NORTH FALLS

Offshore Wind Farm

ENVIRONMENTAL STATEMENT

Chapter 12 Marine Mammals

Document Reference:	3.1.14
Volume:	3.1
APFP Regulation:	5(2)(a)
Date:	July 2024
Revision:	0

Project Reference: EN010119

Project	North Falls Offshore Wind Farm
Document Title	Environmental Statement Chapter 12 Marine Mammals
Document Reference	3.1.14
APFP Regulation	5(2)(a)
Supplier	Royal HaskoningDHV
Supplier Reference No	PB9244-RHD-PE-OF-RP-OF-0054

Revision	Date	Status/Reason for Issue	Originator	Checked	Approved
0	July 2024	Submission	RHDHV	NFOW	NFOW

Contents

Tables

Plates

Figures (Volume 3.2)

Appendices (Volume 3.3)

Appendix 12.1 Marine Mammal Consultation

Appendix 12.2 Marine Mammal Baseline Information

Appendix 12.3 Underwater Noise Modelling Report

Appendix 12.4 Underwater Noise Technical Assessment

Appendix 12.5 Unexploded Ordnance Clearance Information and Assessment Screening

Appendix 12.6 Marine Mammal Cumulative Effect Assessment Screening

Glossary of Acronyms

μPa	Pascal
ADD	Acoustic Deterrent Device
AIS	Automatic Identification System
ASCOBANS	Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas
BEIS	Department for Business, Energy and Industrial Strategy
BSI	British Standards Institution
c.	Circa
CEA	Cumulative Effect Assessment
Cefas	Centre for the Environment, Fisheries and Aquaculture Science
CGNS	Celtic and Greater North Seas
CI	Confidence Interval
CIEEM	Chartered Institute of Ecology and Environmental Management
CL	Confidence Limit
CPOD	Cetacean Porpoise Detector
CSIP	Cetacean Strandings Investigation Programme
CTV	Crew Transfer Vessels
CV	Coefficient of Variation
DAERA	Department of Agriculture, Environment and Rural Affairs
dB	Decibels
DCO	Development Consent Order
DECC	Department of Energy and Climate Change
Defra	Department for Environment, Food and Rural Affairs
DEP	Dudgeon Extension Project
DEPONS	Disturbance Effects of Noise on the Harbour Porpoise Population in the North Sea
DESNZ	Department for Energy Security and Net Zero
DOWL	Dudgeon Offshore Windfarm Limited
EDR	Effective Deterrence Range
EEA	European Economic Area
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EMF	Electromagnetic Fields
EMODnet	European Marine Observation and Data Network
EPP	Evidence Plan Process
EPS	European Protected Species
ES	Environmental Statement
ETG	Expert Topic Group
EU	European Union
EUNIS	European Nature Information System
FCS	Favourable Conservation Status
GBS	Gravity Based Systems
HiDef	HiDef Aerial Surveying Limited
HRA	Habitats Regulations Assessment
IAMMWG	Inter-Agency Marine Mammal Working Group

JCP	Joint Cetacean Protocol
JNCC	Joint Nature Conservation Committee
kHz	Kilo Hertz
L_{peak}	Peak Sound Pressure
ML	Marine Licence
MMMP	Marine Mammal Mitigation Protocol
MMO	Marine Management Organisation
MPS	Marine Policy Statements
MSR	Marine Strategy Regulations
MU	Management Units
NE	North-east
nm	Nautical Mile
NPS	National Policy Statements
NRW	Natural Resources Wales
NS	North Sea
NSIP	Nationally Significant Infrastructure Project
O&M	Operation and Maintenance
OSP	Offshore Substation Platform
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
OWF	Offshore Wind Farm
PEIR	Preliminary Environmental Information Report
PEMP	Project Environmental Management Plan
PLONOR	Pose Little or No Risk to the Environment
PTS	Permanent Threshold Shift
RIAA	Report to Inform Appropriate Assessment
rms	Root – Mean - Spare
RoC	Review of Consents
RWE	Renewables UK Swindon Limited
SAC	Special Area of Conservation
SBP	Sub-Bottom Profilers
SCANS	Small Cetaceans in the European Atlantic and North Sea
SCOS	Special Committee on Seals
SD	Standard Deviation
SE	South-east
SEL	Sound Exposure Level
SEL_{cum}	Cumulative Sound Exposure Level
SEL_{ss}	Sound Exposure Level (single strike)
SEP	Sheringham Shoal Extension Project
SIP	Site Integrity Plan
SSER	Renewables Offshore Windfarm Holdings Limited
SMASS	Scottish Marine Animal Stranding Scheme
SMRU Ltd	Sea Mammal Research Unit Ltd
SNCB	Statutory Nature Conservation Body
SoS	Secretary of State

