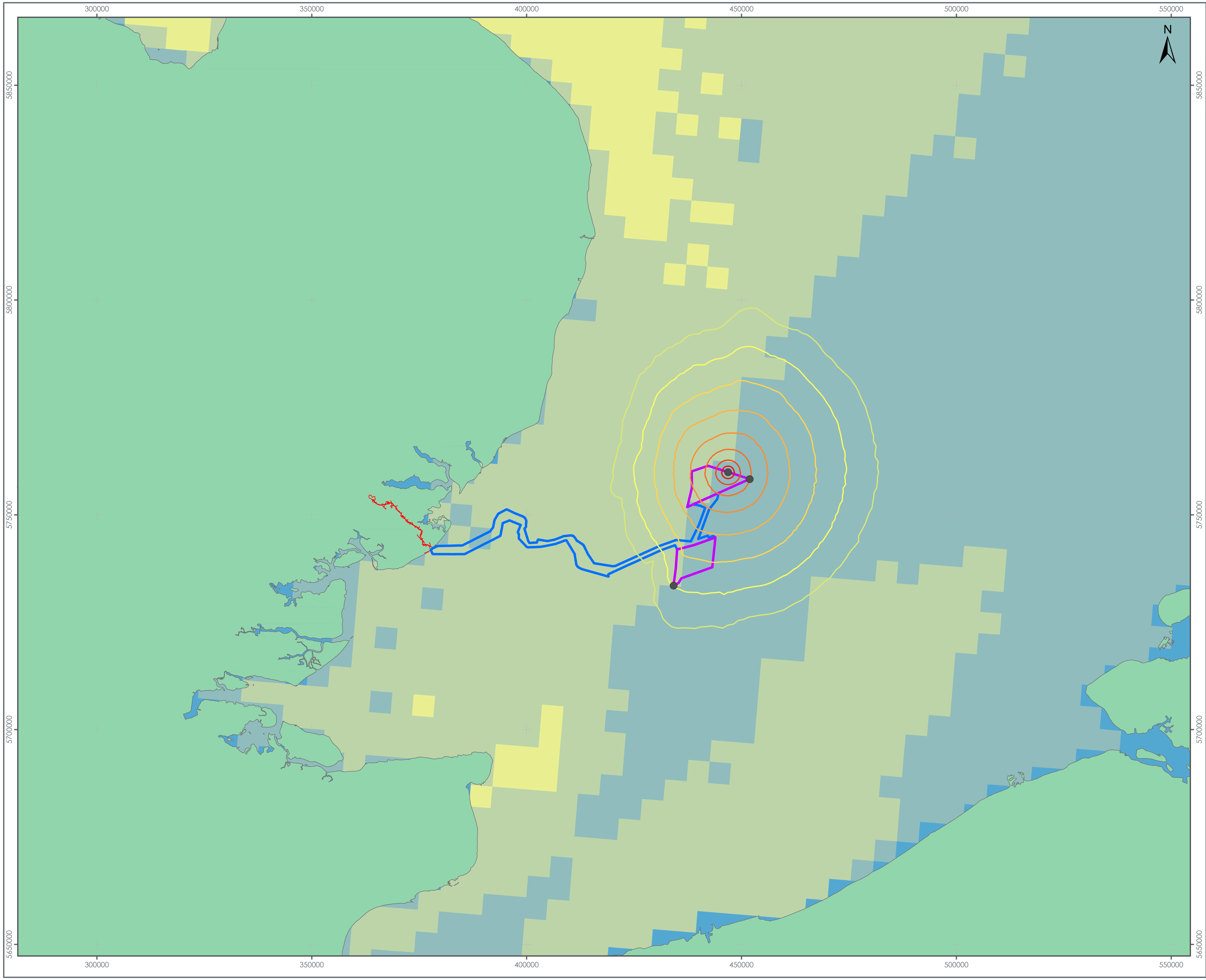


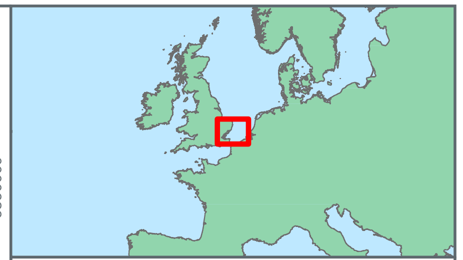
Figure 7.15: Probability distributions showing the consensus of the expert elicitation for grey seal disturbance from piling (Booth *et al*., 2019). Left: the number of days of disturbance (i.e. days on which an animal does not feed for six hours) a pregnant female could 'tolerate' before it has any 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

7.10.142 The results of disturbance to grey seals from pile driving are presented in Table 7.31. 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 monopile location, disturbing 102 grey seals (95% CI: 0.02-0.29%) of the MU population (Figure 7.16).

7.10.143 During concurrent piling, the maximum disturbance is predicted to occur during piling at the SW&N monopile locations. This is predicted to disturb 152 grey seals (95% CI: 17-284), equivalent to 0.23% (95% CI: 0.03-0.43%) of the MU population.





LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Order Limits
- 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 5,000 10,000 20,000
Meters

Data Source:

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

Grey Seal Behavioural Disturbance Contours from Worst Case Scenario

VER	DATE	REMARKS	Drawn	Checked
1	26/01/2024	For Issue	BPHB	JB

DRAWING NUMBER: 7.16

SCALE: 1:800,000 | PLOT SIZE: A3 | DATUM: WGS84 | PROJECTION: UTM31N

FIVE ESTUARIES OFFSHORE WIND FARM

7.10.144 The impact is predicted to be of local spatial extent, short term duration (up to 85 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

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

MITIGATED

7.10.146 The following Section provides the quantitative assessment of disturbance from unmitigated pile driving of a WTG at the N location 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 7.32).

7.10.147 If noise mitigation methods are used (leading to a 10 dB reduction in source level), the number of animals predicted to experience behaviour disturbance decreases. For unmitigated piling of a monopile at the N location, 6,466 harbour porpoise were predicted to be disturbed (1.87% MU) (using the site-specific DAS density estimate); this reduces to 2,839 porpoise (0.82% MU) assuming noise mitigation leading to a 10 dB reduction (using the site-specific DAS density estimate). This therefore reduced the magnitude from Low to Negligible for harbour porpoise.

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

7.10.149 For unmitigated piling of a monopile at the N location, 102 grey seals were predicted to be disturbed (0.06% MU); this reduces to 29 grey seals (0.04% MU) assuming noise mitigation leading to a 10 dB reduction. While the number of seals predicted to experience disturbance is reduced, the mitigated magnitude remains Negligible.

Table 7.32 Number of marine mammals and percentage of the MU predicted to experience potential behavioural disturbance from mitigated piling of a monopile WTG at the N location.

Species	Density	Modelling location	N (mitigated)
Harbour porpoise	DAS (1.82/km^2)	# porpoise	2,839
		% MU	0.82
	SCANS III surface	# porpoise	888
		% MU	0.26
	SCANS IV (0.3096/km^2)	# porpoise	483
		% MU	0.14
Harbour seal	Carter *et al.* (2020) (grid cell specific)	# seals (mean & 95% CI)	<1 (<1 – <1)
		% MU (mean & 95% CI)	0.02 (0.00-0.04)
Grey seal	Carter *et al.* (2020) (grid cell specific)	# seals (mean & 95% CI)	29 (3-56)
		% MU (mean & 95% CI)	0.04 (0.00-0.09)

OFFSHORE EXPORT CABLE CORRIDOR

7.10.150 As piling of structures are not planned for the Offshore ECC there is no pathway for effect on marine mammals and therefore no risk of disturbance.

LANDFALL SHEET PILING

Disturbance from impact piling of sheet piles at the landfall sheet piling site is expected to result in no disturbance to marine mammals given the very small impact ranges (Table 7.33

Table 7.33 Number of marine mammals and percentage of the MU predicted to experience potential behavioural disturbance from sheet piling for the cofferdam.

Species		MHWS	MLWS
Harbour porpoise (SCANS III density surface)	# porpoise	<1	<1
	% MU	<0.01	<0.01
Harbour porpoise (SCANS IV 0.3096/km^2)	# porpoise	<1	<1
	% MU	<0.01	<0.01
Harbour seal (Carter et al., 2020,2022)	# harbour seals	<1	<1

Species		MHWS	MLWS
	% MU	<0.02	<0.02
Grey seal (Carter et al., 2020,2022)	# grey seals	<1	<1
	% MU	<0.01	<0.01

IMPACT 6: PTS, TTS AND DISTURBANCE FROM OTHER CONSTRUCTION ACTIVITIES

PTS

ARRAY AREA AND OFFSHORE EXPORT CABLE CORRIDOR IMPACTS

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

SENSITIVITY

7.10.152 **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 medium.

7.10.153 **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 medium.

7.10.154 **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 medium and as such, sensitivity of marine mammals to PTS from cable laying is assessed as medium.

7.10.155 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 medium.

MAGNITUDE

7.10.156 Non-piling construction noise sources will have a very local spatial extent, and are transient and intermittent. Given that the PTS-onset ranges are so small (<100 m) (Table 7.34) the magnitude of impact is Negligible.

Table 7.34 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

SIGNIFICANCE

7.10.157 The magnitude of the impact has been assessed as negligible and the sensitivity of both porpoise and seals as medium. 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.

TTS

ARRAY AREA IMPACTS AND OFFSHORE EXPORT CABLE CORRIDOR IMPACTS

7.10.158 The TTS-onset impact areas and ranges for other construction activities are detailed in Volume 6, Part 5, Annex 6.2: Underwater Noise Technical Report. As previously outlined (see Sections 7.6.40 - 7.6.48), 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.

7.10.159 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 7.35). For both seal species, all impact ranges are predicted to be <100 m (Table 7.35).

Table 7.35 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

DISTURBANCE

ARRAY AREA AND OFFSHORE EXPORT CABLE CORRIDOR IMPACTS

SENSITIVITY

7.10.160 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).

7.10.161 Harbour porpoise occurrence decreased at the Beatrice and Moray East offshore wind farms during non-piling construction periods. The probability of detecting porpoise during construction 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 and 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 (as shown in the Benhemma-Le Gall et al. 2021 study), and thus it is not expected that individual vital rates would be impacted. Therefore, the sensitivity of porpoise to disturbance from other construction activities is considered to be medium.

7.10.162 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 low.

MAGNITUDE

7.10.163 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).

7.10.164 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).

7.10.165 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.

7.10.166 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 magnitude.

SIGNIFICANCE

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

IMPACT 7: COLLISION RISK FROM CONSTRUCTION VESSELS

ARRAY AREA IMPACTS

7.10.168 The area surrounding VE already experiences high levels of vessel traffic (see Volume 6, Part 2, Chapter 9: Shipping and Navigation for full details) with an average of 102 vessels per day in the winter and 116 vessels per day In the summer (14 day survey period each season) in the Array Area. The maximum design scenario for the array area and ECC (Table 7.13) states there will be a maximum of 96 construction vessels, with an indicative peak number of vessels on site simultaneously as 35. totalling 4,311 round trips (array area and Offshore ECC):

- 38 WTG and OSP foundation installation vessels (including tugs and feeders);
- 10 WTG installation vessels (including tugs and feeders);
- 4 OSP topside installation vessels (including tugs and feeders);
- 5 commissioning vessels (including accommodation vessels);
- 15 other vessels; and
- 12 array cable installation vessels (includes support, cable protection and anchor handling vessels).

7.10.169 Cargos, tankers, wind farm vessels and fishing vessels were frequently recorded within the array traffic study area. Shipping activities within and near VE study area appeared to be frequent between 2017 and 2022, with three to 60 hours of total shipping operations per km^2 monthly throughout the inshore and offshore waters (EMODnet, 2021). The introduction of additional vessels during construction in the VE array is therefore not a novel impact for marine mammals present in the area.

7.10.170 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. Slow speeds and predictable movement are known to be key factors in minimising collision risk between vessels and marine mammals (Nowacek *et al*., 2001; Lusseau, 2003; Lusseau *et al.,* 2006). Once on-site, piling vessels are anticipated to travel slowly e.g.1.1-1.3 m/s (ca. 2.14–2.53 knots), and in consistent and predictable patterns, following predetermined routes as stated in Volume 9, Report 18.1: Working in Proximity to Wildlife. When considering slow speeds and the predictable movement of the vessels, animals have the opportunity to detect and react to the vessel. This has been demonstrated with similarly slow vessels as used in dredging (Todd *et al*., 2015). The installation vessels manoeuvres are expected to be slow, allowing time for animals to respond if necessary. In addition, Volume 9, Report 18.1: Working in Proximity to Wildlife defines how vessels should behave in the presence of marine mammals.

7.10.171 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[14], 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.

7.10.172 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 a*l., 2001, Lusseau 2003, 2006). The adoption of Volume 9, Report 18.1: Working in Proximity to Wildlife based on best practice vessel handing protocols (e.g. following the Codes of Conduct provided by the WiSe Scheme[15], Scottish Marine Wildlife Watching Code[16] or Guide to Best Practice for Watching Marine Wildlife[17]) as appropriate and possible during construction will minimise the potential for any collision impact.

7.10.173 It is anticipated that without mitigation, the risk of vessel collisions occurring is of Low magnitude. With the introduction of Volume 9, Report 18.1: Working in Proximity to Wildlife, the mitigated 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 such as London Gateway Port, and ports further afield such as the Port of Felixstowe, Harwich Haven, Dover Strait, Port of Lowestoft and Port of Hull (Volume 6, Part 2, Chapter 9: Shipping and Navigation) therefore potential collision risk is not an entirely novel impact.

7.10.174 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 very high sensitivity to vessel collisions.

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

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

OFFSHORE EXPORT CABLE CORRIDOR IMPACTS

7.10.176 The area surrounding VE already experiences high levels of vessel traffic (see Volume 6, Part 2 Chapter 9: Shipping and Navigation for full details) with an average of 44 unique vessels per day in the winter and 70 unique vessels per day in the summer (14 day survey period each season) in the Export Cable Corridor. The maximum design scenario (Table 7.13) states for the construction period (array and ECC) there will be a maximum of 96 construction vessels with an indicative peak number of vessels on site simultaneously as 35, totalling 4,311 round trips (array area and Offshore ECC) :

- 12 export cable installation spreads (includes support, cable protection and anchor handling vessels).

7.10.177 Given that the regional study area and baseline for marine mammals is the same for both the array and ECC (Section 7.1 and Figure 7.1) the impacts from vessel collision in the ECC will be the same as those assessed in the array. The magnitude of the impact has been assessed as negligible when considering the mitigation (Volume 9, Report 18.1: Working in Proximity to Wildlife) and the sensitivity of receptors as very high (see paragraphs 7.10.173 and 7.10.174). 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.

PORT IMPACTS

7.10.178 The ports under consideration for the construction phase include Green Port Hull on the Humber, therefore vessels could transit past the Humber Estuary, the Wash, and the North Norfolk coast where there are designated sites, breeding sites and haul-outs for grey and harbour seals. The area around the Humber and Lincolnshire coast has a higher density of grey seals (≥ 0.1% at-sea population per 25 km^2) compared to the Array Area and ECC Area (≤ 0.01% at-sea population per 25km^2) (Figure 7.16) (Carter et al., 2022). The area around the Wash has a higher density of harbour seals (≥ 0.1% at-sea population per 25 km^2) compared to the Array Area and ECC Area (≤ 0.001% at-sea population per 25km^2) (Figure 7.14) (Carter et al., 2022). Whilst there are increased densities of grey and harbour seals, given the mitigation presented within Volume 9, Report 18.1: Working in Proximity to Wildlife the magnitude has been assessed as negligible (see paragraph 7.10.173). The sensitivity of seals is considered to be very high given the potential for serious injury or mortality should a vessel collision occur (see paragraph 7.10.174)**.** 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.

IMPACT 8: DISTURBANCE FROM CONSTRUCTION VESSELS

ARRAY AREA IMPACTS

7.10.179 Disturbance to marine mammals by vessels will be driven by a combination of underwater noise and the physical presence of the vessel itself (e.g. Pirotta *et al.* 2015b). It is not simple to disentangle these drivers and thus disturbance from vessels is assessed here in general terms, covering disturbance driven by both vessel presence and underwater noise. As stated above, the area surrounding VE already experiences high levels of vessel traffic (see Volume 6, Part 2, Chapter 9: Shipping and Navigation for full details). The maximum design scenario (Table 7.13) states there will be a maximum of 96 construction vessels with an indicative peak number of vessels on site simultaneously as 35, totalling 4,311 round trips (array area and Offshore ECC).. Given the previous shipping activities present in the array area (EMODnet, 2021), the introduction of additional vessels during construction of VE is not a novel impact for marine mammals present in the area.

7.10.180 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; Erbe *et al.,* 2019) with an estimated source level of 161 – 168 SEL_{cum} dB re 1 µPa @ 1 m (RMS) for medium and large-sized construction vessels. OSPAR (2009) summarises general characteristics of commercial vessel noise dominated by sounds from propellers, thrusters and various rotating machinery (e.g., power generation, pumps). 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.

7.10.181 It is anticipated there will be maximum of 96 construction vessels in total in the array area and ECC, of which 35 may be on site at once 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 Volume 9, Report 18.1: Working in Proximity to Wildlife based on best practice vessel handing protocols (e.g. following the Codes of Conduct provided by the WiSe Scheme, Scottish Marine Wildlife Watching Code or Guide to Best Practice for Watching Marine Wildlife) during construction will minimise the potential for any impact. Therefore, the post- mitigation impact is expected to be of low magnitude.

7.10.182 Harbour porpoises 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. The noise frequencies are also out of their estimated range of peak sensitivity from 12 kHz to 140 kHz (Southall *et al.*, 2019), meaning at lower SPLs (or received levels, relative to the distance the animal is from the source) the noise is unlikely to be detected. However, they are known to exhibit an avoidance response to vessels that contain low levels of high frequency components (Dyndo *et al*. 2015). Porpoise occurrence within the Moray Firth decreased with increasing vessel presence during the construction of Beatrice and Moray East offshore windfarms, with the magnitude of decrease depending on the distance to the vessel (Benhemma-Le Gall *et al.,* 2021). At a mean vessel distance of 3 km, the probability decreased by up to 57% to 0.16 for the highest vessel intensity, and no apparent response was observed at 4 km. Behaviour-based modelling has indicated the potential for vessel disturbance to have population level effects on harbour porpoises under certain circumstances, although not as severe as the theoretical impact of bycatch on population size (Nabe-Nielsen *et al.*, 2014). There are however, studies showing 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. In conclusion, there is some evidence that changes in harbour porpoise behaviour and presence can potentially result from disturbance by vessel presence.

7.10.183 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. The sensitivity of harbour porpoise to vessel disturbance has, therefore, been assessed as medium.

7.10.184 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. On the northwest coast of Ireland, a study of vessel traffic and marine mammal presence found grey seals sightings to decrease with increased vessel activity in the surrounding area, though the effect size was small (Anderwald *et al.,* 2013); and the authors noted that relationships between sightings and vessel numbers were weaker than those with environmental variables such as sea state. 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 low.

7.10.185 The magnitude of the impact has been assessed as low and the sensitivity of receptors as medium (porpoise) or negligible (seal species). Therefore, the significance of the effect of disturbance from vessels is concluded to be of **Minor** (adverse) significance for harbour porpoises and **Negligible** significance for grey and harbour seals, which is not significant in terms of the EIA regulations 2017.

OFFSHORE EXPORT CABLE CORRIDOR IMPACTS

7.10.186 As stated above, the area surrounding VE already experiences high levels of vessel traffic (see Volume 6, Part 2, Chapter 9: Shipping and Navigation for full details). The maximum design scenario (Table 7.13) states there will be a maximum of 96 construction vessels with an indicative peak number of vessels on site simultaneously as 35, totaling 4,311 round trips (array area and Offshore ECC). VE has committed to Volume 9, Report 18.1: Working in Proximity to Wildlife to mitigate the impacts.

7.10.187 Given that the regional study area and baseline for marine mammals is the same for both the array and ECC (Sections 7.4 and 7.7), the impacts from vessel disturbance in the ECC will be the same as those assessed in the array. The magnitude of the impact has been assessed as low (see paragraph 7.10.181) and the sensitivity of receptors as medium (porpoise) and negligible (seals) (see paragraphs 7.10.183 and 7.10.184). Therefore, the significance of the effect of disturbance from vessels is concluded to be of **Minor** (adverse) significance, which is not significant in terms of the EIA regulations 2017.

PORT IMPACTS

7.10.188 The ports under consideration for the constructions phase include Green Port Hull on the Humber, therefore vessels could transit past the Humber Estuary, the Wash, and the North Norfolk coast where there are designated sites, breeding sites and haul-outs for grey and harbour seals. The area around the Humber and Lincolnshire coast has a higher density of grey seals (≥ 0.1% at-sea population per 25 km^2) compared to the Array Area and ECC Area (≥0.01% at-sea population per 25km^2) (Figure 7.16) (Carter et al., 2022). The area around the Wash has a higher density of harbour seals (≥0.1% at-sea population per 25 km^2) compared to the Array Area and ECC Area (≥0.001% at-sea population per 25 km^2) (Figure 7.18) (Carter et al., 2022).