SOV	Service Operation Vessels
SPL	Sound Pressure Level
SSC	Suspended Sediment Concentrations
TSHD	Trailing Suction Hopper Dredgers
TTS	Temporary Threshold Shift
USBL	Ultra-Short Base Line
UXO	Unexploded Ordnance
WTG	Wind Turbine Generators
WWT	The Wildfowl and Wetlands Trust
ZSL	Zoological Society London

Glossary of Terminology

Array area	The offshore wind farm area, within which the wind turbine generators, array cables, platform interconnector cable, offshore substation platform(s) and/or offshore converter platform will be located.
Array cables	Cables which link the wind turbine generators with each other, the offshore substation platform(s) and/or the offshore converter platform.
Horizontal directional drill	Trenchless technique to bring the offshore cables ashore at the landfall. The technique will also be used for installation of the onshore export cables at sensitive areas of the onshore cable route.
Landfall	The location where the offshore cables come ashore at Kirby Brook.
Offshore cable corridor	The corridor of seabed from array area to the landfall within which the offshore export cables will be located.
Offshore converter platform	Should an offshore connection to a third party HVDC cable be selected, an offshore converter platform would be required. This is a fixed structure located within the array area, containing HVAC and HVDC electrical equipment to aggregate the power from the wind turbine generators, increase the voltage to a more suitable level for export and convert the HVAC power generated by the wind turbine generators into HVDC power for export to shore via a third party HVDC cable. Should an offshore connection to a third party HVDC cable be selected, an offshore converter platform would be required. This is a fixed structure located within the array area, containing HVAC and HVDC electrical equipment to aggregate the power from the wind turbine generators, increase the voltage to a more suitable level for export and convert the HVAC power generated by the wind turbine generators into HVDC power for export to shore via a third party HVDC cable.
Offshore export cables	The cables which bring electricity from the offshore substation platform(s) to the landfall, as well as auxiliary cables.
Offshore project area	The overall area of the array area and the offshore cable corridor.
Offshore substation platform(s)	Fixed structure(s) located within the array area, containing electrical equipment to aggregate the power from the wind turbine generators and convert it into a more suitable voltage for export to shore via offshore export cables.
Platform interconnector cable	Cable connecting the offshore substation platforms (OSP); or the OSP and offshore converter platform (OCP)
Safety zones	A marine zone outlined for the purposes of safety around a possibly hazardous installation or works / construction area
Scour protection	Protective materials to avoid sediment being eroded away from the base of the wind turbine generator foundations and offshore substation platform (OSP) or / and offshore converter platform (OCP) foundations as a result of the flow of water.
The Applicant	North Falls Offshore Wind Farm Limited (NFOW).
The Project Or 'North Falls'The Project Or 'North Falls'	North Falls Offshore Wind Farm, including all onshore and offshore infrastructure. North Falls Offshore Wind Farm, including all onshore and offshore infrastructure.

Transition joint bay	Underground structures that house the joints between the offshore export cables and the onshore export cables
Trenchless crossing compound	Areas within the cable corridor which will house trenchless crossing (e.g., HDD) entry or exit points.
Wind turbine generator	Power generating device that is driven by the kinetic energy of the wind

12 Marine Mammals

12.1 Introduction

1. This chapter of the Environmental Statement (ES) considers the likely significant effects of the North Falls offshore wind farm (hereafter 'North Falls' or 'the Project') on marine mammals. The chapter provides an overview of the existing environment for the proposed offshore project area, followed by an assessment of likely significant effects for the construction, operation, maintenance and decommissioning phases of the Project.