7.10.189 The counts of harbour seal between Donna Nook and Scroby Sands have declined by approximately 30% compared to the mean of the previous five years (2019-2022 mean: 2758, 2015- 2018 mean: 3399) (SCOS, 2023) with the Wash decreasing by 19%, Donna Nook by 57% and Scroby Sands by 70%. The counts of grey seal at the Humber Estuary had been increasing since the early 2000’s however, the most recent counts at the Donna Nook colony indicate a levelling off and possible decline, coincident of harbour seal decline (SCOS, 2023). Whilst there are declines of harbour seals and potentially grey seals in the Humber, there are already very high levels of vessel traffic in the region therefore it is not a novel impact. The sensitivity has been assessed as low (see paragraph 7.10.184) and the post-mitigation magnitude of seals is considered to be low (see paragraph 7.10.181). Therefore, the significance of the effect of collisions from vessels is concluded to be of **Negligible** significance, which is not significant in terms of the EIA regulations 2017.

IMPACT 9: CHANGE IN WATER QUALITY FROM CONSTRUCTION ACTIVITIES

ARRAY AREA IMPACTS

7.10.190 Disturbance to water quality as a result of construction activities in the array area can have both direct and indirect impacts on marine mammals. Indirect impacts include effects on prey species (see paragraphs 7.10.201 to 7.10.205), whereas direct impacts include the impairment of visibility and therefore foraging ability which might be expected to reduce foraging success.

7.10.191 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 (Volume 6, Part 2, Chapter 2: Marine Geology, Oceanography and Physical Processes). The main activities resulting in disturbance of seabed sediments in the array area are:

- Pre-lay cable trenching (of inter-array cables in array area) ;
- Sandwave clearance;
- Cable installation (of inter-array cables in array area);
- Dredge spoil disposal; and
- Drill arisings release.

7.10.192 Background surface Suspended Sediment Concentrations (SCCs) across the array areas are known to vary seasonally with summer SSC ranging from 1-3mg/l in the array, increasing to 10-20mg/l during the winter months. Higher SSCs are anticipated during spring tides and storm conditions, with greatest concentrations close to the seabed (Volume 6, Part 5, Annex 2:1 Physical Processes Baseline Technical Report).

7.10.193 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 6, Part 2, Chapter 2: Marine Geology, Oceanography and Physical Processes and Volume 6, Part 5, Annex 2.1 Physical Processes Baseline 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).

7.10.194 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 (Hanke *et al.,* 2010, Hanke and Dehnhardt 2013, Hanke *et al.,* 2013).

7.10.195 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 low sensitivity to changes in water quality.

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

OFFSHORE EXPORT CABLE CORRIDOR IMPACTS

7.10.197 During construction of VE ECC, 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 in the ECC are:

- Pre-lay cable trenching (of export cables along ECC);
- Sandwave clearance; and
- Cable installation (of export cables along ECC).

7.10.198 SSC are higher in the offshore ECC compared to array areas and reach a peak close to the coast at the landfall. During winter months, mean values exceed 100 mg/l although, as for array areas, higher values are anticipated during spring tides and storm conditions, with concentrations greater closer to the seabed (Volume 6, Part 5, Annex 2:1 Physical Processes Baseline Technical Report).

7.10.199 As detailed in paragraph 7.10.193, it is considered in relation to construction works for the ECC that an hour after disturbance there will be no measurable ongoing deposition. 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 low sensitivity to changes in water quality.

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

IMPACT 10: CHANGE IN FISH ABUNDANCE/DISTRIBUTION FROM CONSTRUCTION ACTIVITIES

ARRAY AREA IMPACTS

7.10.201 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 7.36.

7.10.202 Regarding fish prey species, potential impacts of underwater noise will arise from the piling of foundations, cable installation, vessel disturbance and UXO clearance during the construction phase in the array area. There is potential for fish mortality and mortal injury, recoverable injury, TTS and behavioural impacts arising from underwater noise from these activities however, no significant effects on fish prey species were concluded (Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology). In addition, there is the potential for other impacts to occur on fish prey species including of direct damage and crushing, temporary habitat loss, temporary increase in SSC and sediment deposition, and potential accidental contamination arising from seabed disturbances however, no significant effects were concluded on fish prey species. Detailed assessment of impacts upon fish and shellfish species are presented in Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology.

7.10.203 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 localised impact (see paragraph 6.11.182 of Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology for more details). Impacts arising from UXO detonations are considered to have a lower likelihood of triggering a population level effect in fish prey species than that associated from piling operations, due to the significantly reduced temporal footprint that would arise from UXO operations.

7.10.204 Fishing pressure will be reduced during construction at the VE array area 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 population level effects would be minimised by fisheries management measures which reduces the impact on all receptors to minor adverse (see section 8.7 in Volume 6, Part 2, Chapter 8: Commercial Fisheries).

Table 7.36 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 (2023)
Grey seal	**Sandeel**, **cod**, **whiting**, **haddock**, ling, **plaice**, sole, flounder, **dab**	SCOS (2023)

7.10.205 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.

7.10.206 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 medium.

7.10.207 The magnitude of the impact has been assessed as negligible and the sensitivity of receptors as medium. Therefore, the significance of the effect of changes in fish abundance/distribution is concluded to be of **Negligible** significance, which is not significant in terms of the EIA regulations 2017.

OFFSHORE EXPORT CABLE CORRIDOR IMPACTS

7.10.208 Regarding fish prey species, potential impacts of underwater noise will arise from the ECC cable installation, vessel disturbance, UXO clearance and installation of sheet piled exit pits at landfall during the construction phase in the ECC. As for array area impacts, there is potential for fish mortality and mortal injury, recoverable injury, TTS and behavioural impacts arising from underwater noise from construction activities in the ECC. Additionally, there is the potential for direct impacts to occur on fish prey species inclusive of direct damage and crushing, temporary habitat loss, temporary increase in SSC and sediment deposition, and potential accidental contamination arising from seabed disturbances. All such impacts during construction phase were assessed, and no significant effects were concluded on fish prey species. Detailed assessment of impacts upon fish and shellfish species is presented in Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology. Disruption to fishing activity along the offshore ECC is expected to be limited both spatially and temporally as any changes would be limited to the vicinity of the installation vessel as it moves along the route.

7.10.209 Given that the baseline for marine mammal prey species is the same in the array and ECC, the impacts on species will be the same. The sensitivity is considered medium and the magnitude is negligible (see paragraphs 7.10.205 and 7.10.206), therefore 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.

IMPACT 11: HABITAT LOSS

ARRAY AREA IMPACTS

7.10.210 The maximum area of temporary habitat loss within the Order Limits is 36,513,188 m^2 with 21,771,734 m^2 in the array area from foundation installation, seabed preparation for foundations, JUVs and anchoring operations, and cable preparation and installation (see Volume 6, Part 2, Chapter 5: Benthic Ecology and Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology).

7.10.211 The disturbance would be temporary during the construction phase with most of the disturbance occurring during the installation of foundations. Most impacts will be highly localised and occur over a short period of time.

7.10.212 Temporary habitat loss during construction is not considered a direct impact on marine mammals as any impacts of habitat loss would only cause an indirect effect in terms of changes to prey availability. The magnitude of temporary habitat loss during construction in the array area has been assessed as low in both Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology and in Volume 6, Part 2, Chapter 5: Benthic Ecology. Due to the lack of significant effect on benthic, shellfish and fish receptors the magnitude on marine mammals is low. Given the highly mobile nature of the harbour porpoise, grey seal and harbour seal, the widely available comparable habitat, and the generalist/opportunist nature of the species (Table 7.36) the sensitivity to displacement from foraging grounds is considered to be medium. Therefore, the effect of temporary habitat loss on marine mammals is concluded to be of **Minor** significance, which is not significant in terms of the EIA regulations 2017.

OFFSHORE EXPORT CABLE CORRIDOR IMAPCTS

7.10.213 The maximum area of temporary habitat loss within the Order Limits is 36,487,636 m^2 with 14,739,204 m^2 in the array area from seabed preparation, trenching and burial of Offshore ECC, and cable protection (see Volume 6, Part 2, Chapter 5: Benthic Ecology and Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology).

7.10.214 As above, temporary habitat loss during construction is not considered a direct impact on marine mammals as any impacts of habitat loss would only cause an indirect effect in terms of changes to prey availability. The magnitude of temporary habitat loss during construction in the Offshore ECC has been assessed as low in both Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology and in Volume 6, Part 2, Chapter 5: Benthic Ecology. Due to the lack of significant effect on benthic, shellfish and fish receptors the magnitude on marine mammals is low. Given the highly mobile nature of the harbour porpoise, grey seal and harbour seal, the widely available comparable habitat, and the generalist/opportunist nature of the species (Table 7.36) the sensitivity to displacement from foraging grounds is considered to be medium. Therefore, the effect of temporary habitat loss on marine mammals is concluded to be of **Minor** significance, which is not significant in terms of the EIA regulations 2017.

IMPACT 12: DISTURBANCE AT SEAL HAUL OUT SITES

7.10.215 Grey and harbour seals are known to haul out at various points along the East coast of England with the majority of large haul outs north of VE array area and ECC area on East Anglia, East Midlands and Humber coasts. Key haul out sites include Donna Nook, the Wash, Blakeney Point, Horsey, Scroby Sands and the Humber Estuary. There is the potential for disturbance to seals at these haul out sites as a result of the transit and physical presence of vessels as the Green Port Hull on the Humber is under consideration for VE during the construction phase. Closer to the VE array area and ECC seals haul out at Hamford Water, Buxey Sand North, Buxey Sand South, Southend-on-Sea and Margate (Barker et al., 2014).

7.10.216 Previous studies have demonstrated the disturbance effects of vessel presence and/or operations on harbour seals at haul-out sites. For example, controlled disturbance vessel trials have shown that harbour seals would reduce the amount of time hauled out around the point of disturbance and they would embark on a foraging trip before hauling out again at the next low-tide cycle (Paterson *et al.,* 2015). This was also shown in Andersen *et al.* (2011) where extended inter-haul-out trips occurred directly after a disturbance event. This could be of particular importance in terms of energetic consequences if this disturbance occurs at a time that is critical for seals to be hauled out, such as during the annual moult or the breeding season. Vessel traffic has been recorded to disturb seals at haul out sites and often result in the animals flushing into the water (Jansen *et al.,* 2015), while large vessel disturbance could occur as far as 1km (Young *et al.,* 2014). Andersen et al., (2011) showed that flushing out at Danish haul out sites occurred at distances of 510 - 830 m from approaching vessels.

7.10.217 The haul out sites listed above are all situated more than 1km away from the landfall site and these sites are already exposed to relatively high levels of vessel activities, especially high-speed crafts between the period from 2017 to 2022 (EMODnet, 2011). It is therefore considered that there will be a de minimis disturbance effect to seals at haul out caused by the additional vessels for VE (see the vessel disturbance assessment above, and Table 7.13). Additionally, the vessel transit routes for VE are based on the assumption of Green Port Hull on the Humber being the main port for construction activities.

7.10.218 The impact is predicted to be of local spatial extent, short term duration, intermittent and reversible. In line with best-practice vessel management measures I dentified in Volume 9, Report 18.1: Working in Proximity to Wildlife, where possible vessel traffic associated with VE will follow existing shipping routes and are therefore is unlikely to transit close to key haul out sites (*e.g.,* at Donna Nook and within the Wash).The magnitude is therefore considered to be low with mitigation being in place, 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.

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

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

7.10.221 Overall, the sensitivity of seals to disturbance has been assessed as medium and the magnitude is predicted to be negligible with mitigation in place. Therefore, the resulting impact significance for disturbance to seal haul outs is **negligible** (not significant) (both pre- and post-mitigation) in EIA terms.

7.11 ENVIRONMENTAL ASSESSMENT: OPERATIONAL PHASE

IMPACT 13: OPERATIONAL NOISE

ARRAY AREAS IMPACT

PTS

SENSITIVITY

7.11.1 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 low.

MAGNITUDE

7.11.2 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 6, Part 5, Annex 6.2: Underwater Noise Technical Report for full details.

7.11.3 Table 7.37 shows PTS-onset impact ranges are minimal (<100 m). Therefore, the magnitude of impact of PTS from operational noise is considered Negligible.

Table 7.37 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

7.11.4 The magnitude of the impact has been assessed as negligible and the sensitivity of marine mammals as low. 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

7.11.5 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 disturbance at this frequency would result in little impact to vital rates. Therefore, the sensitivity of porpoise and seals to disturbance from operational noise is assessed as low.

MAGNITUDE

7.11.6 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, Brasseur *et al.*, 2012).

7.11.7 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).

7.11.8 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 6, Part 5, Annex 6.2: Underwater 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

7.11.9 The magnitude of the impact has been assessed as negligible and the sensitivity of marine mammals as low. 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.

OFFSHORE EXPORT CABLE CORRIDOR

7.11.10 As operational WTGs are not planned for the Offshore ECC there is no pathway for effect on marine mammals and therefore no risk of PTS.

IMPACT 14: COLLISION RISK FROM O&M VESSELS

ARRAY AREA IMPACTS

7.11.11 As stated in section 7.1.1, the area surrounding VE already experiences a high amount of vessel traffic (EMODnet 2021, also see Volume 6, Part 2, Chapter 9: Shipping and Navigation for full details). Volume 6, Part 2, Chapter 1: Offshore Project Description states there will be 27 total vessels and an indicative peak number of 27 vessels on site simultaneously during operation totalling 1,776 trips annually (array area and Offshore ECC). The introduction of additional vessels during O&M of VE is not a novel impact for marine mammals present in the area.

7.11.12 Slow speeds and predictability of vessel movement are known to be a key aspect in minimising the potential risks imposed by vessel traffic on marine mammals (Nowacek *et al*. 2001, Lusseau 2003, 2006). The adoption of Volume 9, Report 18.1: Working in Proximity to Wildlife based on best practice vessel handing protocols (e.g. following the Codes of Conduct provided by the WiSe Scheme, Scottish Marine Wildlife Watching Code or Guide to Best Practice for Watching Marine Wildlife) will minimise the potential for any impact, in ways such as vessel operations along predetermined routes. 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).

7.11.13 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, allowing sufficient time for animals to detect and react to the vessel. In addition, Volume 9, Report 18.1: Working in Proximity to Wildlife defines how vessels should behave in the presence of marine mammals.

7.11.14 It is not expected that the level of vessel activity during operations would cause a significant increase in the risk of mortality from collisions. The adoption of Volume 9, Report 18.1: Working in Proximity to Wildlife during O&M will minimise the potential for any impact. Therefore, the risk of vessel collisions occurring is of negligible magnitude with mitigation in place.

7.11.15 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.

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

OFFSHORE EXPORT CABLE CORRIDOR IMPACTS

7.11.17 The area surrounding VE already experiences high levels of vessel traffic (see Volume 6, Part 2, Chapter 9: Shipping and Navigation) with an indicative peak number of 27 vessels on site simultaneously during operation totalling 1,776 trips annually (array area and Offshore ECC).

7.11.18 Given that the regional study area and baseline for marine mammals is the same for both the array and ECC (Section 7.4 and 7.7), the impacts from vessel collision in the ECC will be the same as those assessed in the array. The magnitude of the impact has been assessed as negligible when considering the mitigation Vessel Traffic Management Plan and the sensitivity of receptors as very 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.

PORTS

7.11.19 The ports under consideration for the operation phase include Great Yarmouth, Felixstowe and Harwich therefore vessel transit routes will be avoiding the Humber Estuary, the Wash, and the North Norfolk coast where there are designated sites, breeding sites and haul-outs for grey and harbour seals. The area around the Array Area and ECC Area have a low density of harbour seals (≤ 0.01% at-sea population per $25km^2$) (Figure 7.16) (Carter et al., 2022) and given the mitigation presented within Vessel Traffic Management Plan the magnitude has been assessed as negligible. The sensitivity of seals is considered to be very high given the potential for serios injury or mortality should a vessel collision occur**.** 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.

IMPACT 15: DISTURBANCE FROM O&M VESSELS

ARRAY AREA IMPACTS

7.11.20 As stated in paragraph 7.10.179, the area surrounding VE already experiences a high amount of vessel traffic (see Volume 6, Part 2, Chapter 9: Shipping and Navigation for full details). Volume 6, Part 2, Chapter 1: Offshore Project Description states there will be an indicative peak number of 27 vessels on site simultaneously during operation totalling 1,776 trips annually (array area and Offshore ECC). The introduction of additional vessels during construction of VE is not a novel impact for marine mammals present in the area. Disturbance to marine mammals by vessels will be driven by a combination of underwater noise and the physical presence of the vessel itself (*e.g.,* Pirotta et al., 2015).

7.11.21 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) (Erbe *et al.*, 2019, Sinclair *et al*. 2021) with an estimated source level of 161 – 168 SEL_{cum} dB re 1 µPa @ 1 m (RMS). OSPAR (2009) summarises general characteristics of commercial vessel noise dominated by sounds from propellers, thrusters and various rotating machinery (e.g., power generation, pumps). 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). 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, SOVs would be 2, and nine crew-transfer vessels (Table 1.40 of Volume 6, Part 2, Chapter 1: Offshore Project Description refers).

7.11.22 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 a Volume 9, Report 18.1: Working in Proximity to Wildlife based on best practice vessel handing protocols (e.g. following the Codes of Conduct provided by the WiSe Scheme, Scottish Marine Wildlife Watching Code or Guide to Best Practice for Watching Marine Wildlife) during O&M will minimise the potential for any impact. Therefore, the impact is expected to be of low magnitude with Volume 9, Report 18.1: Working in Proximity to Wildlife in place.

7.11.23 Given the existing evidence of behavioural responses to vessels, the sensitivity levels of harbour porpoises and seal species under consideration to vessel disturbance have been assessed as medium and negligible respectively as per paragraphs 7.10.183 and 7.10.184.

7.11.24 Therefore, the post-mitigation significance of the effect of disturbance from O&M vessels is concluded to be of **Minor** and **Negligible** significance to harbour porpoises and seal species respectively, which are not significant in terms of the EIA regulations 2017.

OFFSHORE EXPORT CABLE CORRIDOR IMPACTS

7.11.25 As stated above, the area surrounding VE already experiences high levels of vessel traffic (see Volume 6, Part 2, Chapter 9: Shipping and Navigation for full details). Volume 6, Part 2, Chapter 1: Offshore Project Description states there will be an indicative peak number of 27 vessels on site simultaneously during operation totalling 1,776 trips annually (array area and Offshore ECC). VE has committed to Volume 9, Report 18.1: Working in Proximity to Wildlife to mitigate the impacts.

7.11.26 Given that the regional study area and baseline for marine mammals is the same for both the array and ECC (Section Figure 7.4 and 7.7), the impacts from vessel disturbance in the ECC will be the same as those assessed in the array. The magnitude of the impact has been assessed as low and the sensitivity of receptors as medium (porpoise) and low (seals). Therefore, the significance of the effect of disturbance from vessels is concluded to be of **Minor and Negligible** significance for harbour porpoise and seal species respectively, which is not significant in terms of the EIA regulations 2017.

PORTS

7.11.27 The ports under consideration for the operation phase include Great Yarmouth, Felixstowe and Harwich therefore vessel transit routes will be avoiding the Humber Estuary, the Wash, and the North Norfolk coast where there are designated sites, breeding sites and haul-outs for grey and harbour seals. The area around the Array Area and ECC Area have a low density of harbour seals (≤ 0.01% at-sea population per 25km^2) (Figure 7.16) (Carter et al., 2022).

7.11.28 There are already very high levels of vessel traffic in the region therefore it is not a novel impact. The sensitivity has been assessed as medium and the post-mitigation magnitude of seals is considered to be low. Therefore, the significance of the effect of collisions from vessels is concluded to be of **Negligible** significance, which is not significant in terms of the EIA regulations 2017.

IMPACT 16: CHANGE IN FISH ABUNDANCE/DISTRIBUTION FROM OPERATION

ARRAY AREA IMPACTS

7.11.29 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 7.36. According to Section 10.7 of Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology, potential impacts from underwater noise will arise from turbine operation. The fish and shellfish species are estimated to also be impacted during O&M phase by long-term habitat loss due to turbine installation, temporary increase in SSC and deposition, displaced fishing pressure, increased hard substrate and structural complexity, accidental pollution, direct damage and disturbances from O&M activities, and temporary habitat loss/disturbance from maintenance works.

7.11.30 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 6, Part 2, Chapter 6: Fish and Shellfish Ecology).

7.11.31 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 6, Part 2, Chapter 8: Commercial Fisheries). It would however not be expected that any changes in fishing activities in this area would lead to changes in populations of prey species.

7.11.32 Any effects on fish species during the operational phase will be highly localised and therefore it will have a low magnitude on prey availability for marine mammals, given no significant operational phase effects were concluded on fish prey species as per Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology.

7.11.33 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.

7.11.34 The magnitude of the impact has been assessed as negligible and the sensitivity of receptors as medium. Therefore, the significance of the effect of changes in fish abundance/distribution during O&M is concluded to be of **Negligible** significance, which is not significant in terms of the EIA regulations 2017.

OFFSHORE EXPORT CABLE CORRIDOR

7.11.35 Regarding fish prey species, potential impacts will arise from the ECC cable maintenance, direct damage and disturbances from O&M activities, temporary habitat loss/disturbance from maintenance works, temporary increase in SSC and potential accidental contamination from seabed disturbances. All such impacts during operation phase were assessed, and no significant effects were concluded on fish prey species. Detailed assessment of impacts upon fish and shellfish species is presented in Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology.

7.11.36 Given that the baseline for marine mammal prey species is the same in the array and ECC, the impacts on species will be the same. The sensitivity is considered medium and the magnitude is negligible, therefore 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.