2. This chapter has been written by Royal HaskoningDHV, with the assessment undertaken with specific reference to the relevant legislation and guidance, of which the primary sources are the National Policy Statements (NPS). Details of these and the methodology used for the Environmental Impact Assessment (EIA) and Cumulative Effect Assessment (CEA) are presented in Section 6.7.3 of Chapter 6 EIA Methodology (Document Reference: 3.1.8). Assessments for marine mammals have been undertaken following the approach outlined in Section 12.4.3.

3. The assessment should be read in conjunction with following linked chapters (Volume 3.1):

   - ES Chapter 3 Policy and Legislative Context (Document Reference: 3.1.5);
   - ES Chapter 5 Project Description (Document Reference: 3.1.7);
   - ES Chapter 6 EIA Methodology (Document Reference: 3.1.8);
   - ES Chapter 7 Technical Consultation (Document Reference: 3.1.9);
   - ES Chapter 9 Marine Water and Sediment Quality (Document Reference: 3.1.11);
   - ES Chapter 10 Benthic and Intertidal Ecology (Document Reference: 3.1.12);
   - ES Chapter 11 Fish and Shellfish Ecology (Document Reference: 3.1.13); and
   - ES Chapter 15 Shipping and Navigation (Document Reference: 3.1.17).

4. Additional information to support the marine mammal assessment includes (Volume 3.3):

   - Appendix 12.1 Marine Mammal Consultation (Document Reference: 3.3.6);
   - Appendix 12.2 Marine Mammal Baseline (Document Reference: 3.3.7);
   - Appendix 12.3 Underwater Noise Modelling Report (Document Reference: 3.3.8);
   - Appendix 12.4 Underwater Noise Technical Assessment (Document Reference: 3.3.9);
   - Appendix 12.5 Unexploded Ordnance Clearance Information and Assessment (Document Reference: 3.1.10); and

- Appendix 12.6 Marine Mammal Cumulative Effect Assessment Screening (Document Reference: 3.1.11).

12.2 Consultation

5. Consultation with regard to marine mammals has been undertaken in line with the general process described in ES Chapter 6 EIA Methodology (Document Reference: 3.1.8). The key elements to date have included consultation on the scoping report, Preliminary Environmental Information Report (PEIR), draft Report to Inform Appropriate Assessment (RIAA) and consultation via the Marine Mammal Expert Topic Group (ETG). The feedback received has been considered in preparing the ES. Full details of the issues raised by consultees and how these have been addressed are provided in Appendix 12.1 (Document Reference: 3.3.6)

6. This chapter has been updated following the consultation on the PEIR in order to produce the final assessment. Full details of the consultation process will also be presented in the Consultation Report as part of the DCO application.

12.3 Scope

12.3.1 Study area

7. The study area for marine mammals has been defined on the basis of marine mammals being highly mobile and transitory in nature; therefore, it is necessary to examine species occurrence not only within the offshore project area, but also over the wider area. For each species of marine mammal, the following study areas have been defined based on the relevant Management Units (MUs) (see Figure 1.1 (Document Reference: 3.3.7)), current knowledge and understanding of the biology of each species:

   - Harbour porpoise: North Sea (NS) MU;
   - Minke whale: Celtic and Greater North Seas (CGNS) MU;
   - Grey seal: South-east (SE) England and North-east (NE) England Mus; and
   - Harbour seal: SE England MU.

8. The status and activity of marine mammals known to occur within or adjacent to the offshore project area are considered in the context of regional population dynamics at the scale of the southern North Sea, or wider North Sea, depending on the data available for each species and the extent of the agreed reference population.