IMPACT 17: HABITAT LOSS

ARRAY AREA IMPACTS

TEMPORARY HABITAT LOSS

7.11.37 Total temporary habitat disturbance within Order Limits is 734,894 m^2 with 589,052 m^2 in the array areas. Temporary habitat loss has not been assessed as a direct impact on marine mammals as habitat loss would only cause direct effects in terms of changes in prey availability.

7.11.38 Impacts to prey will be on a smaller scale than during the construction period as the areas for temporary habitat disturbance are reduced. The magnitude of temporary habitat loss during operation in the array area has been assessed as low in both Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology and in Volume 6, Part 2, Chapter 5: Benthic Ecology. Due to the lack of significant effect on benthic, shellfish and fish receptors the magnitude on marine mammals is low and the sensitivity is medium. Therefore, the effect of temporary habitat loss on marine mammals is concluded to be of **Minor** significance, which is not significant in terms of the EIA regulations 2017.

PERMANENT HABITAT LOSS

7.11.39 Total permanent habitat loss within Order Limits is 3,415,083 m^2 with 3,112,079 m^2 in the array areas as a result of the seabed lost due to the placement of structures and scour protection. Given the highly mobile nature of the harbour seal, grey seal and harbour porpoise and comparable habitats being widespread in the North Sea, the sensitivity of this impact is medium. Additionally, there is evidence that during the operational phase marine mammals are not permanently excluded from the array area (as benthic and shellfish species could be). Long-term monitoring at Horns Rev and Nysted offshore wind farms in Denmark showed that both harbour porpoise and harbour seals were sighted regularly within the operational OWFs, (Diederichs et al. 2008). Additionally, monitoring 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) and suggested it could be due to increased food opportunities as a result of the reef-effect with sessile organisms colonizing the hard structures leading to changes in fish community composition. Tagged harbour and grey seals have also moved in grid-like patterns in between WTG monopiles suggesting they are using operational wind farm for foraging (Russell et al. 2014). As a result, the magnitude of permanent habitat loss is considered low**.** Therefore, the effect of permanent habitat loss on marine mammals is concluded to be of **Negligible** significance, which is not significant in terms of the EIA regulations 2017.

OFFSHORE EXPORT CABLE CORRIDOR

TEMPORARY HABITAT LOSS

7.11.40 The total temporary habitat disturbance within Order Limits is 734,894 m^2 with 145,842 m^2 in the Offshore ECC as a result of JUV operations and cable replacement. Temporary habitat loss has not been assessed as a direct impact on marine mammals as habitat loss would only cause direct effects on terms of changes in prey availability.

7.11.41 Impacts to prey will be on a smaller scale than during the construction period as the areas for temporary habitat disturbance are reduced. The magnitude of temporary habitat loss during operation in the Offshore ECC has been assessed as low in both Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology and in Volume 6, Part 2, Chapter 5: Benthic Ecology. Due to the lack of significant effect on benthic, shellfish and fish receptors the magnitude on marine mammals is low and the sensitivity is medium. Therefore, the effect of temporary habitat loss on marine mammals is concluded to be of **Minor** significance, which is not significant in terms of the EIA regulations 2017.

PERMANENT HABITAT LOSS

7.11.42 Total permanent habitat loss within Order Limits is 3,415,083 m^2 with 303,004 m^2 in the Offshore ECC as a result of the seabed lost due to cable protection and cable crossings. Given the highly mobile nature of the harbour seal, grey seal and harbour porpoise and comparable habitats being widespread in the North Sea, the sensitivity of this impact is medium. Additionally, there is evidence that during the operational phase marine mammals are not permanently excluded from the array area (as benthic and shellfish species could be). Therefore, the effect of permanent habitat loss on marine mammals is concluded to be of **Negligible** significance, which is not significant in terms of the EIA regulations 2017.

IMPACT 18: DISTURBANCE AT SEAL HAUL OUT SITES

7.11.43 The majority of large haul outs north of VE array area and ECC area on East Anglia, East Midlands and Humber coasts. Closer to the VE array area and ECC seals haul out at Hamford Water, Buxey Sand North, Buxey Sand South, Southend-on-Sea and Margate (Barker et al., 2014). The ports under consideration for the operation phase include Great Yarmouth, Felixstowe and Harwich.

7.11.44 Overall, the sensitivity of seals to disturbance has been assessed as medium and the magnitude is predicted to be negligible with mitigation in place. Therefore, the resulting impact significance for disturbance to seal haul outs is **negligible** (not significant) (both pre- and post-mitigation) in EIA terms.

7.12 ENVIRONMENTAL ASSESSMENT: DECOMMISSIONING PHASE

7.12.1 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 19: PTS AND DISTURBANCE FROM DECOMMISSIONING

7.12.2 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.

7.12.3 As the exact methods to be used for decommissioning are yet 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 7.16) 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 20: COLLISION RISK FROM DECOMMISSIONING VESSELS

7.12.4 As stated in paragraph 7.1.1, the area surrounding VE already experiences a high amount of vessel traffic (EMODnet 2021, also see Volume 6, Part 2, Chapter 9: Shipping and Navigation). Volume 6, Part 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.

7.12.5 The adoption of Volume 9, Report 18.1: Working in Proximity to Wildlife based on best practice vessel handing protocols (e.g. following the Codes of Conduct provided by the WiSe Scheme, Scottish Marine Wildlife Watching Code or Guide to Best Practice for Watching Marine Wildlife) during decommissioning will minimise the potential for any impact. It is assumed that similar vessel types and number will be present in the 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.

7.12.6 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 a Volume 9, Report 18.1: Working in Proximity to Wildlife will minimise the potential for any impact. Therefore, the risk of vessel collisions occurring is of Negligible magnitude post-mitigation.

7.12.7 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.

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

IMPACT 21: DISTURBANCE FROM DECOMMISSIONING VESSELS

7.12.9 Disturbance to marine mammals by vessels during decommission phase will be driven by a combination of underwater noise and the physical presence of the vessel itself (e.g. Pirotta *et al.* 2015). 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). OSPAR (2009) summarises general characteristics of commercial vessel noise dominated by sounds from propellers, thrusters and various rotating machinery (e.g., power generation, pumps). 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. It is anticipated that levels and types of vessel traffic during decommissioning would be similar to that during construction.

7.12.10 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 post-mitigation impact is expected to be of low magnitude.

7.12.11 The sensitivity levels of harbour porpoises and seal species under consideration to vessel disturbance have been assessed as medium and low respectively as per paragraphs 7.10.183 and 7.10.184. The magnitude of the impact has been assessed as low and the sensitivity of harbour porpoise as medium and grey and harbour seals as low. 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 22: CHANGE IN FISH ABUNDANCE/ DISTRIBUTION FROM DECOMMISSIONING

7.12.12 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 7.36. While there may be certain species that comprise the main part of their diet, all marine mammals in this assessment are considered to be generalist feeders and are thus not reliant on a single prey species. Therefore, they are assessed as having a medium sensitivity to changes in prey abundance and distribution.

7.12.13 Decommissioning of offshore infrastructure for VE may result in temporarily elevated underwater noise levels which may have effects on fish. However, Volume 6, Part 5, Annex 6.2: Underwater 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 6, Part 2, Chapter 6: Fish and Shellfish Ecology indicates that the overall adverse impacts, including temporary increase in SSC and sediment deposition, long-term and temporary loss/disturbance of seabed habitat to fish species from the decommissioning of VE will be of negligible to minor significance and thus the predicted impact on marine mammals is of negligible magnitude.

7.12.14 The magnitude of the impact has been assessed as negligible and the sensitivity of receptors as medium. Therefore, the significance of the effect of changes in fish abundance/distribution is concluded to be of **Negligible** significance, which is not significant in terms of the EIA regulations 2017.

IMAPCT 23: HABITAT LOSS

7.12.15 Temporary habitat loss/disturbance from the decommissioning works will be similar to that for construction and are of a similar magnitude. As for construction, temporary habitat loss has not been assessed as a direct impact on marine mammals as any impacts on habitat loss would only cause an indirect effect in terms of changes in prey availability. The magnitude of the impact and the sensitivities to benthic, fish and shellfish receptors is low. Due to the lack of significant effect on benthic, shellfish and fish receptors the magnitude on marine mammals is low. The sensitivity to displacement from foraging grounds is considered to be medium. Therefore, the effect of temporary habitat loss on marine mammals is concluded to be of **Minor** significance, which is not significant in terms of the EIA regulations 2017.

IMPACT 24: DISTURBANCE AT HAUL OUT SITES

7.12.16 The majority of large haul outs north of VE array area and ECC area on East Anglia, East Midlands and Humber coasts. Closer to the VE array area and ECC seals haul out at Hamford Water, Buxey Sand North, Buxey Sand South, Southend-on-Sea and Margate (Barker et al., 2014). The ports under consideration for the decommissioning phase are unknown at this stage.

7.12.17 Overall, the sensitivity of seals to disturbance has been assessed as medium and the magnitude is predicted to be negligible with mitigation in place. Therefore, the resulting impact significance for disturbance to seal haul outs is negligible (not significant) (both pre- and post-mitigation) in EIA terms.

7.13 ENVIRONMENTAL ASSESSMENT: CUMULATIVE EFFECTS

7.13.1 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 6, Part 1, Annex 3.1: Cumulative Effects Assessment.

7.13.2 In assessing the potential cumulative impacts for VE, it is important to consider that some projects, predominantly those ‘proposed’ or identified in development plans, may not actually be taken forward, or fully built out as described within their MDS. There is, therefore, a need to build in some consideration of certainty (or uncertainty) with respect to the potential impacts which might arise from such proposals. For example, those projects under construction are likely to contribute to cumulative impacts (providing effect or spatial pathways exist), whereas those proposals not yet approved are less likely to contribute to such an impact, as some may not achieve approval or may not ultimately be built due to other factors.

7.13.3 Therefore, 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 7.38. The proposed tier structure for marine mammals is different to that presented for other receptors. This is due to the need to consider 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 tier system proposed in Natural England (2022).

Table 7.38: 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 have produced a PEIR and have characterisation data within the public domain.	Preliminary environmental characterisation survey data (e.g., interim survey report after 1 year of surveys) from proposed project (including preliminary data analysis and interpretation).
6	Tier 5 + 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).
7	Tier 6 + 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

7.13.4 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 based on effect–receptor pathway, data confidence and the temporal and spatial scales involved. 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 harbour porpoise, Southeast MU for harbour seals, combined Southeast and Northeast MUs for grey seals).

7.13.5 The time period considered in the CEA for marine mammals is 2023 to 2031 inclusive. This allows for the quantification of impacts to the respective MUs both prior to the construction of VE (since the baseline was collated) and during the potential construction window for VE (UXO clearance is to be undertaken in 2028 and the potential piling window for VE is expected to be sometime between 2029-2030 inclusive).

7.13.6 The CEA methodology and long list are described in Volume 6, Part 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.

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

- Aggregates (all operational: ongoing impact and part of the baseline);
- Cables and pipelines (screened out OWF cables as OWF considered separately);
- Coastal developments (all active: ongoing impact and part of the baseline);
- Commercial fisheries (all operational: ongoing impact and part of the baseline);
- Military, Aviation & Radar (all active: ongoing impact and part of the baseline)
- Oil and Gas projects (all active or not in use);
- Shipping (all active: ongoing impact and part of the baseline);
- Wave developments (all listed as completed);

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

- Offshore wind farms;
- Tidal developments;
- Cables and pipelines (telecommunication cables)
- Carbon capture and storage;

> Oil and Gas seismic airgun surveys (illustrative).

7.13.9 The projects taken forward to the cumulative assessment are presented in Table 7.39. Depending on project stage, some of them have PEIR or ES chapter available in the public domain with quantitative assessment of impacts on marine mammals and therefore the cumulative assessment was informed using project-specific data. Projects that are at the early stages of development, which do not have the PEIR or ES chapter submitted, were also shortlisted and included in the assessment in line with assumptions described in detail in paragraph 7.13.14 *et seq*. The timelines of UXO clearance and piling for projects with and without quantitative assessment (PEIR or ES chapter) are presented in Table 7.40 and Table 7.41, respectively.

Table 7.39: Marine mammal CEA short list.

Project	Type	Status	TIER[18]	HP	HS	GS
VE	OWF	This application	n/a	Y	Y	Y
Borkum Riffgrund 3	OWF	Under Construction	2	Y	N	N
EnBW He Dreidt	OWF	Under Construction	2	Y	N	N
Gode Wind 3	OWF	Under Construction	2	Y	N	N
Moray West	OWF	Under Construction	2	Y	N	N
Eastern Link 1	Cable	Under construction	2	Y	N	Y
NeuConnect Interconnector	Cable	Under construction	2	Y	Y	Y
Endurance	CCS	Under construction	2	Y	Y	Y
NEP Exploration Drilling Licence	CCS	Ongoing	2	Y	Y	Y
Dogger Bank A	OWF	Consented	3	Y	Y	Y
Dogger Bank B	OWF	Consented	3	Y	Y	Y
Dogger Bank C	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
Hornsea 3	OWF	Consented	3	Y	Y	Y
Norfolk Boreas	OWF	Consented	3	Y	Y	Y
Norfolk Vanguard	OWF	Consented	3	Y	Y	Y
PTEC	Tidal	Consented	3	Y	N	N
Sofia	OWF	Consented	3	Y	Y	Y
Hornsea 4	OWF	Consented	3	Y	Y	Y

[18] This information is correct as of the time of the assessment (January 2024)

Project	Type	Status	TIER[18]	HP	HS	GS
Pentland	OWF	Consented	3	Y	N	N
Avalon Floating	OWF	Application submitted	4	Y	N	N
Berwick Bank Firth of Forth	OWF	Application submitted	4	Y	N	N
Green Volt Floating	OWF	Application submitted	4	Y	N	N
Sheringham Extension	OWF	Application Submitted	4	Y	Y	Y
West of Orkney	OWF	Application Submitted	4	Y	N	N
Dudgeon Extension	OWF	Application Submitted	4	Y	Y	Y
Berwick Bank	OWF	Application Submitted	4	Y	N	N
Rampion 2 Extension	OWF	Pre-Consent	4	Y	N	N
Arven Floating	OWF	Pre-Consent	6	Y	N	N
Aspen Floating	OWF	Pre-Consent	6	Y	N	N
Ayre Floating	OWF	Pre-Consent	6	Y	N	N
Beech Floating	OWF	Pre-Consent	6	Y	N	N
Bellrock Floating	OWF	Pre-Consent	6	Y	N	N
Blyth Demo	OWF	Pre-Consent	5	Y	N	Y
Blyth Demo 2&3	OWF	Pre-Consent	6	Y	N	N
Bowdun	OWF	Pre-Consent	6	Y	N	N
Broadshore Floating	OWF	Pre-Consent	6	Y	N	N
Buchan	OWF	Pre-Consent	6	Y	N	N
Caledonia	OWF	Pre-Consent	6	Y	N	N
Campion Wind	OWF	Pre-Consent	6	Y	N	N
Cedar Floating	OWF	Pre-Consent	6	Y	N	N
Cenos Floating	OWF	Pre-Consent	6	Y	N	N
Culzean Floating	OWF	Pre-Consent	6	Y	N	N
DBS East	OWF	Pre-Consent	5	Y	Y	Y
DBS West	OWF	Pre-Consent	5	Y	Y	Y
Dogger Bank D	OWF	Pre-Consent	6	Y	Y	Y
Dogger Bank South	OWF	Pre-Consent	5	Y	Y	Y
Dunkerque	OWF	Pre-Consent	5	Y	N	N
Flora Floating	OWF	Pre-Consent	6	Y	N	N
Harbour Energy South Floating	OWF	Pre-Consent	6	Y	N	N
Kincardine Phase 2	OWF	Pre-Consent	6	Y	N	N

Project	Type	Status	TIER[18]	HP	HS	GS
Ijmuiden Ver	OWF	Pre-Consent	6	Y	N	N
MarramWind Floating	OWF	Pre-Consent	6	Y	N	N
Morven	OWF	Pre-Consent	6	Y	N	N
Muir Mhor	OWF	Pre-Consent	6	Y	N	N
N-3.7	OWF	Pre-Consent	7	Y	N	N
N-3.8	OWF	Pre-Consent	7	Y	N	N
N-7.2	OWF	Pre-Consent	7	Y	N	N
North Falls	OWF	Pre-Consent	5	Y	Y	Y
Ossian Floating	OWF	Pre-Consent	6	Y	N	N
Outer Dowsing	OWF	Pre-Consent	5	Y	Y	Y
Parc Eolien Normadie (AO4)	OWF	Pre-Consent	6	Y	N	N
Salamander	OWF	Pre-Consent	6	Y	N	N
SENSEWind Pelastar Floating	OWF	Pre-Consent	6	Y	N	N
Stromar Floating	OWF	Pre-Consent	6	Y	N	N
Stoura Floating	OWF	Pre-Consent	6	Y	N	N
Thor	OWF	Pre-Consent	3	Y	N	N
Eurolink	Cable	Pre-Consent	5	Y	Y	Y
Nautilius	Cable	Pre-Consent	5	Y	Y	Y
Belgium-Energiø Nordsøen-Denmark	Cable	Concept / early planning	7	Y	N	N
N-11.1	OWF	Pre-Consent	7	Y	N	N
N-12.1	OWF	Pre-Consent	7	Y	N	N
N-12.2	OWF	Pre-Consent	7	Y	N	N
Seismic Survey 1	Seismic	NA	7	Y	Y	Y
Seismic Survey 2	Seismic	NA	7	Y	Y	Y
Seismic Survey 3	Seismic	NA	7	Y	N	N
Seismic Survey 4	Seismic	NA	7	Y	N	N

Table 7.40: Projects considered within the marine mammal CEA with a PIER or ES chapter available in the public domain.

Project	Tier	Q4 2023	Q1 2024	Q2 2024	Q3 2024	Q4 2024	Q1 2025	Q2 2025	Q3 2025	Q4 2025	Q1 2026	Q2 2026	Q3 2026	Q4 2026	Q1 2027	Q2 2027	Q3 2027	Q4 2027	Q1 2028	Q2 2028	Q3 2028	Q4 2028	Q1 2029	Q2 2029	Q3 2029	Q4 2029	Q1 2030	Q2 2030	Q3 2030	Q4 2030	Q1 2031	Q2 2031	Q3 2031	Q4 2031	HP	HS	GS
Five Estuaries	-																		U	U	U	U	P	P	P	P	P	P	P	P					Y	Y	Y
Avalon	4		P	P																															Y	N	N
Berwick Bank	4						P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P											Y	N	N
Dogger Bank A	3	P	P	P	P	P	P																												Y	Y	Y
Dogger Bank B	3	P	P	P	P	P	P																												Y	Y	Y
Dogger Bank C	3		P	P	P	P	P	P	P	P	P	P	P	P	P																				Y	Y	Y
Dudgeon Ext	4		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P																	Y	Y	Y
East Anglia 1 N	3							U	U	U	U	P	P	P	P	P	P	P	P	P	P	P													Y	Y	Y
East Anglia 2	3			U	U	U	U	P	P	P	P	P	P	P	P	P	P	P	P																Y	Y	Y
East Anglia 3	3	P	P																																Y	Y	Y
Green Volt	4														P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	Y	N	N
Hornsea 3	3			U	U	U	U	U	U	U					P	P	P	P	P	P															Y	Y	Y
Hornsea 4	3												U	U	U	P	P	P	P																Y	Y	Y
Moray West	2	P	P	P	P	P	P																												Y	N	N
Norfolk Boreas	3								U	U	U	P	P	P	P	P	P	P																	Y	N	N
Norfolk Vanguard	3		U	P	P	P	P	P	P	P	P																								Y	Y	Y
North falls	5										P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P					Y	Y	Y
Outer Dowsing	5														P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P					Y	Y	Y
Pentland Demo	3							P	P																										Y	N	N
Rampion 2 Ext	4		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P																	Y	Y	Y
Sherringham Ext	4								U	U	U	U	P	P	P																				Y	Y	Y

Project	Tier	Q4 2023	Q1 2024	Q2 2024	Q3 2024	Q4 2024	Q1 2025	Q2 2025	Q3 2025	Q4 2025	Q1 2026	Q2 2026	Q3 2026	Q4 2026	Q1 2027	Q2 2027	Q3 2027	Q4 2027	Q1 2028	Q2 2028	Q3 2028	Q4 2028	Q1 2029	Q2 2029	Q3 2029	Q4 2029	Q1 2030	Q2 2030	Q3 2030	Q4 2030	Q1 2031	Q2 2031	Q3 2031	Q4 2031	HP	HS	GS
Sofia	3	U	U	U	P	P	P	P	P	P	P																								Y	Y	Y
West of Orkney	4																		U	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	Y	N	N
Easternlink	2	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C																	Y	N	Y
NeuConnect	2	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C													Y	Y	Y
Endurance	2	C	C	C	C	C	C	C	C	C																									Y	Y	Y
Dogger Bank South	5											P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P					Y	Y	Y
Thor	3						P	P	P	P	P	P	P	P																					Y	N	N

U = UXO, P = Piling, S = Seismic Survey, C=Construction, 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)

Table 7.41: Projects considered within the marine mammal CEA without a PIER or ES chapter available in the public domain.