12.3.2 Realistic worst case scenario

9. The final design of North Falls will be confirmed through detailed engineering design studies that will be undertaken post-consent. In order to provide a precautionary but robust impact assessment at this stage of the development process, realistic worst case scenarios have been defined in terms of the potential impacts that may arise. This approach to EIA, referred to as the Rochdale Envelope, is common practice for developments of this nature, as set

out in Planning Inspectorate Advice Note Nine (2018). The Rochdale Envelope for a project outlines the realistic worst case scenario for each individual impact, so that it can be safely assumed that all other scenarios within the design envelope will have less impact. Further details are provided in ES Chapter 6 EIA Methodology (Document Reference: 3.1.8).

10. One area of optionality is in relation to the National Grid connection point (discussed further in ES Chapter 5 Project Description (Document Reference: 3.1.7) .The following grid connection options are included in the Project design envelope:

- Option 1: Onshore electrical connection at a national grid connection point within the Tendring peninsula of Essex, with a project alone onshore cable route and onshore substation infrastructure;
- Option 2: Onshore electrical connection at a national grid connection point within the Tendring peninsula of Essex, sharing an onshore cable route and onshore duct installation (but with separate onshore export cables) and co-locating separate project onshore substation infrastructure with Five Estuaries; or
- Option 3: Offshore electrical connection, supplied by a third party.

11. For the offshore project area, options 1 and 2 would be the same. Within the array area, under options 1 and 2 there would be up to two offshore substation platforms; whereas for option 3 there would be one offshore converter platform (OCP) and up to one offshore substation platform (OSP), i.e. under all scenarios there would be a maximum of two platforms. For option 3, there would be no project export cables to shore.

12. The realistic worst case scenarios for the likely significant effects scoped into the EIA for the marine mammal assessment relate to options 1 and 2 and these are summarised in Table 12.1. These are based on North Falls parameters described in ES Chapter 5 Project Description (Document Reference: 3.1.7), which provides further details regarding specific activities and their durations.

13. A range of wind turbine generator (WTG) sizes are included in the design envelope, which take into account currently available models and predicted technology developments. Table 12.1 outlines the parameters of relevance to marine mammals associated with the range of WTGs, from the greatest number of smallest WTG to the fewest, largest WTG within the envelope[1].

14. The potential impacts on marine mammals are:

- Underwater noise (including, UXO clearance, piling, cable laying, dredging, trenching, rock placement, vessels, operational turbines, Operation and Maintenance (O&M) activities and decommissioning activities);
- Any barrier effects from underwater noise;
- Any increased collision risk with vessels;
- Disturbance at seal haul-out sites;

[1] Further information on the scaling up from existing noise data is provided in Appendix 12.3 (Document Reference: 3.3.8).

- Disturbance of foraging at sea;
- Changes to water quality;
- Changes to prey resources; and
- Cumulative effects.

Table 12.1 Realistic worst case parameters for marine mammal assessments

Potential impact	Parameter	Notes
Construction		
Impact 1: Underwater noise during piling, including: • Permanent auditory injury; • Temporary auditory injury; and • Disturbance.	Spatial worst case scenario: • 57 WTGs on monopile foundations; • Two OSP/OCP on monopile foundations; • Maximum pile diameter for WTG and OSP/OCP monopiles: 17m; • 6,000 kJ hammer energy, 7.5 hours piling duration per monopile including a 10 minute soft start at 15% hammer energy and 120 minute (2 hour) ramp up to full energy (where required); • Maximum number of monopiles to be installed per 24 hour period: three; • Total WTG active piling duration: 427.5 hours (equivalent to 17.8 days); • Total OSP/OCP active piling duration: 15 hours (equivalent to less than one day); • Duration of foundation installation: 12 months • Simultaneous piling: only two piles will be piled simultaneously within the North Falls array area. Temporal WCS: • 57 WTGs on pin-piled jacket foundations, with up to four legs per jacket and two piles per leg (i.e. eight piles per jacket; 456 total); • Two OSP/OCPs on pin-piled jacket foundations, with up to six legs per jacket and two piles per leg (i.e. 12 piles per jacket; 24 total piles); • Maximum pile diameter for WTG pin piles: 6m; • Maximum pile diameter for OSP/OCP pin piles: 3.5m; • WTGs: 4,400 kJ hammer energy, 4.5 hours piling duration including a 10 minute soft start at 15%	The spatial worst case scenario is based on the largest hammer energy which is required for monopile foundations. The temporal worst case scenario is based on the greatest number of piles which is the pin-piled jacket foundations[3]. Full hammer energy is unlikely to be required on all piles but is assessed for all piles as a worst case scenario. Drive-drill-drive is an option for installation, however, 100% pile driving is the worst case and has been assessed. Alternative foundation types (including suction bucket monopiles, and gravity based for both monopiles and pin piles) are an option, but do not represent the worst case for underwater noise. Activation of (ADD) is indicative only and the details will be confirmed during the post-consent phase, through the finalisation of the MMMP.