Project	Tier	Q4 2023	Q1 2024	Q2 2024	Q3 2024	Q4 2024	Q1 2025	Q2 2025	Q3 2025	Q4 2025	Q1 2026	Q2 2026	Q3 2026	Q4 2026	Q1 2027	Q2 2027	Q3 2027	Q4 2027	Q1 2028	Q2 2028	Q3 2028	Q4 2028	Q1 2029	Q2 2029	Q3 2029	Q4 2029	Q1 2030	Q2 2030	Q3 2030	Q4 2030	Q1 2031	Q2 2031	Q3 2031	Q4 2031	HP	HS	GS
Five Estuaries	-																		U	U	U	U	P	P	P	P	P	P	P	P					Y	Y	Y
Borkum Riffgrund 3	2	P	P	P	P	P																													Y	N	N
EnBW He Dreidt	2	P	P	P	P	P																													Y	N	N
Gode Wind 3	2	P																																	Y	N	N
PTEC	3														P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	Y	N	N
Aspen	6														P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	Y	N	N
Arven	6										P	P	P	P	P	P	P	P	P	P	P	P													Y	N	N
Ayre	6																				U	U	P	P	P	P									Y	N	N
Beech	6														P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	Y	N	N
Bellrock	6														P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	Y	N	N
Blyth Demo 2&3	6		P	P	P	P	P																												Y	N	N
Bowdun	6																				P	P	P	P	P	P									Y	N	N
Broadshore	6														P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	Y	N	N
Buchan	6														P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	Y	N	N
Caledonia	6																		U	U	P	P	P	P	P	P	P	P	P	P					Y	N	N
CampionWind	6														P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	Y	N	N
Cedar	6														P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	Y	N	N
Cenos	6														U	U	U	U	P	P	P	P	P	P	P	P									Y	N	N
Culzean	6				P																														Y	N	N
Dogger Bank D	6														U	U	U	U	P	P	P	P													Y	Y	Y
Dunkerque (Dunkirk)	6										P	P	P	P	P	P	P	P	P	P	P	P													Y	N	N
Flora Floating Wind Farm	6														P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	Y	N	N
Harbour Energy South INTOG Floating Wind Farm	6														P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	Y	N	N
Kincardine - phase 2 Floating Wind Farm	6														P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	Y	N	N
IJmuiden Ver	6																		P	P	P	P	P	P	P	P									Y	N	N
MarramWind Floating Wind Farm	6														P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	Y	N	N
Morven	6														P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	Y	N	N
Muir Mhor	6																						U	P	P	P									Y	N	N
N-3.7	7								P	P	P	P	P																						Y	N	N

Project	Tier	Q4 2023	Q1 2024	Q2 2024	Q3 2024	Q4 2024	Q1 2025	Q2 2025	Q3 2025	Q4 2025	Q1 2026	Q2 2026	Q3 2026	Q4 2026	Q1 2027	Q2 2027	Q3 2027	Q4 2027	Q1 2028	Q2 2028	Q3 2028	Q4 2028	Q1 2029	Q2 2029	Q3 2029	Q4 2029	Q1 2030	Q2 2030	Q3 2030	Q4 2030	Q1 2031	Q2 2031	Q3 2031	Q4 2031	HP	HS	GS
N-3.8	7								P	P	P	P	P	P	P	P	P	P																	Y	N	N
N-7.2	7										P	P	P	P																					Y	N	N
N-11.1	7														P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	Y	N	N
N-12.1	7														P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	Y	N	N
N-12.2	7														P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	Y	N	N
Ossian Floating Wind Farm	6														P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	Y	N	N
Parc eolien pose au large de la Normadie (AO4)	6																		P	P	P	P	P	P	P	P									Y	N	N
Salamander Offshore Wind Farm	6														P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	Y	N	N
SENSEWind Pelastar Full-Scale Prototype Floating Wind Farm	6														P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	Y	N	N
Stromar Floating Wind Farm	6														P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	Y	N	N
Stoura Floating Wind Farm	6														P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	Y	N	N
Belgium-Energiø Nordsøen-Denmark	7										C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C									Y	N	N
Eurolink	6										C	C	C	C	C	C	C	C	C	C	C	C													Y	Y	Y
Nautilius MPI	6														C	C	C	C																	Y	Y	Y
NEP Exploration	2	C	C	C	C	C	C	C	C	C																									Y	Y	Y
Seismic Survey 1	7	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	Y	Y	Y
Seismic Survey 2	7	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	Y	Y	Y
Seismic Survey 3	7	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	Y	N	N
Seismic Survey 4	7	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	Y	N	N

U = UXO, P = Piling, S = Seismic Survey, C = Construction, 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

7.13.10 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.

7.13.11 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.

7.13.12 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

7.13.13 The MDS for the marine mammal CEA is described in Table 7.42. As described in paragraph 7.13.5, the time period considered in the CEA for marine mammals is 2023 to 2031 inclusive to allows for the quantification of impacts to the respective MUs both prior to the construction of and during the potential construction window for VE (Table 7.40, Table 7.41).

Table 7.42: 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: Projects where construction 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 due

Potential effect	Scenario	Justification
	decommissioning periods are expected to take place between 2023 to 2031.	to the spatial extent of 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 2023 to 2031 that weren'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 due to the high mobility of marine mammal receptors.

DISTURBANCE FROM UNDERWATER NOISE

METHOD

UXO CLEARANCE

7.13.14 For all offshore projects that had a quantitative impact assessment publicly available for UXO clearance (PEIR or ES chapter, Table 7.40), 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.

7.13.15 For all projects that have no quantitative impact assessment publicly available (PEIR or ES chapter, Table 7.41), 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 IV block-wide density estimate for each project. To estimate the number of harbour and grey seals predicted to be disturbed, the average densities across the respective MUs were calculated. For harbour seal that included the abundance in Southeast England MU (4,868 individuals) divided by the area of MU (131,453.7 km^2) equating to a density of 0.037 harbour seals/km^2. Similarly, grey seal density calculations considered the abundance in Southeast and Northeast England MUs (65,505 individuals) divided by the area of MUs (194,290.6 km^2) equating to a density of 0.337 grey seals per km^2.

PILING FOR OWF

7.13.16 For all offshore projects that had a quantitative impact assessment for pile driving publicly available (PEIR or ES chapter, Table 7.40), 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.

7.13.17 For all projects that have no quantitative impact assessment available (PEIR or ES chapter, Table 7.41), 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 IV block-wide density estimate for each project. To estimate the number of harbour and grey seals predicted to be disturbed, the average densities across the respective MUs were calculated (see paragraph 7.13.15 for more details, the densities of 0.037 and 0.337 individuals/km^2 were used for harbour and grey seal, respectively).

TIDAL, INTERCONNECTOR CABLES AND CARBON CAPTURE PROJECTS

7.13.18 For tidal, interconnector cables and carbon capture and storage projects it is assumed there will be no pile driving. Therefore, construction-related impacts are limited to a 5 km EDR. The density of harbour porpoise used to calculate the number of animals impacted was the relevant SCANS IV block wide density estimate for each project. To estimate the number of harbour and grey seals predicted to be disturbed, the average densities across the respective MUs were calculated (see paragraph 7.13.15 for more details, the densities of 0.037 and 0.337 individuals/km^2 were used for harbour and grey seal, respectively).

SEISMIC SURVEYS

7.13.19 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 area of disturbance for seismic surveys is 1,759 km^2 as per the advice provided in JNCC (2023). This footprint assumes that the seismic lines are undertaken sequentially from one line to the adjacent line (<500 m away).

7.13.20 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). It was assumed that the CEA for harbour porpoise would incorporate four seismic survey operations within the North Sea MU at any one time.

7.13.21 To estimate the number of harbour and grey seals predicted to be disturbed, the average densities across the respective MUs were calculated (see paragraph 7.13.15 for more details, the densities of 0.037 and 0.337 individuals/km^2 were used for harbour and grey seal, respectively). 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.

PRECAUTION IN THE CEA

7.13.22 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 1-7 projects would require that 39 offshore wind farm developments, 1 tidal energy development, 4 interconnector cables and 4 seismic surveys are all active at the same time. This is considered to be extremely unrealistic given the availability of piling vessels world-wide.

- The inclusion of lower tier developments. In reality, the best information in terms of construction timeline is available for Tier 1-3 projects which have consent. By including projects that have no consent (Tiers 4, 5, 6, 7), no ES chapter or no submitted information at all then worst-case scenarios have to be assumed in the absence of other information.
- The assumption that 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 2029 to 2030 (which results in 2 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 assumption of a 26 km EDR for monopiles. A review on the literature relating to disturbance ranges found that most studies have shown temporary displacement out to 10- 20 km, and that an EDR of 26 km exceeds the range at which the majority of effects are reported (Brown et al., 2023).

HARBOUR PORPOISE

7.13.23 The potential number of harbour porpoise disturbed per day by project is provided in Table 7.43 and Table 7.44 for projects with and without PEIR/ES chapter available, respectively.

7.13.24 A summary of the total disturbance impact to harbour porpoise per day by Tier is provided in Table 7.45. Additionally, a summary of minimum, average and maximum numbers of harbour porpoise disturbed by underwater noise across the CEA timeframe (2023 to 2031) and UXO clearance/piling window at VE (2028 to 2030) is presented in Table 7.46.

7.13.25 A summary of the total disturbance impact to harbour porpoise per day across all projects in Tier 1-3 is provided in Figure 7.17.

7.13.26 Across all years considered in the CEA (2023 to 2031 inclusive) and all Tiers, the periods with highest levels of predicted disturbance to harbour porpoise are in the years preceding the piling window for VE (Q1 2027).

7.13.27 While this CEA has attempted to quantify potential impacts across all Tiers (1-7), the conclusions have been drawn based upon the quantitative assessment for Tiers 1-3 since these projects are consented and thus have the highest levels of data confidence in terms of potential construction timeline and the availability of a quantitative assessment for the animals disturbed.

7.13.28 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 Q1 2028, when several projects located in the North Sea may be under construction (Berwick Bank, Hornsea 3, Hornsea 4, East Anglia projects, North Falls, Outer Dowsing). At this time, a maximum of 32,542 porpoise (9.39% 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). The number of harbour porpoise disturbed as a result of UXO clearance at VE constitutes around 12% of the total in Q1 2028 (Figure 7.17).

7.13.29 The total impact to the North Sea MU is expected to be lower as the VE construction progresses. For example, in Q2 2028 a maximum of 24,574 porpoise (7.09% 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), reducing to 5,178 porpoise (1.49% MU) in Q3-Q4 2028 and to 8,977 porpoise (2.59% MU) throughout 2029 and 2030 (Table 7.45).

Table 7.43: Number of harbour porpoise potentially disturbed by underwater noise by project (with PEIR/ES chapter available). VE construction period (UXO clearance in 2028, piling between 2029 and 2030) is indicated by orange box. Colours denote: UXO, Piling, Seismic Survey, Construction

Project	Tier	Q4 2023	Q1 2024	Q2 2024	Q3 2024	Q4 2024	Q1 2025	Q2 2025	Q3 2025	Q4 2025	Q1 2026	Q2 2026	Q3 2026	Q4 2026	Q1 2027	Q2 2027	Q3 2027	Q4 2027	Q1 2028	Q2 2028	Q3 2028	Q4 2028	Q1 2029	Q2 2029	Q3 2029	Q4 2029	Q1 2030	Q2 2030	Q3 2030	Q4 2030	Q1 2031	Q2 2031	Q3 2031	Q4 2031
Five Estuaries	-																		3865	3865	3865	3865	8953	8953	8953	8953	8953	8953	8953	8953				
Avalon	4		423	423																														
Berwick Bank	4						2822	2822	2822	2822	2822	2822	2822	2822	2822	2822	2822	2822	2822	2822	2822	2822	2822	2822										
Dogger Bank A	3	4302	4302	4302	4302	4302	4302																											
Dogger Bank B	3	3931	3931	3931	3931	3931	3931																											
Dogger Bank C	3		1920	1920	1920	1920	1920	1920	1920	1920	1920	1920	1920	1920	1920																			
Dudgeon Ext	4		5161	5161	5161	5161	5161	5161	5161	5161	5161	5161	5161	5161	5161	5161	5161	5161																
East Anglia 1 N	3							1289	1289	1289	1289	1289	1289	1289	1289	1289	1289	1289	1289	1289	1289	1289												
East Anglia 2	3			1551	1551	1551	1551	1551	1551	1551	1551	1551	1551	1551	1551	1551	1551	1551	1551															
East Anglia 3	3	3825	3825																															
Green Volt	4														5208	5208	5208	5208	5208	5208	5208	5208	5208	5208	5208	5208	5208	5208	5208	5208	5208	5208	5208	5208
Hornsea 3	3			1869	1869	1869	1869	1869	1869	1869					1396	1396	1396	1396	1396	1396														
Hornsea 4	3												3394	3394	3394	6417	6417	6417	6417															
Moray West	2	1609	1609	1609	1609	1609	1609																											
Norfolk Boreas	3								2251	2251	2251	2251	2251	2251	2251	2251	2251	2251																
Norfolk Vanguard (East & West)	3		1886	4354	4354	4354	4354	4354	4354	4354	4354																							
North falls	5										1072	1072	1072	1072	1072	1072	1072	1072	1072	1072	1072	1072	1072	1072	1072	1072	1072	1072	1072	1072				
Outer Dowsing	5														3981	3981	3981	3981	3981	3981	3981	3981	3981	3981	3981	3981	3981	3981	3981	3981				
Pentland Demonstrator	3							323	323																									
Rampion 2 Ext	4		630	630	630	630	630	630	630	630	630	630	630	630	630	630	630	630																
Sherringham Ext	4								1886	1886	1886	1886	1338	1338	1338																			
Sofia	3	3394	3394	3394	2035	2035	2035	2035	2035	2035	2035																							
West of Orkney	4																		3394	1349	1349	1349	1349	1349	1349	1349	1349	1349	1349	1349	1349	1349	1349	1349
Eastern Link 1	2	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16																
NueConnect	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0												

Project	Tier	Q4 2023	Q1 2024	Q2 2024	Q3 2024	Q4 2024	Q1 2025	Q2 2025	Q3 2025	Q4 2025	Q1 2026	Q2 2026	Q3 2026	Q4 2026	Q1 2027	Q2 2027	Q3 2027	Q4 2027	Q1 2028	Q2 2028	Q3 2028	Q4 2028	Q1 2029	Q2 2029	Q3 2029	Q4 2029	Q1 2030	Q2 2030	Q3 2030	Q4 2030	Q1 2031	Q2 2031	Q3 2031	Q4 2031
Endurance	2	0	0	0	0	0	0	0	0	0																								
Dogger Bank South	5											5658	5658	5658	5658	5658	5658	5658	5658	5658	5658	5658	5658	5658	5658	5658	5658	5658	5658	5658				
Thor	3						0	0	0	0	0	0	0	0																				

Table 7.44: Number of harbour porpoise potentially disturbed by underwater noise by project (without PEIR/ES chapter available). VE construction period (UXO clearance in 2028, piling between 2029 and 2030) is indicated by orange box. Colours denote: UXO, Piling, Seismic Surveys, Construction

Project	Tier	Q4 2023	Q1 2024	Q2 2024	Q3 2024	Q4 2024	Q1 2025	Q2 2025	Q3 2025	Q4 2025	Q1 2026	Q2 2026	Q3 2026	Q4 2026	Q1 2027	Q2 2027	Q3 2027	Q4 2027	Q1 2028	Q2 2028	Q3 2028	Q4 2028	Q1 2029	Q2 2029	Q3 2029	Q4 2029	Q1 2030	Q2 2030	Q3 2030	Q4 2030	Q1 2031	Q2 2031	Q3 2031	Q4 2031
Five Estuaries	N/A																		3865	3865	3865	3865	3865	3865	3865	3865	3865	3865	3865	3865				
Borkum Riffgrund 3	2	568	568	568	568	568																												
EnBW He Dreidt	2	435	435	435	435	435																												
Gode Wind 3	2	435																																
PTEC	3														8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Aspen	6														423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423
Arven	6										364	364	364	364	364	364	364	364	364	364	364	364												
Ayre	6																				597	597	199	199	199	199								
Beech	6														423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423
Bellrock	6														423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423
Blyth Demo 2&3	6		423	423	423	423	423																											
Bowdun	6																				423	423	423	423	423	423								
Broadshore	6														364	364	364	364	364	364	364	364	364	364	364	364	364	364	364	364	364	364	364	364
Buchan	6														364	364	364	364	364	364	364	364	364	364	364	364	364	364	364	364	364	364	364	364
Caledonia	6																		597	597	597	597	597	597	597	597	597	597	597	597				
CampionWind	6														423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423
Cedar	6														423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423
Cenos	6														1271	1271	1271	1271	423	423	423	423	423	423	423	423								
Culzean	6				423																													
Dogger Bank D	6														1280	1280	1280	1280	1280	1280	1280	1280												
Dunkerque	6										74	74	74	74	74	74	74	74	74	74	74	74												
Flora	6														1280	1280	1280	1280	1280	1280	1280	1280	1280	1280	1280	1280	1280	1280	1280	1280	1280	1280	1280	1280
Harbour Energy South	6														423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423
Kincardine Phase 2	6														423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423
IJmuiden Ver	6																		568	568	568	568	568	568	568	568								
MarramWind	6														423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423
Morven	6														1271	1271	1271	1271	1271	1271	1271	1271	1271	1271	1271	1271	1271	1271	1271	1271	1271	1271	1271	1271
Muir Mhor	6																						1271	423	423	423								
N-3.7	7								435	435	435	435	435																					
N-3.8	7								435	435	435	435	435	435	435	435	435	435																

Project	Tier	Q4 2023	Q1 2024	Q2 2024	Q3 2024	Q4 2024	Q1 2025	Q2 2025	Q3 2025	Q4 2025	Q1 2026	Q2 2026	Q3 2026	Q4 2026	Q1 2027	Q2 2027	Q3 2027	Q4 2027	Q1 2028	Q2 2028	Q3 2028	Q4 2028	Q1 2029	Q2 2029	Q3 2029	Q4 2029	Q1 2030	Q2 2030	Q3 2030	Q4 2030	Q1 2031	Q2 2031	Q3 2031	Q4 2031
N-7.2	7										435	435	435	435																				
N-11.1	7														435	435	435	435	435	435	435	435	435	435	435	435	435	435	435	435	435	435	435	435
N-12.1	7														435	435	435	435	435	435	435	435	435	435	435	435	435	435	435	435	435	435	435	435
N-12.2	7														435	435	435	435	435	435	435	435	435	435	435	435	435	435	435	435	435	435	435	435
Ossian	6														423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423
Parc eolien pose au large de la Normadie (AO4)	6																		74	74	74	74	74	74	74	74								
Salamander	6														423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423
SENSEWind Pelastar	6														423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423
Stromar	6														199	199	199	199	199	199	199	199	199	199	199	199	199	199	199	199	199	199	199	199
Stoura	6														364	364	364	364	364	364	364	364	364	364	364	364	364	364	364	364	364	364	364	364
Belgium-Energiø Nordsøen-Denmark	7										63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63								
Eurolink	6										63	63	63	63	63	63	63	63	63	63	63	63												
Nautilius MPI	6														24	24	24	24																
NEP Exploration	2	47	47	47	47	47	47	47	47	47																								
4 seismic surveys	7	3596	3596	3596	3596	3596	3596	3596	3596	3596	3596	3596	3596	3596	3596	3596	3596	3596	3596	3596	3596	3596	3596	3596	3596	3596	3596	3596	3596	3596	3596	3596	3596	3596

Table 7.45: 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 construction period (UXO clearance in 2028, piling between 2029 and 2030) is indicated by orange box.