[3] Assessments for pin piles for the OSP/OCP are based on the parameters for pin piles for the WTG as a worst-case

Potential impact	Parameter	Notes
	hammer energy, and 80 minute ramp up to full energy (where required); • OSP/OCPs: 3,000 kJ hammer energy; • Maximum number of pin piles to be installed per 24 hour period: six; • Total WTG active piling duration: 2,052 hours (equivalent to 85.5 days); • Total OSP/OCP active piling duration: 108 hours (equivalent to 4.5 days); • Duration of foundation installation: 12 months • Simultaneous piling: only two piles will be piled simultaneously within the North Falls array area. Additional disturbance from ADD: • Indicative activation time of 37 minutes[2]	
Impact 2: Underwater noise during other construction activities, including: • Permanent auditory injury; • Temporary auditory injury; and	UXO devices that could be present within the North Falls offshore project area has been estimated as 750 kg. 40 clearance operations are estimated (25 in the array area and 15 in the offshore cable corridor).	Appendix 12.3 (Document Reference: 3.3.8) provides underwater noise modelling for 750 kg alongside a range of smaller devices, these are 0.5kg (for low-order detonation), 25 kg, 55 kg, 120 kg, 240 kg and 525 kg.
	Seabed clearance methods: Pre-lay grapnel run, boulder clearance, sand wave levelling (pre-sweeping), dredging.	Appendix 12.3 (Document Reference: 3.3.8) provides underwater noise modelling for suction dredging to represent the worst case scenario of these activities.

[2] Calculated based on the maximum Permanent Threshold Shift (PTS) distances for UXO clearance and piling.

Potential impact	Parameter	Notes
• Disturbance.	<u>Cable installation methods:</u> It is anticipated that the offshore cables will be installed via either ploughing, jetting, trenching, or a combination of these techniques. Surface laid cable protection could be required in areas where cables cannot be buried (e.g., at cable crossings and hard ground conditions. Array cables total length: 170km Export cable total length 125.4km (based on 2 cables) Platform interconnector cable: 20km Indicative duration of offshore construction: approximately two years (including commissioning)	Appendix 12.3 (Document Reference: 3.3.8) provides underwater noise modelling for cable laying, trenching and rock placement to represent the worst case scenario for these activities.
Impact 3: Underwater noise due to construction vessels, including: • Permanent auditory injury; • Temporary auditory injury; and • Disturbance.	Vessel movements: Maximum indicative peak number of construction vessels on site at any one time: up to 35 vessels Construction vessel round trips to port (vessel movements): 2,532 over two year offshore construction period (average of 1,266 vessel movements per year; 3.5 movements per day) Construction port: To be determined, could be any North Sea port (UK and/or EU).	The maximum numbers of vessels and associated vessel movements represents the maximum potential for disturbance. Appendix 12.3 (Document Reference: 3.3.8) provides underwater noise modelling for noise from large and medium sized vessels.
Impact 4: Barrier effects due to underwater noise during construction	Maximum impact range from all three underwater noise assessments (worst case parameters described above), further details of the three underwater noise assessments are found in Section 12.6.1.	The maximum spatial area of potential impact, and duration of impacts, are considered to cause the worst case barrier impact.
Impact 5: Collision risk due to construction vessels	Vessel movements: Maximum Indicative peak number of construction vessels on site at any one time: up to 35 vessels Construction vessel movements: 2,532 over two year offshore construction period (average of 1,266 movements per year; 3.5 movements per day)	The maximum numbers of vessels and associated vessel movements represents the maximum potential for collision risk.