Year	VE alone		VE + T1-3		VE + T1-4		VE + T1-5		VE + T1-7	
	#	% MU	#	% MU	#	% MU	#	% MU	#	% MU
Q4 2023	0	0.00%	18562	5.36%	18562	5.36%	18562	5.36%	22158	6.39%
Q1 2024	0	0.00%	21933	6.33%	28147	8.12%	28147	8.12%	32166	9.28%
Q2 2024	0	0.00%	23996	6.92%	30210	8.72%	30210	8.72%	34229	9.88%
Q3 2024	0	0.00%	22637	6.53%	28428	8.20%	28428	8.20%	32870	9.48%
Q4 2024	0	0.00%	22637	6.53%	28428	8.20%	28428	8.20%	32447	9.36%
Q1 2025	0	0.00%	21634	6.24%	30247	8.73%	30247	8.73%	34266	9.89%
Q2 2025	0	0.00%	13404	3.87%	22017	6.35%	22017	6.35%	25613	7.39%
Q3 2025	0	0.00%	15655	4.52%	26154	7.55%	26154	7.55%	30621	8.83%
Q4 2025	0	0.00%	15332	4.42%	25831	7.45%	25831	7.45%	30298	8.74%
Q1 2026	0	0.00%	13416	3.87%	23915	6.90%	24987	7.21%	30453	8.79%
Q2 2026	0	0.00%	7027	2.03%	17526	5.06%	24256	7.00%	29722	8.58%
Q3 2026	0	0.00%	10421	3.01%	20372	5.88%	27102	7.82%	32568	9.40%
Q4 2026	0	0.00%	10421	3.01%	20372	5.88%	27102	7.82%	32132	9.27%
Q1 2027	0	0.00%	29841	8.61%	44984	12.98%	57821	16.68%	72668	20.97%
Q2 2027	0	0.00%	30944	8.93%	44749	12.91%	57586	16.61%	72433	20.90%
Q3 2027	0	0.00%	30944	8.93%	44749	12.91%	57586	16.61%	72433	20.90%
Q4 2027	0	0.00%	30944	8.93%	44749	12.91%	57586	16.61%	72433	20.90%
Q1 2028	3865	1.12%	32542	9.39%	40085	11.57%	52922	15.27%	71565	20.65%

Year	VE alone		VE + T1-3		VE + T1-4		VE + T1-5		VE + T1-7	
	#	% MU	#	% MU	#	% MU	#	% MU	#	% MU
Q2 2028	3865	1.12%	24574	7.09%	30072	8.68%	42909	12.38%	61552	17.76%
Q3 2028	3865	1.12%	5178	1.49%	10676	3.08%	23513	6.78%	43176	12.46%
Q4 2028	3865	1.12%	5178	1.49%	10676	3.08%	23513	6.78%	43176	12.46%
Q1 2029	8953	2.58%	8977	2.59%	9387	2.71%	22224	6.41%	46067	13.29%
Q2 2029	8953	2.58%	8977	2.59%	9387	2.71%	22224	6.41%	45219	13.05%
Q3 2029	8953	2.58%	8977	2.59%	6565	1.89%	19402	5.60%	42397	12.23%
Q4 2029	8953	2.58%	8977	2.59%	6565	1.89%	19402	5.60%	42397	12.23%
Q1 2030	8953	2.58%	8977	2.59%	6565	1.89%	19402	5.60%	40224	11.61%
Q2 2030	8953	2.58%	8977	2.59%	6565	1.89%	19402	5.60%	40224	11.61%
Q3 2030	8953	2.58%	8977	2.59%	6565	1.89%	19402	5.60%	40224	11.61%
Q4 2030	8953	2.58%	8977	2.59%	6565	1.89%	19402	5.60%	40224	11.61%
Q1 2031	0	0.00%	24	0.01%	6565	1.89%	8691	2.51%	19963	5.76%
Q2 2031	0	0.00%	24	0.01%	6565	1.89%	8691	2.51%	19963	5.76%
Q3 2031	0	0.00%	24	0.01%	6565	1.89%	8691	2.51%	19963	5.76%
Q4 2031	0	0.00%	24	0.01%	6565	1.89%	8691	2.51%	19963	5.76%

Table 7.46: A summary of numbers of harbour porpoise disturbed by underwater noise across the Tiers between 2023 to 2031 and during UXO clearance / piling phase at VE (2028 to 2030).

Years		VE alone		VE + T1-3		VE + T1-4		VE + T1-5		VE + T1-7	
		#	% MU	#	% MU	#	% MU	#	% MU	#	% MU
2023 to 2031	Minimum	0	0.00	24	0.01	6565	1.89	8691	2.51	19963	5.76
	Average	2639	0.76	14519	4.19	20466	5.90	27592	7.96	40176	11.59
	Maximum	8953	2.58	32542	9.39	44984	12.98	57821	16.68	72668	20.97
2028 to 2030	Minimum	3865	1.12	5178	1.49	6565	1.89	19402	5.60	40224	11.61
	Average	7257	2.09	11607	3.35	12473	3.60	25310	7.30	46371	13.38
	Maximum	8953	2.58	32542	9.39	40085	11.57	52922	15.27	71565	20.65

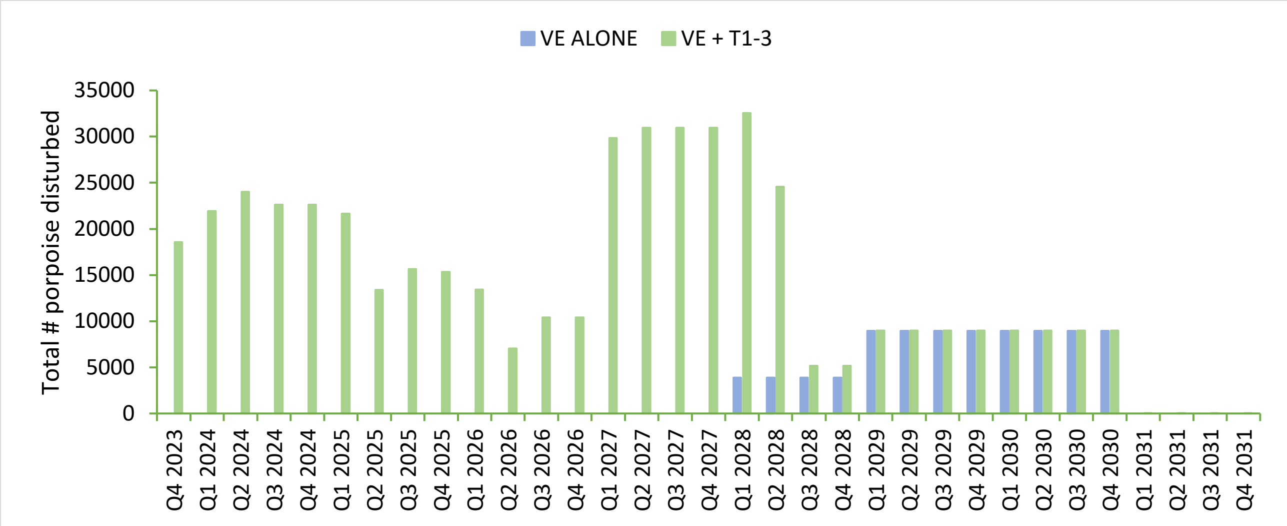


Figure 7.17: Cumulative underwater noise disturbance estimates to harbour porpoise for VE alone and VE in addition to Tier 1-3 projects.

7.13.30 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 72,688 porpoise to be disturbed across all Tier 1-7 projects in Q1 2027, this would require that 39 offshore wind farm developments, 1 tidal energy development, 4 interconnector cables and 4 seismic surveys are all constructing/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% probability of response at 7.4 km and a 28% probability 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 7.18) (Graham *et al.,* 2019). Likewise, pile driving at the first seven large-scale offshore windfarms in the German Bight (including unmitigated piling) found declines in porpoise out to only 17 km, with unmitigated piling in isolation also illustrating only weak declines beyond approximately 17 km (Brandt *et al.,* 2018). Benhemma-Le Gall et al. (2021) examined the broad-scale responses of harbour porpoise to pile-driving and vessel activities during offshore windfarm construction and found that there was approximately a reduction in harbour porpoise foraging activity close to piling activity (2 – 10 km) and an increase further way (16 – 30 km). This suggests animals were not significantly affected by this specific disturbance – but moved away and continued foraging.

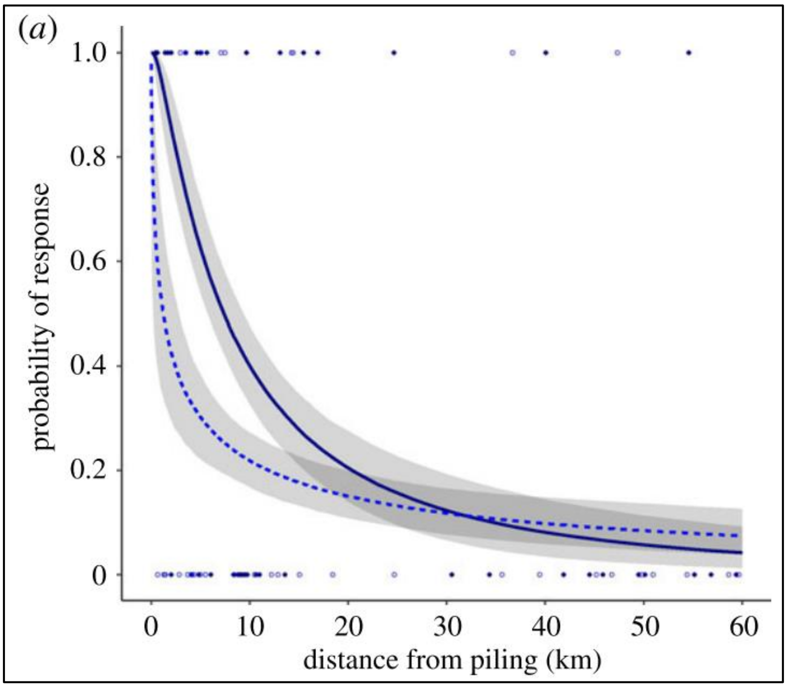


Figure 7.18: The probability of harbour porpoise response (24 h) in relation to the partial contribution of distance from piling for the first location piled (solid navy line) and the final location piled (dashed blue line) (Graham *et al*., 2019).

7.13.31 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 days of disturbance across multiple years. 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).

7.13.32 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. While cumulative population modelling has not been specifically conducted here for the CEA, results from previous relevant cumulative population modelling studies can be used to draw conclusions as to the potential for population level impacts.

7.13.33 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). The number of porpoise assumed to be disturbed by construction across the Tier 1-3 projects in this CEA is lower than was modelled in Booth *et al*., (2017) (average disturbed per day between 2023 and 2031 is 14,519 porpoise over an eight year period, or an average of 11,607 porpoise per day over the three years VE is constructing)[19]. Therefore, with fewer porpoise predicted to be disturbed per day, across fewer years than the previous modelling, the likelihood of population level effects is expected to be very low.

7.13.34 More recently, the iPCoD model was used to explore noise management in the Southern North Sea SAC for harbour porpoise (Brown et al., 2023). This study provided a wide range of iPCoD simulations including disturbance to harbour porpoise over a 10-year period at the scale of the North Sea MU. One of the most extreme disturbance scenarios assumed a seasonally variable base-level daily disturbance of c. 3,500 - 7,000 porpoise throughout the MU, in addition to disturbance at up to twice the Southern North Sea SAC seasonal disturbance thresholds (up to c. 16,000 porpoise disturbed per day in summer, averaging c. 8,000 disturbed across the season). Even at these persistently high disturbance levels, the predicted declines were low, generally ≤5% after 10 years of disturbance, and in each case, the population remained at a stable size once piling disturbance ended, indicating no long-term effect on the population trajectory (it is important to note here that iPCoD does not allow for density dependence and as such the population cannot increase back to baseline levels after disturbance has ceased).

7.13.35 Similarly, the DEPONS model has been used to predict the potential population-level effects of cumulative OWF construction in the North Sea. Nabe-Nielsen *et al*., (2018) showed that the North Sea porpoise population was unlikely to be significantly impacted by the construction of 60 wind farms each with 65 turbines resulting in 3,900 disturbance days between 2011-2020, unless impact ranges were assumed to be much larger (exceeding 50 km) than that indicated by existing studies. Even at these extreme disturbance scenarios, the modelled North Sea population showed a quick recovery to baseline size (within 6-7 years) despite up to a 20% decline in population size.

7.13.36 While cumulative population modelling has not been specifically conducted here for the CEA, results from previous large-scale cumulative population modelling studies show that persistent (i.e. 10+ years) high levels of disturbance, which are higher per day and/or over longer timescales than assumed in this CEA, are unlikely to result in long-term populations declines. Further, these previous modelling studies have shown that, even under extreme scenarios, the North Sea population is expected to recover quickly from any short-term decline.

[19] Note: Even the number of porpoise disturbed across Tier 1-4 projects are less than was modelled in Booth *et al*., (2017) (average of 23,084 porpoise per day over an eight year period, or an average of 19,730 porpoise per day over the three years VE is constructing).

7.13.37 In addition to this, the presence of the Southern North Sea SAC and consideration of its conservation objectives (specifically relating to disturbance thresholds) means that disturbance impacts in the Southern North Sea population will be highly regulated and controlled (though a SIP) such that extreme scenarios (such as including Tiers 6 and 7 in the CEA here) will not be permitted to occur.

7.13.38 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**.

7.13.39 The sensitivity of harbour porpoise to disturbance from both piling and UXO clearance has been assessed as **Medium**. The same has been assumed here for disturbance from seismic surveys.

7.13.40 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

7.13.41 The potential number of harbour seals disturbed per day by project is provided in Table 7.47.

7.13.42 A summary of the total disturbance impact to harbour seals per day by Tier, is provided in Table 7.48.

7.13.43 A summary of the total disturbance impact to harbour seals per day across all projects in Tiers 1-3 is provided in Figure 7.19. Additionally, a summary of minimum, average and maximum numbers of harbour seal disturbed by underwater noise across the CEA timeframe (2023 to 2031) and UXO clearance/piling window at VE (2028 to 2030) is presented in Table 7.49.

7.13.44 Across all years considered in the CEA (2023 to 2031 inclusive) and all Tiers, the periods with highest levels of predicted disturbance to harbour seals are in the years preceding the piling window for VE (Q1 2024).

7.13.45 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 also in Q1 2024, when several central/southern North Sea projects are constructing (East Anglia 3, Norfolk Vanguard). At this time, a maximum of 251 harbour seals (5.16% MU, Table 7.49) may be disturbed per day (assuming all Tier 1-3 projects are constructing at the same time, and that disturbance is additive across projects).

7.13.46 By comparison, the total impact to the Southeast England MU is expected to be much lower throughout the VE construction window (2028 to 2030). In Q1 2028 a maximum of 51 harbour seals (1.05% 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). The number of harbour seals disturbed as a result of UXO clearance at VE constitutes around 75% of the total in Q1 2028. Additionally, the total impact to the Southeast England MU is expected to be lower as the VE construction progresses. For example, in Q2 2028 a maximum of 44 harbour seals (0.90% 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), reducing to 39 harbour seals (0.80% MU) in Q3-Q4 2028 and to 2 harbour seals (0.04% MU) throughout 2029 and 2030 (Table 7.48).

7.13.47 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 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.

7.13.48 It is noted that the Southeast England harbour seal MU is currently in decline, where the 2021 August moult haul-out count was 24% lower than the 2016 count (SCOS, 2023). However, the drivers of this decline are not currently known. To date, there is no evidence that underwater noise from offshore construction activity is driving the decline, though potential causal factors include grey seal competition for prey, grey seal predation, seal health and disease, emigration, direct human disturbance (boats or disturbance at haul-outs) and some aspect of anthropogenic activity (SCOS, 2023). Given the current lack of evidence that offshore wind farm construction is a contributing factor to the population decline, it is not expected that the cumulative disturbance predicted in this CEA would be sufficient to alter the population trajectory nor exacerbate the current rate of decline. The magnitude of the cumulative increase in disturbance from underwater noise is therefore **Medium**.

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

7.13.50 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 7.47: Number of harbour seals potentially disturbed by underwater noise by project. VE construction period (UXO clearance in 2028, piling between 2029 and 2030) is indicated by orange box. Colours denote: UXO, Piling, Seismic Survey, Construction

Project	Tier	Q4 2023	Q1 2024	Q2 2024	Q3 2024	Q4 2024	Q1 2025	Q2 2025	Q3 2025	Q4 2025	Q1 2026	Q2 2026	Q3 2026	Q4 2026	Q1 2027	Q2 2027	Q3 2027	Q4 2027	Q1 2028	Q2 2028	Q3 2028	Q4 2028	Q1 2029	Q2 2029	Q3 2029	Q4 2029	Q1 2030	Q2 2030	Q3 2030	Q4 2030	Q1 2031	Q2 2031	Q3 2031	Q4 2031
Project with available PEIR/EIA chapter																																		
Five Estuaries	N/A																		38	38	38	38	2	2	2	2	2	2	2	2				
Dogger Bank A	3	0	0	0	0	0	0																											
Dogger Bank B	3	0	0	0	0	0	0																											
East Anglia 3	3	36	36																															
Sofia	3	0	0	0	0	0	0	0	0	0	0																							
Dogger Bank C	3		0	0	0	0	0	0	0	0	0	0	0	0	0																			
East Anglia 1 N	3							17	17	17	17	1	1	1	1	1	1	1	1	1	1	1												
East Anglia 2	3			15	15	15	15	2	2	2	2	2	2	2	2	2	2	2	2															
Hornsea 3	3			3	3	3	3	3	3	3					5	5	5	5	5	5														
Hornsea 4	3												11	11	11	5	5	5	5															
Norfolk Vanguard	3		212	2	2	2	2	2	2	2	2																							
North Falls	5										8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8				
Dudgeon Extension	4						18	18	18	18	18	18	18	18	18	18	18	18																
Rampion 2 Extension	4						0	0	0	0	0	0	0	0	0	0	0	0																
Sheringham Extension	4								0	0	0	0	38	38	38																			
Outer Dowsing	5														35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35				
NueConnect	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0												
Endurance	2	0	0	0	0	0	0	0	0	0																								
Dogger Bank South	5											10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10				
Projects without available PEIR/EIA chapter																																		
Dogger Bank D	6														79	79	79	79	79	79	79	79												
Eurolink	6										3	3	3	3	3	3	3	3	3	3	3	3												
Nautilius MPI	6														3	3	3	3																
NEP Exploration	2	3	3	3	3	3	3	3	3	3																								
2 Seismic Surveys	7	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130

Table 7.48: 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 construction period (UXO clearance in 2028, piling between 2029 and 2030) is indicated by orange box.

Project	VE alone		VE + T1-3		VE + T1-4		VE + T1-5		VE + T1-7	
	#	% MU	#	% MU	#	% MU	#	% MU	#	% MU
Q4 2023	0	0.00%	39	0.80%	39	0.80%	39	0.80%	169	3.47%
Q1 2024	0	0.00%	251	5.16%	251	5.16%	251	5.16%	381	7.83%
Q2 2024	0	0.00%	23	0.47%	23	0.47%	23	0.47%	153	3.14%
Q3 2024	0	0.00%	23	0.47%	23	0.47%	23	0.47%	153	3.14%
Q4 2024	0	0.00%	23	0.47%	23	0.47%	23	0.47%	153	3.14%
Q1 2025	0	0.00%	23	0.47%	41	0.84%	41	0.84%	171	3.51%
Q2 2025	0	0.00%	27	0.55%	45	0.92%	45	0.92%	175	3.59%
Q3 2025	0	0.00%	27	0.55%	45	0.92%	45	0.92%	175	3.59%
Q4 2025	0	0.00%	27	0.55%	45	0.92%	45	0.92%	175	3.59%
Q1 2026	0	0.00%	21	0.43%	39	0.80%	47	0.97%	180	3.70%
Q2 2026	0	0.00%	3	0.06%	21	0.43%	39	0.80%	172	3.53%
Q3 2026	0	0.00%	14	0.29%	70	1.44%	88	1.81%	221	4.54%
Q4 2026	0	0.00%	14	0.29%	70	1.44%	88	1.81%	221	4.54%
Q1 2027	0	0.00%	19	0.39%	75	1.54%	207	4.25%	343	7.05%
Q2 2027	0	0.00%	13	0.27%	31	0.64%	163	3.35%	299	6.14%
Q3 2027	0	0.00%	13	0.27%	31	0.64%	163	3.35%	299	6.14%
Q4 2027	0	0.00%	13	0.27%	31	0.64%	163	3.35%	299	6.14%
Q1 2028	38	0.78%	51	1.05%	51	1.05%	183	3.76%	316	6.49%

Project	VE alone		VE + T1-3		VE + T1-4		VE + T1-5		VE + T1-7	
	#	% MU	#	% MU	#	% MU	#	% MU	#	% MU
Q2 2028	38	0.78%	44	0.90%	44	0.90%	176	3.62%	309	6.35%
Q3 2028	38	0.78%	39	0.80%	39	0.80%	171	3.51%	304	6.24%
Q4 2028	38	0.78%	39	0.80%	39	0.80%	171	3.51%	304	6.24%
Q1 2029	2	0.04%	2	0.04%	2	0.04%	55	1.13%	185	3.80%
Q2 2029	2	0.04%	2	0.04%	2	0.04%	55	1.13%	185	3.80%
Q3 2029	2	0.04%	2	0.04%	2	0.04%	55	1.13%	185	3.80%
Q4 2029	2	0.04%	2	0.04%	2	0.04%	55	1.13%	185	3.80%
Q1 2030	2	0.04%	2	0.04%	2	0.04%	55	1.13%	185	3.80%
Q2 2030	2	0.04%	2	0.04%	2	0.04%	55	1.13%	185	3.80%
Q3 2030	2	0.04%	2	0.04%	2	0.04%	55	1.13%	185	3.80%
Q4 2030	2	0.04%	2	0.04%	2	0.04%	55	1.13%	185	3.80%
Q1 2031	0	0.00%	0	0.00%	0	0.00%	0	0.00%	130	2.67%
Q2 2031	0	0.00%	0	0.00%	0	0.00%	0	0.00%	130	2.67%
Q3 2031	0	0	0	0.00%	0	0.00%	0	0.00%	130	2.67%
Q4 2031	0	0	0	0	0	0	0	0.00%	130	2.67%

Table 7.49: A summary of numbers of harbour seals disturbed by underwater noise across the Tiers between 2023 to 2031 and during UXO clearance / piling phase at VE (2028 to 2030).