Potential impact	Parameter	Notes
	Construction port: To be determined, could be any North Sea port (UK and/or EU).	
Impact 6: Disturbance at seal haul-out sites	Vessel movements: Maximum Indicative peak number of construction vessels on site at any one time: up to 35 vessels Construction vessel movements: 2,532 over two year offshore construction period (average of 1,266 movements per year; 3.5 movements per day) Location of works: • Minimum distance of array area to coastline: 40km • Landfall: Kirby Brook, Tendring Peninsula of Essex. • Construction port: to be determined Indicative duration of offshore construction: approximately two years (including commissioning)	Number of vessel movements and proximity to seal haul out sites defines the worst case scenario.
Impact 7: Changes to water quality	Suspended sediments arising from: • Seabed preparation for foundation installation = 1.14Mm^3 • Array and platform interconnector cable installation = 28.96Mm^3 • Export cable installation = 1.7Mm^3	The worst case scenario for marine mammals is based on the conclusions of the assessments presented in ES Chapter 9 Marine Water and Sediment Quality (Document Reference: 3.1.11).
Impact 8: Changes to prey resources	Prey impacts from temporary habitat loss / disturbance: Total seabed disturbance within the offshore project area = 5.88km^2	The worst case scenario for maximum area of temporary habitat loss / disturbance of seabed from offshore cable installation, seabed preparation, jack-up vessels and anchoring). See ES Chapters 10 and 11 Fish and Shellfish Ecology (Document Reference: 3.1.13) for further detail.
	Prey impacts from underwater noise parameters as outlined for Impacts 1 to 3, above and Appendix 12.2 Underwater Noise Modelling Report.	Worst case scenario for marine mammals is based on the conclusions of the assessments presented in ES Chapter 10 Benthic Ecology (Document Reference: 3.1.12) and ES Chapter 11 Fish Shellfish Ecology (Document Reference: 3.1.13).
	Prey impacts resulting from changes to water quality as described for Impact 7, above.	

Potential impact	Parameter	Notes
Operation		
Impact 1: Underwater noise from operational wind turbines, including: • Permanent auditory injury; • Temporary auditory injury; and • Disturbance.	Indicative operational life of North Falls: 30 years Number of WTGs: • 57 x smallest WTGs (rotor diameter 236m), or • 34 x largest WTGs (rotor diameter 337m). Minimum turbine spacing: • Smallest WTGs = 944m (crosswind) and 1,180m (downwind), or • Largest WTGs = 1,348m (crosswind) and 1,685m (downwind).	Worst case assessment is based on the underwater noise modelling results presented Appendix 12.3 Document Reference: 3.3.8).
Impact 2: Underwater noise from O&M activities, including: • Permanent auditory injury; • Temporary auditory injury; and • Disturbance.	Unplanned repairs and reburial of cables may be required during O&M, the following estimates are included: • Reburial of c.2.75% of array cable length over the life of the project • Reburial of c.2.75% of platform interconnector cable over the life of the project • Reburial of c. 4% of offshore export cable over the life of the project • Five array/platform interconnector cable repairs are estimated over the project life. • Four export cable repairs are estimated over the project life. Anchored vessels placed during the no. of cable repairs included above. Maintenance of offshore infrastructure would be required during O&M. An estimated 177 major component replacement activities may be required during the lifetime of the project, using jack up vessels and/or anchoring.	Underwater noise modelling for other activities presented Appendix 12.3 Document Reference: 3.3.8)
Impact 3: Underwater noise due to O&M vessels	Indicative peak number of vessels on site at any one time: 22 • Two jack-up vessels • Two Service Operation Vessels (SOVs)	Worst case is based on the maximum number of vessel movements.

Potential impact	Parameter	Notes
	• Six small O&M vessels (e.g., crew transfer vessels (CTVs) • Two lift vessels • Two cable maintenance vessels • Eight auxiliary vessels (e.g., survey vessels, diver platform vessels, tugs, cargo vessels, scour replacement vessels)	
	Indicative O&M vessel movements per year: 1,095 round trips of small vessels, and 127 round trips of large vessels (1,222 in total): • Seven round trips per year of jack-up vessels • 52 SOV round trips per year • 1,095 small O&M vessel round trips per year • Seven round trips per year of lift vessels • One cable maintenance vessel round trip per year • 60 round trips per year of auxiliary vessels, dependent on size of vessel	
Impact 4: Barrier effects due to underwater noise during operation	Maximum impact range from operation and maintenance phase underwater noise Impacts 1 to 3 (as above).	The maximum spatial area of potential impact, and duration of impacts, are considered to cause the worst case barrier impact.
Impact 5: Increased collision risk due to O&M vessels	Indicative O&M vessel movements per year: 1,095 round trips of small vessels, and 127 round trips of large vessels (1,222 in total).	Worst case is based on the maximum number of vessel movements.
Impact 6: Disturbance at seal haul-out sites	Vessel movements: • Indicative O&M vessel movements per year: 1,095 round trips of small vessels, and 127 round trips of large vessels (1,222 in total). Location of works: • Minimum distance of array area to coastline: 40km • O&M base location: potentially Harwich or Felixstowe.	Operation and maintenance activities could happen at any time of year.

Potential impact	Parameter	Notes
Impact 7: Changes to water quality	Suspended sediments arising from: • Reburial of c.2.75% of array cable length (170km) is estimated over the life of the project (24m disturbance width and average 1.2m depth) = 134,640m^3 • Reburial of c.2.75% of platform interconnector cable (20km) is estimated over the life of the project (24m disturbance width and average 1.2m depth) = 15,840m^3 • Reburial of c. 4% of offshore export cable (125.4km) is estimated over the life of the project (24m disturbance width and average 1.2m depth) = 144,460.8m^3 • Five array/platform interconnector cable repairs are estimated over the project life. 600m section removed x 24m disturbance width x average 1.2m depth = 86,400m^3 • Four export cable repairs are estimated over the project life. 600m section removed x 24m disturbance width x average 1.2m depth = 69,120m^3.	The worst case scenario for marine mammals is based on the conclusions of the assessments presented in ES Chapter 9 Marine Water and Sediment Quality (Document Reference: 3.1.11).
Impact 8: Changes to prey resources	Prey impacts from habitat loss within the offshore project area = 5.5km^2 (5.37km^2 in the array area and 0.08km^2 in the offshore cable corridor).	The worst case scenario for maximum area of temporary habitat loss / disturbance of seabed from offshore cable installation, seabed preparation, jack-up vessels and anchoring). See ES Chapters 10 Benthic and Intertidal Ecology Document Reference: 3.1.12) and 11 Fish and Shellfish Ecology (Document Reference: 3.1.13) for further detail. Worst case scenario for marine mammals is based on the conclusions of the assessments presented in ES Chapter 10 Benthic Ecology (Document Reference: 3.1.12) and ES Chapter 11 Fish and Shellfish Ecology (Document Reference: 3.1.13).
	Prey impacts from underwater noise parameters as outlined for Impacts 1 to 3, above and Appendix 12.3.	
	Prey impacts resulting from changes to water quality as described for Impact 7, above.	
Decommissioning		
Impact 1: Underwater noise from decommissioning activities	<u>Foundations</u> Cutting of piles below the seabed surface:	No decision has yet been made regarding the final decommissioning arrangements for the offshore project infrastructure. It is also recognised that

Potential impact	Parameter	Notes

Impact 2 & 4: Underwater noise and increased collision risk due to decommissioning vessels
 	