Years		VE alone		VE + T1-3		VE + T1-4		VE + T1-5		VE + T1-7	
		#	% MU	#	% MU	#	% MU	#	% MU	#	% MU
2023 to 2031	Minimum	0	0.00%	0	0.00%	0	0.00%	0	0.00%	130	2.67%
	Average	5	0.10%	23	0.47%	33	0.68%	80	1.64%	211	4.34%
	Maximum	38	0.78%	251	5.16%	251	5.16%	251	5.16%	381	7.83%
2028 to 2030	Minimum	2	0.04%	2	0.04%	2	0.04%	55	1.13%	185	3.80%
	Average	14	0.29%	16	0.32%	16	0.32%	95	1.95%	226	4.64%
	Maximum	38	0.78%	51	1.05%	51	1.05%	183	3.76%	316	6.49%

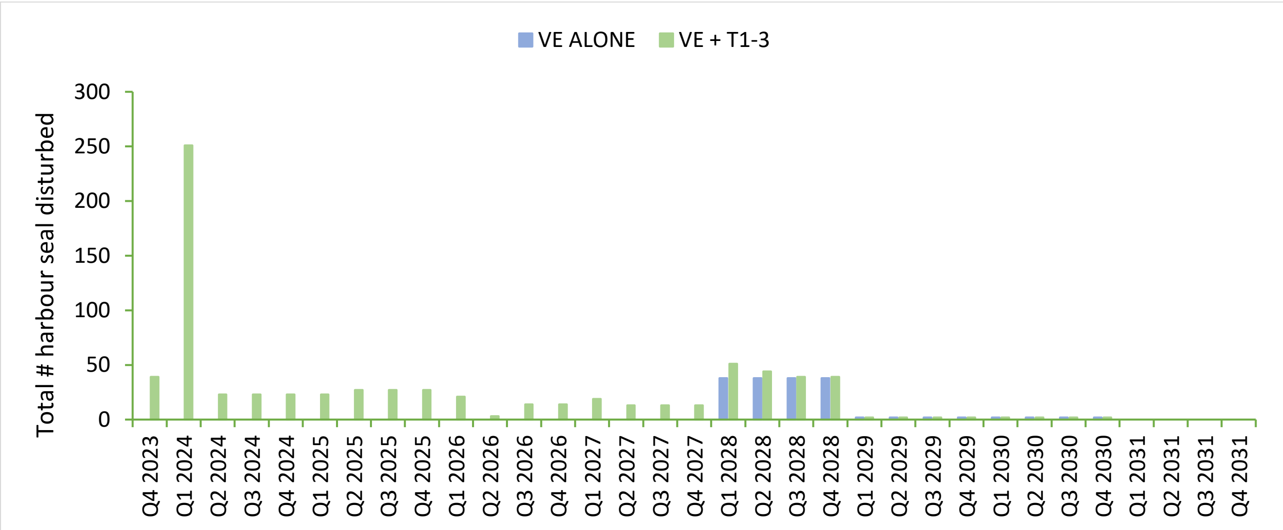


Figure 7.19: Cumulative underwater noise disturbance estimates to harbour seals for VE alone and VE in addition to Tier 1-3 projects.

GREY SEAL

7.13.51 The potential number of grey seals disturbed per day by project is provided in Table 7.50.

7.13.52 A summary of the total disturbance impact to grey seals per day by Tier, is provided in Table 7.51. Additionally, a summary of minimum, average and maximum numbers of grey seal disturbed by underwater noise across the CEA timeframe (2023 to 2031) and UXO clearance/piling window at VE (2028 to 2030) is presented in Table 7.52.

7.13.53 A summary of the total disturbance impact to grey seals per day across all projects in Tier 1-3 is provided in Table 7.20.

7.13.54 Across all years considered in the CEA (2023 to 2031 inclusive) and all Tiers, the periods with highest levels of predicted disturbance to grey seals are in the years preceding the piling window for VE (Q1 2027).

7.13.55 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 Q1 2027, when several central/southern North Sea projects are in construction (Dogger Bank projects, Hornsea 3, Hornsea 4, East Anglia projects, North Falls, Outer Dowsing). At this time, a maximum of 2,122 grey seals (3.24% 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).

7.13.56 By comparison, the total impact to the Southeast and Northeast England MU is expected to be lower throughout the VE construction window (2028 to 2030). In Q1 2028 a maximum of 1,808 grey seals (2.76% 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). Additionally, the total impact to the Southeast and Northeast England MU is expected to be lower as the VE construction progresses. For example, in Q2 2028 a maximum of 276 grey seals (0.42% 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), reducing to 227 seals (0.35% MU) in Q3-Q4 2028 and to 152 seals (0.23% MU) throughout 2029 and 2030 (Table 7.51).

7.13.57 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 1-7 (up to 11.17% 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**.

7.13.58 The sensitivity of grey seals to disturbance from UXO clearance has been assessed as **medium** and for disturbance from piling as **low**.

7.13.59 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 7.50: Number of grey seals potentially disturbed by underwater noise by project. VE construction period (UXO clearance in 2028, piling between 2029 and 2030) is indicated by orange box. Colours denote: UXO, Piling, Seismic Survey, Construction

Project	Tier	Q4 2023	Q1 2024	Q2 2024	Q3 2024	Q4 2024	Q1 2025	Q2 2025	Q3 2025	Q4 2025	Q1 2026	Q2 2026	Q3 2026	Q4 2026	Q1 2027	Q2 2027	Q3 2027	Q4 2027	Q1 2028	Q2 2028	Q3 2028	Q4 2028	Q1 2029	Q2 2029	Q3 2029	Q4 2029	Q1 2030	Q2 2030	Q3 2030	Q4 2030	Q1 2031	Q2 2031	Q3 2031	Q4 2031
Projects with EIA																																	
Five Estuaries	N/A																		225	225	225	225	152	152	152	152	152	152	152	152				
Dogger Bank A	3	2	2	2	2	2	2																											
Dogger Bank B	3	6	6	6	6	6	6																											
East Anglia 3	3	36	36																															
Sofia	3	64	64	64	2	2	2	2	2	2	2																							
Dogger Bank C	3		0	0	0	0	0	0	0	0	0	0	0	0	0																			
East Anglia 1 N	3							64	64	64	64	2	2	2	2	2	2	2	2	2	2	2												
East Anglia 2	3			85	85	85	85	43	43	43	43	43	43	43	43	43	43	43	43															
Hornsea 3	3			98	98	98	98	98	98	98					49	49	49	49	49	49														
Hornsea 4	3												2028	2028	2028	1489	1489	1489	1489															
Norfolk Vanguard	3		340	8	8	8	8	8	8	8	8																							
North Falls	5										140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140				
Dudgeon Extension	4						89	89	89	89	89	89	89	89	89	89	89	89																
Rampion 2 Extension	4						2	2	2	2	2	2	2	2	2	2	2	2																
Sheringham Extension	4								0	0	0	0	119	119	119																			
Outer Dowsing	5														615	615	615	615	615	615	615	615	615	615	615	615	615	615	615	615				
Eastern Link 1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0																
NueConnect	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0												
Endurance	2	0	0	0	0	0	0	0	0	0																								
Dogger Bank South	5											2274	2274	2274	2274	2274	2274	2274	2274	2274	2274	2274	2274	2274	2274	2274	2274	2274	2274	2274				
Projects without EIA																																	
Dogger Bank D	6														716	716	716	716	716	716	716	716												
Eurolink	6										26	26	26	26	26	26	26	26	26	26	26	26												
Nautilius MPI	6														26	26	26	26																
NEP Exploration	2	26	26	26	26	26	26	26	26	26																								
2 seismic surveys	7	1186	1186	1186	1186	1186	1186	1186	1186	1186	1186	1186	1186	1186	1186	1186	1186	1186	1186	1186	1186	1186	1186	1186	1186	1186	1186	1186	1186	1186	1186	1186	1186	1186

Table 7.51: 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 construction period (UXO clearance in 2028, piling between 2029 and 2030) is indicated by orange box.

Project	VE alone		VE + T1-3		VE + T1-4		VE + T1-5		VE + T1-7	
	#	% MU	#	% MU	#	% MU	#	% MU	#	% MU
Q4 2023	0	0.00%	134	0.20%	134	0.20%	134	0.20%	1,320	2.02%
Q1 2024	0	0.00%	474	0.72%	474	0.72%	474	0.72%	1,660	2.53%
Q2 2024	0	0.00%	289	0.44%	289	0.44%	289	0.44%	1,475	2.25%
Q3 2024	0	0.00%	227	0.35%	227	0.35%	227	0.35%	1,413	2.16%
Q4 2024	0	0.00%	227	0.35%	227	0.35%	227	0.35%	1,413	2.16%
Q1 2025	0	0.00%	227	0.35%	318	0.49%	318	0.49%	1,504	2.30%
Q2 2025	0	0.00%	241	0.37%	332	0.51%	332	0.51%	1,518	2.32%
Q3 2025	0	0.00%	241	0.37%	332	0.51%	332	0.51%	1,518	2.32%
Q4 2025	0	0.00%	241	0.37%	332	0.51%	332	0.51%	1,518	2.32%
Q1 2026	0	0.00%	117	0.18%	208	0.32%	348	0.53%	1,560	2.38%
Q2 2026	0	0.00%	45	0.07%	136	0.21%	2550	3.89%	3,762	5.74%
Q3 2026	0	0.00%	2,073	3.16%	2,283	3.49%	4697	7.17%	5,909	9.02%
Q4 2026	0	0.00%	2,073	3.16%	2,283	3.49%	4697	7.17%	5,909	9.02%
Q1 2027	0	0.00%	2,122	3.24%	2,332	3.56%	5361	8.18%	7,315	11.17%
Q2 2027	0	0.00%	1,583	2.42%	1,674	2.56%	4703	7.18%	6,657	10.16%
Q3 2027	0	0.00%	1,583	2.42%	1,674	2.56%	4703	7.18%	6,657	10.16%
Q4 2027	0	0.00%	1,583	2.42%	1,674	2.56%	4703	7.18%	6,657	10.16%
Q1 2028	225	0.34%	1,808	2.76%	1,808	2.76%	4837	7.38%	6,765	10.33%

Project	VE alone		VE + T1-3		VE + T1-4		VE + T1-5		VE + T1-7	
	#	% MU	#	% MU	#	% MU	#	% MU	#	% MU
Q2 2028	225	0.34%	276	0.42%	276	0.42%	3305	5.05%	5,233	7.99%
Q3 2028	225	0.34%	227	0.35%	227	0.35%	3256	4.97%	5,184	7.91%
Q4 2028	225	0.34%	227	0.35%	227	0.35%	3256	4.97%	5,184	7.91%
Q1 2029	152	0.23%	152	0.23%	152	0.23%	3181	4.86%	4,367	6.67%
Q2 2029	152	0.23%	152	0.23%	152	0.23%	3181	4.86%	4,367	6.67%
Q3 2029	152	0.23%	152	0.23%	152	0.23%	3181	4.86%	4,367	6.67%
Q4 2029	152	0.23%	152	0.23%	152	0.23%	3181	4.86%	4,367	6.67%
Q1 2030	152	0.23%	152	0.23%	152	0.23%	3181	4.86%	4,367	6.67%
Q2 2030	152	0.23%	152	0.23%	152	0.23%	3181	4.86%	4,367	6.67%
Q3 2030	152	0.23%	152	0.23%	152	0.23%	3181	4.86%	4,367	6.67%
Q4 2030	152	0.23%	152	0.23%	152	0.23%	3181	4.86%	4,367	6.67%
Q1 2031	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1,186	1.81%
Q2 2031	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1,186	1.81%
Q3 2031	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1,186	1.81%
Q4 2031	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1,186	1.81%

Table 7.52: A summary of numbers of grey seal disturbed by underwater noise across the Tiers between 2023 to 2031 and during UXO clearance / piling phase at VE (2028 to 2030).

Years		VE alone		VE + T1-3		VE + T1-4		VE + T1-5		VE + T1-7	
		#	% MU	#	% MU	#	% MU	#	% MU	#	% MU
2023 to 2031	Minimum	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1186	1.81%
	Average	66	0.10%	534	0.82%	580	0.88%	2325	3.55%	3703	5.65%
	Maximum	225	0.34%	2122	3.24%	2332	3.56%	5361	8.18%	7315	11.17%
2028 to 2030	Minimum	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1186	1.81%
	Average	158	0.24%	162	0.25%	162	0.25%	2939	4.49%	4310	6.58%
	Maximum	225	0.34%	276	0.42%	276	0.42%	3305	5.05%	5233	7.99%

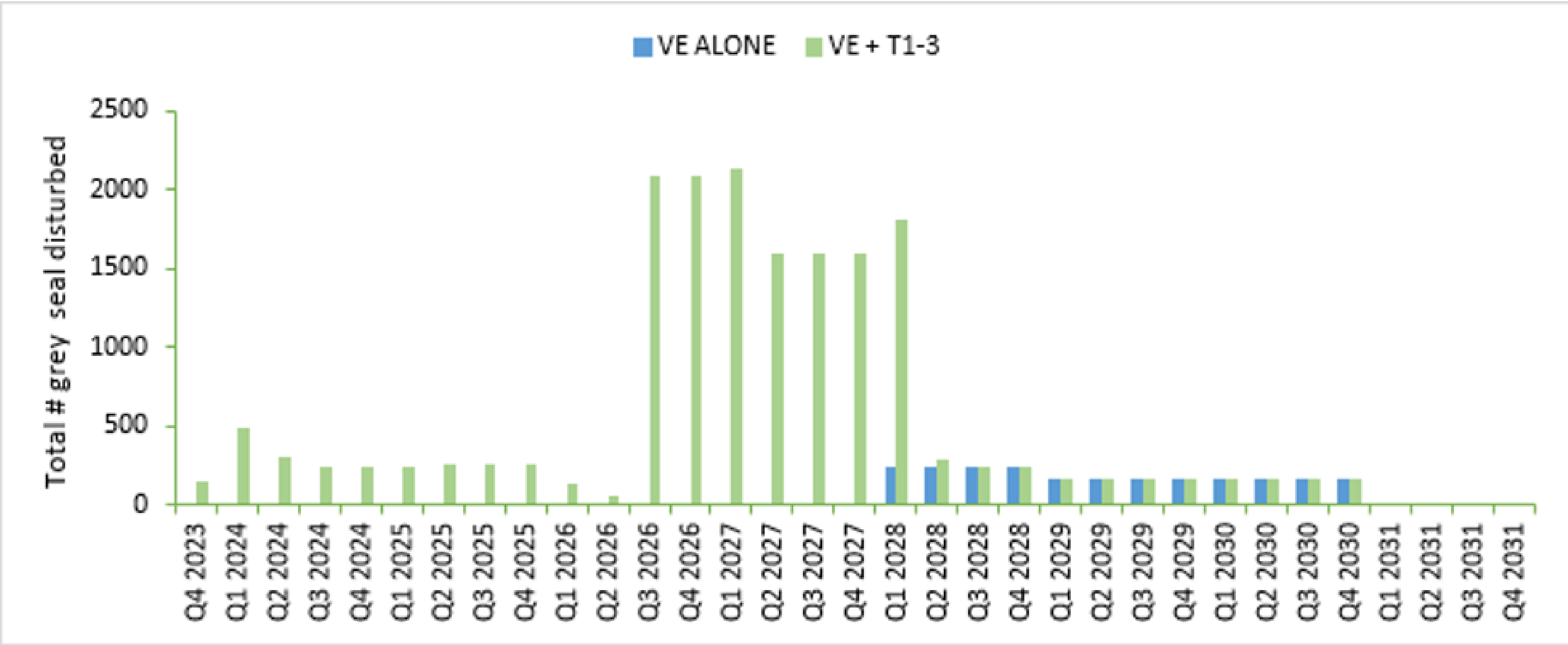


Figure 7.20: Cumulative underwater noise disturbance estimates to grey seals for VE alone and VE in addition to Tier 1-3 projects.

DISTURBANCE FROM VESSEL ACTIVITY

7.13.60 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.

7.13.61 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.

7.13.62 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 existing Marine Wildlife Watching Codes) to minimise any potential effects on marine mammals.

7.13.63 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* 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.

7.13.64 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.

7.13.65 The sensitivity of both porpoise and seal species to vessel disturbance has been assessed as medium and low.

7.13.66 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.

7.14 CLIMATE CHANGE

7.14.1 Climate change has the potential to affect the extent and distribution of marine mammal receptors. This Section assesses the following aspects:

- The effect of climate change on the local area in which the proposed development will take place; and
- The likely impact of climate change and the project in-combination on the receiving environment.

7.14.2 The information provided in this section has been drawn upon and summarised in Volume 6, Part 4, Chapter 1: Climate change. As outlined in Volume 6, Part 4, Chapter 1: Climate Change, the operational phase of VE would enable the use of renewable electricity which would result in a positive greenhouse gas impact, resulting in a significant beneficial effect.

EFFECT OF CLIMATE CHANGE ON THE LOCAL ENVIRONMENT

7.14.3 The following effects of climate change have the potential to affect harbour porpoise, harbour seal and grey seal:

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

7.14.4 A full quantitative assessment of impacts to marine mammals is presented in Volume 6, Part 4, Chapter 1: Climate Change.

7.14.5 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 (scoped in for VE see Section 7.1), white-beaked dolphin and minke whale may come under increased pressure with reduced available habitat, if their range shifts northwards. Several species are already undergoing range shifts including pilot whales in the northwest Atlantic which have shifted northward three times faster than their preferred prey species (Thorne and Nye, 2021), and stranding data in northwest UK waters indicating increases in the proportion of warmer water adapted species (short-beaked common dolphin and striped dolphin) having increased (Coombs *et al.,* 2019). Additional impacts of range shifts are that it will lead to novel interactions, increased predation risk and competition, and disease prevalence (Williamson *et al.,* 2021; Matthews *et al.,* 2020, Martin *et al.,* 2023).

7.14.6 Food-web alterations as ectothermic prey distributions or abundances shift in response and timings of copepod blooms changing may occur as a result of increasing sea surface temperature (Ramp *et al.,* 2015; Nøttestad *et al.,* 2015; Vikingsson *et al.,* 2015). Increasing sea surface temperature in the English Channel has been linked to declines in body size for several copepod species from 2.9% to 10.15% (Rice *et al.,* 2015; Corona *et al.,* 2021) and in the Pacific has led to copepod lifecycles shifting resulting in earlier peaks in abundance (Ashlock *et al.,* 2021). As a result, this could result in tropic mismatches and impact predator-prey dynamics, this could result in a change in marine mammal distributions or foraging strategy.

7.14.7 Harbour seal populations in the UK are experiencing widespread declines (SCOS, 2023) and although the main cause is not known, the prevalence of domoic acid derived from toxins from harmful algal blooms may be a contributory factor and could be exacerbated by increased sea temperatures (SCOS, 2021: Evans and Bjørge 2013). Peaks in domoic acid and paralytic shellfish toxins in fish species sampled in Scotland were consistent with phytoplankton bloom timings (Kerhsaw *et al.,* 2021) which may have contributed to declines in harbour seal populations.

7.14.8 For Baltic grey seals and harbour seals habitat suitability is anticipated to decline over time as a result of changes as a result of changes in sea surface salinity and loss of haul out sites from sea level rise and changing weather patterns (van Beest *et al.,* 2022) which could also lead to increased pup and calf mortality as there is an increase in storm surges (Prime 1985, Gazo *et al.,* 2000, Lea *et al.,* 2009). Whilst it would be possible for new haul out sites to be established, annual seal monitoring programs in the Baltic over the past 20 years have not identified the establishment of any new haul out sites (van Beest *et al.,* 2022).

7.14.9 In the UK there has been limited confirmation on the establishment of new haul out sites for either grey seal or harbour seal. However, one example of where it has occurred is of harbour seals having formed a new haul out in the Solent (Seal Management Unit 10), with three harbour seals first identified in 1994 in Chichester Harbour and then a local research project in 2009 counting 24 harbour seals at two haul-out sites (Chichester Harbour and Langstone Harbour) (Chesworth *et al.,* 2010). Additional counts in 2019 at Chichester Harbour resulted in a maximum of 43 harbour seals at any one time (Castles *et al.,* 2021) highlighting the increase over a 25-year period. Additionally, the first grey seal was identified in 2008 (Chesworth *et al.,* 2010) and in 2019 the maximum count was 19 at any one time (Castles *et al.,* 2021).

7.14.10 Ocean acidification from increased CO_2 is unlikely to directly impact marine mammals however, it has been included as a potential impact to shellfish species (Volume 6, Part 2, Chapter 6: Fish and Shellfish) however, no shellfish species have been included in the key prey species (Table 7.33).

EFFECT OF CLIMATE CHANGE AND THE PROJECT ON THE LOCAL ENVIRONMENT

7.14.11 The project is not predicted to contribute to the impacts od climate change in the local area to any significant extent.

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 mammals is provided in Volume 6, Part 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 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 6, Part 1, Chapter 3, 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 to low and the sensitivity of receptors as Low to Medium. 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 7.53Throughout 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.

7.17.2 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.

Table 7.53 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	Outline UXO MMMP	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	Outline Piling MMMP	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, TTS and disturbance from other construction activities	Negligible significance of effect for all species	No mitigation required	No significant adverse residual effects
Impact 7: Collision risk with vessels	Minor significance of effect for all species	Working in Proximity to Wildlife	No significant adverse residual effects
Impact 8: Disturbance with vessels	Minor significance of effect for harbour porpoises Negligible significance of		No significant adverse residual effects

Description of impact	Effect	Additional mitigation measures	Residual impact
	effect for grey and harbour seals		
Impact 9: Change in water quality	Negligible significance of effect for all species	No mitigation required	No significant adverse residual effects
Impact 10: Change in fish abundance/ distribution	Minor significance of effect for all species	No mitigation required	No significant adverse residual effects
Impact 11: Habitat loss	Minor significance of effect for all species	No mitigation required	No significant adverse residual effects
Impact 12: Disturbance at haul-out sites	Minor significance of effect for all species	Working in Proximity to Wildlife	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 14: Collision risk from vessels	Minor significance of effect for all species	Working in Proximity to Wildlife	No significant adverse residual effects
Impact 15: Disturbance from vessels	Minor significance of effect for harbour porpoises Negligible significance of effect for grey and harbour seals		No significant adverse residual effects
Impact 16: Change in fish abundance/ distribution	Minor significance of effect for all species	No mitigation required	No significant adverse residual effects
Impact 17: Habitat loss	Negligible significance of effect for all species	No mitigation required	No significant adverse residual effects

Description of impact	Effect	Additional mitigation measures	Residual impact
Impact 18: Disturbance at haul-out sites	Minor significance of effect for all species	Working in Proximity to Wildlife	No significant adverse residual effects
Decommissioning			
Impact 19: PTS and disturbance	Minor significance of effect for all species	Decommissioning MMMP	No significant adverse residual effects
Impact 20: Collision risk from vessels	Minor significance of effect for all species	Working in Proximity to Wildlife	No significant adverse residual effects
Impact 21: Disturbance from vessels	Minor significance of effect for harbour porpoises Negligible significance of effect for grey and harbour seals		No significant adverse residual effects
Impact 22: Change in fish abundance/distribution	Minor significance of effect for all species	No mitigation required	No significant adverse residual effects
Impact 23: Habitat loss	Minor significance of effect for all species	No mitigation required	No significant adverse residual effects
Impact 24: Disturbance at haul out sites	Negligible significance for grey and harbour seals	No mitigation required	No significant adverse residual effects
Cumulative effects			
Disturbance from underwater noise	Minor significance of effect for all species	No mitigation required[20]	No significant adverse residual effects
Disturbance from vessels	Negligible significance of effect for all species	No mitigation required. Assumed all projects will adopt vessel	No significant adverse residual effects

[20] An Outline Southern North Sea SAC Site Integrity Plan (Volume 9, Report 15) has been submitted as part of the application. Further details on the potential impact to the Southern North Sea SAC can be found within the RIAA (Volume 5, Report 4).

Description of impact	Effect	Additional mitigation measures	Residual impact
		management plans or comply with existing Marine Wildlife Watching Codes.	

7.18 REFERENCES

Aarts, G., S. Brasseur, and R. Kirkwood. 2018. Behavioural response of grey seals to pile-driving. Wageningen Marine Research report C006/18.

Andersen, S. M., Teilmann, J., Dietz, R., Schmidt, N. M. and Miller, L. A. (2011). 'Behavioural responses of harbour seals to human-induced disturbances', Aquatic conservation: Marine and Freshwater Ecosystems, 22: 113-121.

Anderwald, P., A. Brandecker, M. Coleman, C. Collins, H. Denniston, M. D. Haberlin, M. O'Donovan, R. Pinfield, F. Visser, and L. Walshe. 2013. Displacement responses of a mysticete, an odontocete, and a phocid seal to construction-related vessel traffic. Endangered Species Research.

Arons, A. 1954. Underwater explosion shock wave parameters at large distances from the charge. The Journal of the Acoustical Society of America **26**:343-346.

Ashlock, L., García-Reyes, M., Gentemann, C., Batten, S. and Sydeman, W. (2021) Temperature and patterns of occurrence and abundance of key copepod taxa in the Northeast Pacific. Frontiers in Marine Science, 8, 670795.

Barett, R. 1996. Guidelines for the safe use of explosives underwater. MTD Publication **96**:101.

Barker, J., Seymour, A., Mowat, S., & Debney, A. (2014). Thames harbour seal conservation project. Report for the UK & Europe Conservation Programme, Zoological Society of London

Beck, C. A., W. D. Bowen, and S. J. Iverson. 2003. Sex differences in the seasonal patterns of energy storage and expenditure in a phocid seal. Journal of Animal Ecology **72**:280-291.

DESNZ (2023a). Overarching NPS EN-1. EN-1 Overarching National Policy Statement for Energy (publishing.service.gov.uk) [Accessed January 2024].

DESNZ (2023b). National Policy Statement for Renewable Energy Infrastructure (EN-3) National Policy Statement for renewable energy infrastructure (EN-3) (publishing.service.gov.uk). [Accessed January 2024].

BEIS. 2020. Review of Consented Offshore Wind Farms in the Southern North Sea Harbour Porpoise SAC. The Department for Business Energy and Industrial Strategy.

Benhemma-Le Gall, A., I. Graham, N. Merchant, and P. Thompson. 2021. Broad-scale responses of harbor porpoises to pile-driving and vessel activities during offshore windfarm construction. Frontiers in Marine Science **8**.

Benhemma-Le Gall, A., P. Thompson, I. Graham, and N. Merchant. 2020. Lessons learned: harbour porpoises respond to vessel activities during offshore windfarm construction.*in* Environmental Interactions of Marine Renewables 2020, Online.

Bishop, A., Pomeroy, P. and Twiss, S. (2015). ‘Breeding male grey seals exhibit similar activity budgets across varying exposures to human activity’, Marine Ecology Progress Series, 527:247-259.

Booth, C., and F. Heinis. 2018. Updating the Interim PCoD Model: Workshop Report - New transfer functions for the effects of permanent threshold shifts on vital rates in marine mammal species. Report Code SMRUC-UOA-2018-006, submitted to the University of Aberdeen and Department for Business, Energy and Industrial Strategy (BEIS), June 2018 (unpublished).

Booth, C. G., F. Heinis, and H. J. 2019. Updating the Interim PCoD Model: Workshop Report - New transfer functions for the effects of disturbance on vital rates in marine mammal species. Report Code SMRUC-BEI-2018-011, submitted to the Department for Business, Energy and Industrial Strategy (BEIS), February 2019 (unpublished.

Brandt, M. J., A. Diederichs, K. Betke, and G. Nehls. 2011. Responses of harbour porpoises to pile driving at the Horns Rev II offshore wind farm in the Danish North Sea. Marine Ecology Progress Series **421**:205-216.

Brandt, M. J., A. Dragon, A. Diederichs, A. Schubert, V. Kosarev, G. Nehls, V. Wahl, A. Michalik, A. Braasch, C. Hinz, C. Katzer, D. Todeskino, M. Gauger, M. Laczny, and W. Piper. 2016. Effects of offshore pile driving on harbour porpoise abundance in the German Bight. Report prepared for Offshore Forum Windenergie.

Brandt, M. J., A. C. Dragon, A. Diederichs, M. A. Bellmann, V. Wahl, W. Piper, J. Nabe-Nielsen, and G. Nehls. 2018. Disturbance of harbour porpoises during construction of the first seven offshore wind farms in Germany. Marine Ecology Progress Series **596**:213-232.

Brasseur, S., G. Aarts, E. Meesters, T. van Polanen Petel, E. Dijkman, J. Cremer, and P. Reijnders. 2012. Habitat preference of harbour seals in the Dutch coastal area: analysis and estimate of efects of offshore wind farms.

Brasseur, S., A. de Groot, G. Aarts, E. Dijkman, and R. Kirkwood. 2015a. Pupping habitat of grey seals in the Dutch Wadden Sea. IMARES Wageningen UR.

Brasseur, S., R. Kirkwood, and G. Aarts. 2015b. Seal monitoring and evaluation for the Gemini offshore windfarm: construction - 2015 report. Wageningen University & Research Report C004/18.

Brasseur, S. M., and R. Kirkwood. 2015. Seal monitoring and evaluation for the Gemini offshore windpark: Pre-construction, T0-2014 report. IMARES.

Carter, M., L. Boehme, C. Duck, W. Grecian, G. Hastie, B. McConnell, D. Miller, C. Morris, S. Moss, D. Thompson, P. Thompson, and D. Russell. 2020. Habitat-based predictions of at-sea distribution for grey and harbour seals in the British Isles. Sea Mammal Research Unit, University of St Andrews, Report to BEIS, OESEA-16-76/OESEA-17-78.

Carter, M., Boehme, L., Cronin, M., Duck, C., Grecian, W., Hastie, G., Jessopp, M., Matthiopoulos, J., McConnell, B., Miller, D., Morris, C., Moss, S., Thompson, D., Thompson, P. and Russell, D. (2022). Sympatric Seals, Satellite Tracking and Protected Areas: Habitat-Based Distribution Estimates for Conservation and Management. Frontiers in Marine Science 9.

Castles, R., Woods, F., Hughes, P., Arnott, J., MacCallum, L., & Marley, S. (2021). Increasing numbers of harbour seals and grey seals in the Solent. Ecology and Evolution, 11(23), 16524-16536.

Chesworth, J. C., Leggett, V. L., & Rowsell, E. S. (2010). Solent Seal Tagging Project Summary Report (80 pp.). Wildlife Trusts' South East Marine Programme, Hampshire and Isle of Wight Wildlife Trust, Hampshire.

Corona, S., Hirst, A., Atkinson, D. and Atkinson, A. (2021) Density-dependent modulation of copepod body size and temperature–size responses in a shelf sea. Limnology and Oceanography, 66(11), 3916-3927

Cefas. 2010. Strategic review of offshore wind farm monitoring data associated with FEPA licence conditions – annex 4: underwater noise., Cefas report ME1117.

Coombs, E.J., Deaville, R., Sabin, R.C., Allan, L., O'Connell, M., Berrow, S., Smith, B., Brownlow, A., Doeschate, M.T., Penrose, R. and Williams, R. (2019) What can cetacean stranding recordstell us? A study of UK and Irish cetacean diversity over the past 100 years. Marine Mammal Science, 35(4), 1527-1555

Cox, T. M., J. Barker, J. Bramley, J. Debney, A. Debney, D. Thompson, and A.-C. Cucknell. 2020. Population trends of harbour and grey seals in the Greater Thames Estuary. Mammal Communications **6**:42-51.

Cucknell. A. Moscrop, A. Boisseau, O. and McLanaghan, R. (2020). Confirmation of the presence of harbour porpoise (Phocoena phocoena) within the tidal Thames and Thames Estuary. Mammal Communications 6: 21-28

Dahl, P. H., Jenkins, A. K., Casper, B., Kotecki, S. E., Bowman, V., Boerger, C., Dall'Osto, D. R., Babina, M. A., and Popper, A. N. (2020). "Physical effects of sound exposure from underwater explosions on Pacific sardines (Sardinops sagax)," J. Acoust. Soc. Am. 147(4), 2383–2395.

Dähne, M., A. Gilles, K. Lucke, V. Peschko, S. Adler, K. Krugel, J. Sundermeyer, and U. Siebert. 2013. Effects of pile-driving on harbour porpoises (*Phocoena phocoena*) at the first offshore wind farm in Germany. Environmental Research Letters **8**:025002.

Dähne, M., J. Tougaard, J. Carstensen, A. Rose, and J. Nabe-Nielsen. 2017. Bubble curtains attenuate noise from offshore wind farm construction and reduce temporary habitat loss for harbour porpoises. Marine Ecology Progress Series **580**:221-237.

De Jong, C. A. f., and M. A. Ainslie. 2008. Underwater radiated noise due to the piling for the Q7 Offshore Wind Park. Journal of the Acoustical Society of America **123**:2987.

DECC. (2011a). Overarching National Policy Statement for Energy (EN-1). https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/47854/1938-overarching-nps-forenergy-en1.pdf [Accessed: January 2024].

DECC. (2011b). National Policy Statement for Renewable Energy Infrastructure (EN-3). https://assets.publishing.service.gov.uk/government/uploads/system/ Page 249 of 256 uploads/attachment_data/file/37048/1940-nps-renewable-energyen3.pdf [Accessed: January 2024].

Department for Environment Food & Rural Affairs, Joint Nature Conservation Committee, Natural England, Marine Management Organisation, Department of Agriculture Environment and Rural Affairs (Northern Ireland), Department for Business Energy & Industrial Strategy, and Offshore Petroleum Regulator for Environment and Decommissioning. 2021. Policy paper overview: Marine environment: unexploded ordnance clearance joint interim position statement.

Diederichs, A., G. Nehls, and M. J. Brandt. 2010. Does sand extraction near Sylt affect harbour porpoises? Wadden Sea Ecosystem No. 26 edition. Common Wadden Sea Secretariat, Wilhelmshaven, Germany.

Diederichs, A., G. Nehls, M. Dähne, S. Adler, S. Koschinski, and U. Verfuß. 2008. Methodologies for measuring and assessing potential changes in marine mammal behaviour, abundance or distribution arising from the construction, operation and decommissioning of offshore windfarms.

Donovan, C. R., C. M. Harris, L. Milazzo, J. Harwood, L. Marshall, and R. Williams. 2017. A simulation approach to assessing environmental risk of sound exposure to marine mammals. Ecology and Evolution.

Dunlop, R. A., M. J. Noad, R. D. McCauley, L. Scott-Hayward, E. Kniest, R. Slade, D. Paton, and D. H. Cato. 2017. Determining the behavioural dose–response relationship of marine mammals to air gun noise and source proximity. Journal of Experimental Biology **220**:2878-2886.

Dyndo, M. Wiśniewska, D. M. Rojano-Doñate, L. and Madsen, P. T. (2015). Harbour porpoises react to low levels of high frequency vessel noise. Scientific Reports 5:11083.

EMODnet. (2021). EMODnet Human Activities, Vessel Density Map, funded by the European Commission. Available from: https://ows.emodnet-humanactivities.eu/geonetwork/srv/api/records/0f2f3ff1-30ef-49e1-96e7-8ca78d58a07c. Accessed: 24 October 2023.

Erbe, C., Marley, S. A., Schoeman, R, P., Smith, J. N., Trigg, L, E. and Embling, C. B. (2019). 'The effects of ship noise on marine mammals – a review, Frontiers in Marine Science, 6: 1-21.

Evans, P. G. H. 1990. Marine Mammals in the English Channel in relation to proposed dredging scheme. Sea Watch Foundation, Oxford.

Finneran, J. J. 2015. Noise-induced hearing loss in marine mammals: A review of temporary threshold shift studies from 1996 to 2015. The Journal of the Acoustical Society of America **138**:1702-1726.

Finneran, J. J., D. A. Carder, C. E. Schlundt, and R. L. Dear. 2010. Growth and recovery of temporary threshold shift at 3 kHz in bottlenose dolphins: Experimental data and mathematical models. The Journal of the Acoustical Society of America **127**:3256-3266.

Finneran, J. J., D. A. Carder, C. E. Schlundt, and S. H. Ridgway. 2005. Temporary threshold shift in bottlenose dolphins (Tursiops truncatus) exposed to mid-frequency tones. The Journal of the Acoustical Society of America **118**:2696-2705.

Gazo, M. Aparicio, F. Cedenilla, M. A. Layna, J. F. and González, L. M. (2000). Pup survival in the Mediterranean monk seal (Monachus monachus) colony at Cabo Blanco Peninsula (Western Sahara-Mauritania). Marine Mammal Science 16:158-168.

Gilles, A, Authier, M, Ramirez-Martinez, NC, Araújo, H, Blanchard, A, Carlström, J, Eira, C, Dorémus, G, FernándezMaldonado, C, Geelhoed, SCV, Kyhn, L, Laran, S, Nachtsheim, D, Panigada, S, Pigeault, R, Sequeira, M, Sveegaard, S, Taylor, NL, Owen, K, Saavedra, C, Vázquez-Bonales, JA, Unger, B, Hammond, PS (2023). Estimates of cetacean abundance in European Atlantic waters in summer 2022 from the SCANS-IV aerial and shipboard surveys. Final report published 29 September 2023. 64 pp. https://tinyurl.com/3ynt6swa

Goley, G. S., W. J. Song, and J. H. Kim. 2011. Kurtosis corrected sound pressure level as a noise metric for risk assessment of occupational noises. The Journal of the Acoustical Society of America **129**:1475-1481.

Graham, I. M., A. Farcas, N. D. Merchant, and P. Thompson. 2017a. Beatrice Offshore Wind Farm: An interim estimate of the probability of porpoise displacement at different unweighted single-pulse sound exposure levels. Prepared by the University of Aberdeen for Beatrice Offshore Windfarm Ltd.

Graham, I.M. Pirotta, E. Merchant, N.D. Farcas, A. Barton, T.R. Cheney, B. Hastie, G.D. and Thompson, P.M. (2017b). Responses of bottlenose dolphins and harbor porpoises to impact and vibration piling noise during harbor construction. Ecosphere 8.

Graham, I. M., Cheney, B., Barton, T. R., Thompson, P. M., Farcas, A. and Merchant, N. D. (2018). Porpoise displacement at different noise levels during construction of an offshore windfarm. Oral presentation at the Symposium on Impacts of Impulsive Noise on Porpoises and Seals, Amsterdam, June 2018.

Graham, I. M., N. D. Merchant, A. Farcas, T. R. C. Barton, B. Cheney, S. Bono, and P. M. Thompson. 2019. Harbour porpoise responses to pile-driving diminish over time. Royal Society Open Science **6**:190335.

Hamernik, R. P., W. Qiu, and B. Davis. 2007. Hearing loss from interrupted, intermittent, and time varying non-Gaussian noise exposure: The applicability of the equal energy hypothesis. The Journal of the Acoustical Society of America **122**:2245-2254.

Hammond, P., C. Lacey, A. Gilles, S. Viquerat, P. Börjesson, H. Herr, K. Macleod, V. Ridoux, M. Santos, M. Scheidat, J. Teilmann, J. Vingada, and N. Øie. 2021. Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys - revised June 2021.

Hanke, W., and G. Dehnhardt. (2013). Sensory biology of aquatic mammals. Journal of Comparative Physiology 199:417.

Hanke, W., S. Wieskotten, C. Marshall, and G. Dehnhardt. (2013). Hydrodynamic perception in true seals (Phocidae) and eared seals (Otariidae). Journal of Comparative Physiology A-Neuroethology Sensory Neural and Behavioral Physiology 199:421-440

Hanke, W., M. Witte, L. Miersch, M. Brede, J. Oeffner, M. Michael, F. Hanke, A. Leder, and G. Dehnhardt. (2010). Harbor seal vibrissa morphology suppresses vortex-induced vibrations. Journal of Experimental Biology 213:2665-2672.

Hastie, G., N. D. Merchant, T. Götz, D. J. Russell, P. Thompson, and V. M. Janik. 2019. Effects of impulsive noise on marine mammals: investigating range-dependent risk. Ecological Applications **29**:e01906.

Hastie, G. D., P. Lepper, J. C. McKnight, R. Milne, D. J. F. Russell, and D. Thompson. 2021. Acoustic risk balancing by marine mammals: anthropogenic noise can influence the foraging decisions by seals. Journal of Applied Ecology **n/a**.

Heinänen, S. and Skov, H. (2015). The identification of discrete and persistent areas of relatively high harbour porpoise density in the wider UK marine area. JNCC Report No. 544, JNCC, Peterborough.

Henderson, D., M. Subramaniam, M. A. Gratton, and S. S. Saunders. 1991. Impact noise: the importance of level, duration, and repetition rate. The Journal of the Acoustical Society of America **89**:1350-1357.

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.

HiDef Aerial Surveying Ltd. 2021. Digital video aerial surveys of seabirds and marine mammals at Five Estuaries: Two-year report March 2019 to February 2021.

Hin, V., J. Harwood, and A. M. de Roos. 2019. Bio-energetic modeling of medium-sized cetaceans shows high sensitivity to disturbance in seasons of low resource supply. Ecological Applications:e01903.

Hoekendijk, J., J. Spitz, A. J. Read, M. F. Leopold, and M. C. Fontaine. 2018. Resilience of harbor porpoises to anthropogenic disturbance: Must they really feed continuously? Marine Mammal Science **34**:258-264.

HM Government. (2011). UK Marine Policy Statement. HM Government, Northern Ireland Executive, Scottish Government, Welsh Asembly Government. London: The Stationary Office (March 2021).

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69322/pb3654-marine-policy-statement-110316.pdf [Accessed: January 2024].

IAMMWG. (2023). 'Review of Management Unit boundaries for cetaceans in UK waters (2023)', JNCC Report 734, JNCC, Peterborough, ISSN 0963-8091.

JNCC. (2019a). European Community Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC) Fourth Report by the United Kingdom under Article 17 on the implementation of the Directive from January 2013 to December 2018 Conservation status assessment for the species: S1351 - Harbour porpoise (Phocoena phocoena) UNITED KINGDOM

.

JNCC. (2019b). European Community Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC) Fourth Report by the United Kingdom under Article 17 on the implementation of the Directive from January 2013 to December 2018 Conservation status assessment for the species: S1365 - Common seal (Phoca vitulina) UNITED KINGDOM.

JNCC. (2019c). European Community Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC) Fourth Report by the United Kingdom under Article 17 on the implementation of the Directive from January 2013 to December 2018 Conservation status assessment for the species: S1364 - Grey seal (Halichoerus grypus) UNITED KINGDOM.

JNCC. 2020. Guidance for assessing the significance of noise disturbance against Conservation Objectives of harbour porpoise SACs (England, Wales & Northern Ireland). Report No. 654, JNCC, Peterborough.

JNCC. 2010. JNCC guidelines for minimising the risk of injury to marine mammals using explosives. August 2010.

JNCC. 2017. JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys. August 2017.

Jones, E., G. Hastie, S. Smout, J. Onoufriou, N. D. Merchant, K. Brookes, and D. thompson. 2017. Seals and shipping: quantifying population risk and individual exposure to vessel noise. *Journal of Applied Ecology* 54:1930-1940.

Kastak, D., M. Holt, C. Kastak, B. Southall, J. Mulsow, and R. Schusterman. 2005. A voluntary mechanism of protection from airborne noise in a harbor seal. Page 148 *in* 16th Biennial Conference on the Biology of Marine Mammals. San Diego CA.

Kastelein, R. A., R. Gransier, and L. Hoek. 2013a. Comparative temporary threshold shifts in a harbor porpoise and harbor seal, and severe shift in a seal (L). Journal of the Acoustical Society of America **134**:13-16.

Kastelein, R. A., R. Gransier, L. Hoek, and C. A. de Jong. 2012a. The hearing threshold of a harbor porpoise (Phocoena phocoena) for impulsive sounds (L). Journal of the Acoustical Society of America **132**:607-610.

Kastelein, R. A., R. Gransier, L. Hoek, A. Macleod, and J. M. Terhune. 2012b. Hearing threshold shifts and recovery in harbor seals (*Phoca vitulina*) after octave-band noise exposure at 4 kHz. Journal of the Acoustical Society of America **132**:2745-2761.

Kastelein, R. A., R. Gransier, L. Hoek, and J. Olthuis. 2012c. Temporary threshold shifts and recovery in a harbor porpoise (*Phocoena phocoena*) after octave-band noise at 4kHz. Journal of the Acoustical Society of America **132**:3525-3537.

Kastelein, R. A., R. Gransier, L. Hoek, and M. Rambags. 2013b. Hearing frequency thresholds of a harbor porpoise (*Phocoena phocoena*) temporarily affected by a continuous 1.5 kHz tone. Journal of the Acoustical Society of America **134**:2286-2292.

Kastelein, R. A., R. Gransier, J. Schop, and L. Hoek. 2015. Effects of exposure to intermittent and continuous 6–7 kHz sonar sweeps on harbor porpoise (Phocoena phocoena) hearing. The Journal of the Acoustical Society of America **137**:1623-1633.

Kastelein, R. A., L. Helder-Hoek, J. Covi, and R. Gransier. 2016. Pile driving playback sounds and temporary threshold shift in harbor porpoises (Phocoena phocoena): Effect of exposure duration. The Journal of the Acoustical Society of America **139**:2842-2851.

Kastelein, R. A., L. Helder-Hoek, S. Van de Voorde, A. M. von Benda-Beckmann, F.-P. A. Lam, E. Jansen, C. A. de Jong, and M. A. Ainslie. 2017. Temporary hearing threshold shift in a harbor porpoise (Phocoena phocoena) after exposure to multiple airgun sounds. The Journal of the Acoustical Society of America **142**:2430-2442.

Kastelein, R. A., L. Hoek, R. Gransier, M. Rambags, and N. Claeys. 2014. Effect of level, duration, and inter-pulse interval of 1-2 kHz sonar signal exposures on harbor porpoise hearing. The Journal of the Acoustical Society of America **136**:412-422.

Laist, D. W. Knowlton, A. R. Mead, J. G. Collet, A. S. and Podesta, M. (2001). Collisions between ships and whales. Marine Mammal Science 17:35-75
.
Lea, M.A. Johnson, D. Ream, R. Sterling, J. Melin, S. and Gelatt, T. (2009). Extreme weather events influence dispersal of naive northern fur seals. Biology Letters 5:252-257.

Lindeboom, H. J., H. J. Kouwenhoven, M. J. N. Bergman, S. Bouma, S. Brasseur, R. Daan, R. C. Fijn, D. de Haan, S. Dirksen, R. van Hal, R. Hille Ris Lambers, R. ter Hofstede, K. L. Krijgsveld, M. Leopold, and M. Scheidat. 2011. Short-term ecological effects of an offshore wind farm in the Dutch coastal zone; a compilation. Environmental Research Letters **6**:1-13.

Lusseau, D. (2003). Male and female bottlenose dolphins Tursiops spp. have different strategies to avoid interactions with tour boats in Doubtful Sound, New Zealand. Marine Ecology Progress Series 257:267-274.

Lusseau, D. (2006). The short-term behavioral reactions of bottlenose dolphins to interactions with boats in Doubtful Sound, New Zealand. Marine Mammal Science 22:802-818.

Madsen, P. T., M. Wahlberg, J. Tougaard, K. Lucke, and P. Tyack. 2006. Wind turbine underwater noise and marine mammals: implications of current knowledge and data needs. Marine Ecology Progress Series **309**:279-295.

Martin, S. B., K. Lucke, and D. R. Barclay. 2020. Techniques for distinguishing between impulsive and non-impulsive sound in the context of regulating sound exposure for marine mammals. J Acoust Soc Am **147**:2159.

Martin, E., Banga, R. and Taylor, N. L. (2023). Climate change impacts on marine mammals around the UK and Ireland. MCCIP Science Review 2023, 22pp.

Marubini, F. Gimona, A. Evans, P. G. Wright, P. J. and Pierce, G. J. (2009). Habitat preferences and interannual variability in occurrence of the harbour porpoise Phocoena phocoena off northwest Scotland. Marine Ecology Progress Series 381:297-310.

Matthews, C.J., Breed, G.A., LeBlanc, B. and Ferguson, S.H. (2020) Killer whale presence drives bowhead whale selection for sea ice in Arctic seascapes of fear. Proceedings of the National Academy of Sciences, 117(12), 6590-6598.

McQueen, A. D., B. C. Suedel, C. de Jong, and F. Thomsen. 2020. Ecological risk assessment of underwater sounds from dredging operations. Integrated environmental assessment and management **16**:481-493.

McGarry, T., Boisseau, O., Stephenson, S. and Compton, R. (2017). Understanding the Effectiveness of Acoustic Deterrent Devices (ADDs) on Minke Whale (Balaenoptera acutorostrata), a Low Frequency Cetacean. Report for the Offshore Renewables

Joint Industry Programme (ORJIP) Project 4, Phase 2. Prepared on behalf of the Carbon Trust.

MMO. 2015. Modelled Mapping of Continuous Underwater Noise Generated by Activities
.

MMO. 2014. Review of Post-Consent Offshore Wind Farm Monitoring Data Associated with Marine Licence Conditions. A report produced for the Marine Management Organisation, pp 194. MMO Project No: 1031. ISBN: 978-1-909452-24-4.

Mooney, T. A., P. E. Nachtigall, M. Breese, S. Vlachos, and W. W. Au. 2009. Predicting temporary threshold shifts in a bottlenose dolphin (Tursiops truncatus): The effects of noise level and duration. The Journal of the Acoustical Society of America **125**:1816-1826.

Nabe-Nielsen, J., F. van Beest, V. Grimm, R. Sibly, J. Teilmann, and P. M. Thompson. 2018. Predicting the impacts of anthropogenic disturbances on marine populations. Conservation Letters **e12563**.

Nabe-Nielsen, J., R. M. Sibly, J. Tougaard, J. Teilmann, and S. Sveegaard. (2014). Effects of noise and by-catch on a Danish harbour porpoise population. Ecological Modelling 272:242-251.

National Academies of Sciences Engineering and Medicine. 2016. Approaches to Understanding the Cumulative Effects of Stressors on Marine Mammals. Washington, DC: The National Academies Press.

Natural England. 2022. Offshore Wind Marine Environmental Assessments: Best Practice Advice for Evidence and Data Standards. Phase III: Expectations for data analysis and presentation at examination for offshore wind applications.

Nedwell, J., J. Langworthy, and D. Howell. 2003. Assessment of sub-sea acoustic noise and vibration from offshore wind turbines and its impact on marine wildlife; initial measurements of underwater noise during construction of offshore windfarms, and comparison with background noise. Subacoustech Report ref: 544R0423, published by COWRIE.

Nielsen. K.A. Robbins, J.R. and Embling, C.B. (2021). Spatio-temporal patterns of harbour porpoise density: citizen science and conservation in UK seas. Marine Ecology Progress Series 675: pp. 165-180.

NMFS. 2016. Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts. Page 189. U.S. Department of Commerce, Silver Spring.

NMFS. 2018. Revisions to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts. Page 167. U.S. Department of Commerce, NOAA, Silver Spring.

Nowacek, S. M., Wells, R. S. and Solow, A. R. (2001). Short-term effects of boat traffic on bottlenose dolphins, Tursiops truncatus, in Sarasota Bay, Florida. Marine Mammal Science 17:673-688.

Nowacek, S. M., Wells, R. S. and Solow, and A. R. (2001). Short-term effects of boat traffic on bottlenose dolphins, Tursiops truncatus, in Sarasota Bay, Florida. Marine Mammal Science, 17, pp.673-688.

OSPAR. 2009. Overview of the impacts of anthropogenic underwater sound in the marine environment. Report **441**:2009.

Otani, S., Y. Naito, A. Kato, and A. Kawamura. 2000. Diving behavior and swimming speed of a free-ranging harbor porpoise, *Phocoena phocoena*. Marine Mammal Science **16**:811-814.

Paxton, C., L. Scott-Hayward, M. Mackenzie, E. Rexstad, and L. Thomas. 2016. Revised Phase III Data Analysis of Joint Cetacean Protocol Data Resources.

Pierce, G. J., Santos, M. B. and Cervino, S. (2007). Assessing sources of variation underlying estimates of cetacean diet composition: a simulation study on analysis of harbour porpoise diet in Scottish (UK) waters. *Journal of the Marine Biological Association of the United Kingdom*, 87, pp. 213-221.

Pierpoint, C. (2008). Harbour porpoise (Phocoena phocoena) foraging strategy at a high energy, near-shore site in south-west Wales, UK. Journal of the Marine Biological Association of the UK 88:1167-1173.

Pirotta, E., B. E. Laesser, A. Hardaker, N. Riddoch, M. Marcoux, and D. Lusseau. 2013. Dredging displaces bottlenose dolphins from an urbanised foraging patch. Marine Pollution Bulletin **74**:396-402.

Prime, J. (1985). The current status of the grey seal Halichoerus grypus in Cornwall, England. Biological Conservation 33:81-87.

Ramp, C., Delarue, J., Palsbøll, P.J., Sears, R. and Hammond, P.S. (2015) Adapting to a warmer ocean – seasonal shift of baleen whale movements over three decades. PLoS One, 10(3), e0121374.

Robinson, S. P., L. Wang, S.-H. Cheong, P. A. Lepper, F. Marubini, and J. P. Hartley. 2020. Underwater acoustic characterisation of unexploded ordnance disposal using deflagration. Marine Pollution Bulletin **160**:111646.

Rojano-Doñate, L., B. I. McDonald, D. M. Wisniewska, M. Johnson, J. Teilmann, M. Wahlberg, J. Højer-Kristensen, and P. T. Madsen. 2018. High field metabolic rates of wild harbour porpoises. Journal of Experimental Biology **221**:jeb185827.

Russell, D., and G. Hastie. 2017. Associating predictions of change in distribution with predicted received levels during piling. Report produced for SMRU Consulting.

Russell, D. J., S. M. Brasseur, D. Thompson, G. D. Hastie, V. M. Janik, G. Aarts, B. T. McClintock, J. Matthiopoulos, S. E. Moss, and B. McConnell. 2014. Marine mammals trace anthropogenic structures at sea. Current Biology **24**:R638-R639.

Russell, D. J., G. D. Hastie, D. Thompson, V. M. Janik, P. S. Hammond, L. A. Scott-Hayward, J. Matthiopoulos, E. L. Jones, and B. J. McConnell. 2016a. Avoidance of wind farms by harbour seals is limited to pile driving activities. Journal of Applied Ecology **53**:1642-1652.

Russell, D. J. F., G. D. Hastie, D. Thompson, V. M. Janik, P. S. Hammond, L. A. S. Scott-Hayward, J. Matthiopoulos, E. L. Jones, and B. J. McConnell. 2016b. Avoidance of wind farms by harbour seals is limited to pile driving activities. Pages 1642-1652 *Journal of Applied Ecology*.

Russell, D. J. F., B. McConnell, D. Thompson, C. Duck, C. Morris, J. Harwood, and J. Matthiopoulos. 2013. Uncovering the links between foraging and breeding regions in a highly mobile mammal. Journal of Applied Ecology **50**:499-509.

Salomons, E. M., B. Binnerts, K. Betke, and A. M. v. Benda-Beckmann. 2021. Noise of underwater explosions in the North Sea. A comparison of experimental data and model predictions. The Journal of the Acoustical Society of America **149**:1878-1888.

SCANS. (1995). Distribution and abundance of harbour porpoise and other small cetaceans in the North Sea and adjacent waters. Final report under LIFE Nature project LIFE 92-2/UK/027.

SCANS-II. (2008). Small Cetaceans in the European Atlantic and North Sea (SCANS-II). Final Report. University of St Andrews, UK. http://biology.st-andrews.ac.uk/scans2/.

Scheidat, M., J. Tougaard, S. Brasseur, J. Carstensen, T. van Polanen Petel, J. Teilmann, and P. Reijnders. 2011. Harbour porpoises (*Phocoena phocoena*) and wind farms: a case study in the Dutch North Sea. Environmental Research Letters **6**:1-10.

SCOS. 2021. Scientific Advice on Matters Related to the Management of Seal Populations: 2020.

SCOS. (2022). Scientific Advice on Matters Related to the Management of Seal Populations: 2021

SCOS. (2023). ‘Scientific Advice on Matters Related to the Management of Seal Populations: 2022.’

Sinclair, R., S. Kazer, M. Ryder, P. New, and U. Verfuss. 2021. Review and recommendations on assessment of noise disturbance for marine mammals. NRW Evidence Report No. 529.

SOWFL. 2023. UXO Clerance Close Out Report as required under Marine Licence L/2021/00225/2. Document reference: 004567733.

Southall, B. 2021. Evolutions in Marine Mammal Noise Exposure Criteria. Acoustics Today **17**.

Southall, B., J. J. Finneran, C. Reichmuth, P. E. Nachtigall, D. R. Ketten, A. E. Bowles, W. T. Ellison, D. Nowacek, and P. Tyack. 2019. Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects. Aquatic Mammals **45**:125-232.

Southall, B. L., J. Berkson, D. Bowen, R. Brake, J. Eckman, J. Field, R. Gisiner, S. Gregerson, W. Lang, J. Lewandoski, J. Wilson, and R. Winokur. 2009. Addressing the Effects of Human-Generated Sound on Marine Life: An Integrated Research Plan for U.S. federal agencies.

Southall, B. L., A. E. Bowles, W. T. Ellison, J. J. Finneran, R. L. Gentry, C. R. J. Greene, D. Kastak, D. R. Ketten, J. H. Miller, P. E. Nachtigall, W. J. Richardson, J. A. Thomas, and P. L. Tyack. 2007. Marine mammal noise exposure criteria: initial scientific recommendations. Aquatic Mammals **33**:411-414.

Southall, B. L., D. P. Nowacek, A. E. Bowles, V. Senigaglia, L. Bejder, and P. L. Tyack. 2021. Marine Mammal Noise Exposure Criteria: Assessing the severity of marine mammal behavioral responses to human noise. Aquatic Mammals **47**:421-464.

Sparling, C. E., J. R. Speakman, and M. A. Fedak. 2006. Seasonal variation in the metabolic rate and body composition of female grey seals: fat conservation prior to high-cost reproduction in a capital breeder? Journal of Comparative Physiology B **176**:505-512.

Stöber, U., and F. Thomsen. 2021. How could operational underwater sound from future offshore wind turbines impact marine life? The Journal of the Acoustical Society of America **149**:1791-1795.

Teilmann, J., J. Carstensen, R. Dietz, S. M. C. Edrén, and S. M. Andersen. 2006a. Final report on aerial monitoring of seals near Nysted Offshore Wind Farm.

Teilmann, J., J. Tougaard, and J. Carstensen. 2006b. Summary on harbour porpoise monitoring 1999-2006 around Nysted and Horns Rev Offshore Wind Farms.

Thompson, F., S. R. McCully, D. Wood, F. Pace, and P. White. 2009. A generic investigation into noise profiles of marine dredging in relation to the acoustic sensitivity of the marine fauna in UK waters with particular emphasis on aggregate dredging: PHASE 1 Scoping and review of key issues., MALSF.

Thomsen, F., K. Lüdemann, R. Kafemann, and W. Piper. 2006. Effects of offshore wind farm noise on marine mammals and fish. Biola, Hamburg, Germany on behalf of COWRIE Ltd **62**.

Thorne, L.H. and Nye, J.A. (2021) Trait-mediated shifts and climate velocity decouple an endothermic marine predator and its ectothermic prey. Scientific Reports, 11(1), 1-14.

Todd, N. R. E., M. Cronin, C. Luck, A. Bennison, M. Jessopp, and A. S. Kavanagh. 2020. Using passive acoustic monitoring to investigate the occurrence of cetaceans in a protected marine area in northwest Ireland. Estuarine, Coastal and Shelf Science **232**:106509.

Todd, V. L., I. B. Todd, J. C. Gardiner, E. C. Morrin, N. A. MacPherson, N. A. DiMarzio, and F. Thomsen. 2015. A review of impacts of marine dredging activities on marine mammals. ICES Journal of Marine Science: Journal du Conseil **72**:328-340.

Tougaard, J., L. Hermannsen, and P. T. Madsen. 2020. How loud is the underwater noise from operating offshore wind turbines? J Acoust Soc Am **148**:2885.

Tyack, P. L., and L. Thomas. 2019. Using dose–response functions to improve calculations of the impact of anthropogenic noise. Aquatic Conservation: Marine and Freshwater Ecosystems **29**:242-253.

van Beest, F. M., J. Nabe-Nielsen, J. Carstensen, J. Teilmann, and J. Tougaard. 2015. Disturbance Effects on the Harbour Porpoise Population in the North Sea (DEPONS): Status report on model development.

van Beest, F. M., J. Teilmann, L. Hermannsen, A. Galatius, L. Mikkelsen, S. Sveegaard, J. D. Balle, R. Dietz, and J. Nabe-Nielsen. 2018. Fine-scale movement responses of free-ranging harbour porpoises to capture, tagging and short-term noise pulses from a single airgun. Royal Society Open Science **5**:170110.

Verboom, W. 2014. Preliminary information on dredging and harbour porpoises. JunoBioacoustics.

Vincent, C., M. Huon, F. Caurant, W. Dabin, A. Deniau, S. Dixneuf, L. Dupuis, J.-F. Elder, M.-H. Fremau, and S. Hassani. 2017. Grey and harbour seals in France: Distribution at sea, connectivity and trends in abundance at haulout sites. Deep Sea Research Part II: Topical Studies in Oceanography **141**:294-305.

von Benda-Beckmann, A. M., G. Aarts, H. Ö. Sertlek, K. Lucke, W. C. Verboom, R. A. Kastelein, D. R. Ketten, R. van Bemmelen, F.-P. A. Lam, and R. J. Kirkwood. 2015. Assessing the impact of underwater clearance of unexploded ordnance on harbour porpoises (*Phocoena phocoena*) in the southern North Sea. Aquatic Mammals **41**:503.

Waggitt, J. J., P. G. H. Evans, J. Andrade, A. N. Banks, O. Boisseau, M. Bolton, G. Bradbury, T. Brereton, C. J. Camphuysen, J. Durinck, T. Felce, R. C. Fijn, I. Garcia-Baron, S. Garthe, S. C. V. Geelhoed, A. Gilles, M. Goodall, J. Haelters, S. Hamilton, L. Hartny-Mills, N. Hodgins, K. James, M. Jessopp, A. S. Kavanagh, M. Leopold, K. Lohrengel, M. Louzao, N. Markones, J. Martinez-Cediera, O. O'Cadhla, S. L. Perry, G. J. Pierce, V. Ridoux, K. P. Robinson, M. B. Santos, C. Saavedra, H. Skov, E. W. M. Stienen, S. Sveegaard, P. Thompson, N. Vanermen, D. Wall, A. Webb, J. Wilson, S. Wanless, and J. G. Hiddink. (2020). Distribution maps of cetacean and seabird populations in the North-East Atlantic. Journal of Applied Ecology 57:253-269.

Wahlberg, J. Højer-Kristensen, and P. T. Madsen. 2018. High field metabolic rates.

Ward, W. D. 1997. Effects of High-Intensity Sound. Pages 1497-1507 Encyclopedia of Acoustics.

Whyte, K. F., D. J. F. Russell, C. E. Sparling, B. Binnerts, and G. D. Hastie. 2020. Estimating the effects of pile driving sounds on seals: Pitfalls and possibilities. J Acoust Soc Am **147**:3948.

Williamson, M.J., ten Doeschate, M.T., Deaville, R., Brownlow, A.C. and Taylor, N.L. (2021). Cetaceans as sentinels for informing climate change policy in UK waters. Marine Policy, 131, 104634.

Wisniewska, D. M., M. Johnson, J. Teilmann, L. Rojano-Doñate, J. Shearer, S. Sveegaard, L. A. Miller, U. Siebert, and P. T. Madsen. 2016. Ultra-high foraging rates of harbor porpoises make them vulnerable to anthropogenic disturbance. Current Biology **26**:1441-1446.

Wisniewska, D. M. Johnson, M. Teilmann, J. Siebert, U. Galatius, A. Dietz, R. and Madsen, P. T. (2018). High rates of vessel noise disrupt foraging in wild harbour porpoises (Phocoena phocoena). Proceedings of the Royal Society B: Biological Sciences 285:20172314.

PHONE	0333 880 5306
EMAIL	fiveestuaries@rwe.com
WEBSITE	www.fiveestuaries.co.uk
ADDRESS	Five Estuaries Offshore Wind Farm Ltd Windmill Hill Business Park Whitehill Way, Swindon, SN5 6PB
COMPANY NO	Registered in England and Wales company number 12292474