Impact 3: Barrier effects from underwater noise during decommissioning
 	
Impact 5: Disturbance at seal haul-out sites
 	
Impact 6: Changes to water quality
 	
Impact 7: Changes to prey resources
	• 480 pin-piles of 6m diameter
	    ○ 57 WTGs x 8 piles
	    ○ 2 OSP/OCPs x 12 piles
	
	Or
	
	• 59 monopiles of 17m diameter (57 wind turbines + 2 OSP/OCPs)
	
	Or
	
	Removal of largest foundations (gravity based systems; GBS):
	• 57 WTGs x 65m diameter
	• 2 OSP/OCPs x 65m diameter
	
	Offshore export cables
	Up to 125.4km of offshore export cable (removal to be determined in consultation with key stakeholders as part of the decommissioning plan).
	
	Array cables
	Up to 170km of array cable (removal to be determined in consultation with key stakeholders as part of the decommissioning plan).
	
	Platform interconnector cables:
	Up to 20km of platform interconnector cable (removal to be determined in consultation with key stakeholders as part of the decommissioning plan)
		legislation and industry best practice change over time. However, the following infrastructure is likely to be removed, reused or recycled where practicable:
		• Turbines including monopile, steel jacket and GBS foundations;
		• OSPs/OCP including topsides and steel jacket foundations; and
		• Offshore cables may be removed or left in situ depending on available information at the time of decommissioning.
		
		The following infrastructure is likely to be decommissioned in situ depending on available information at the time of decommissioning, however where it represents the worst case scenario (e.g., for disturbance, removal is assessed):
		• Scour protection;
		• Offshore cables may be removed or left in situ; and
		• Crossings and cable protection.
		
		The detail and scope of the decommissioning works will be determined by the relevant legislation and guidance at the time of decommissioning and will be agreed with the regulator.
		
		Decommissioning arrangements will be detailed in a Decommissioning Plan, which will be prepared in accordance with the Energy Act 2004.

12.3.3 Summary of mitigation embedded in the design

15. This section outlines the embedded mitigation relevant to the marine mammal assessment, which has been incorporated into the design of North Falls (Table 12.2). Where other mitigation measures are proposed, these are detailed in the impact assessment (Section 12.6) and discussed further in Section 12.8.

Table 12.2 Embedded mitigation

Mitigation measure	Description
Underwater Noise	
Soft-start and ramp-up for piling activities	Each piling event would commence with a soft-start at a lower hammer energy followed by a gradual ramp-up to the maximum hammer energy required (the maximum hammer energy is only likely to be required at a few of the piling installation locations), secured through the Outline Marine Mammal Mitigation Plan (Document Reference: 7.7)

UXO clearance methods	Before clearance takes place, the following options will be considered, in order of preference;
	• Left in-situ
	• Micro-siting of project infrastructure to avoid
	• Relocation to a less sensitive area for clearance
	
	If clearance is required, the following methods would be used, in order of preference;
	• Low-order (with three attempts for each device)
	• High-order clearance (only if low-order is unsuccessful, or deemed not possible/unsafe by EOD specialists)
	  o Potential use of bubble curtain depending on environmental variables
	  o Maximum of three high-order clearances across the campaign.
	This would be secured as part of the Marine Licencing process for UXO clearance in accordance with the Draft Marine Mammal Mitigation Protocol (MMMP) (Document Reference: 7.7).

Water Quality	
Pollution prevention	As outlined in ES Chapter 9 Marine Sediment and Water Quality (Document Reference: 3.1.15), the Applicant is committed to the use of industry good practice techniques and due diligence regarding the potential for pollution throughout all construction, operation and maintenance, and decommissioning activities. An outline Project Environmental Management Plan (PEMP) has been submitted alongside the DCO application to set out the details of the measures that will be taken in relation to accidental pollution events. The final PEMP would be agreed with the MMO prior to construction.

12.4 Assessment methodology

12.4.1 Legislation, guidance and policy

12.4.1.1 National Policy Statements

16. The assessment of likely significant effects upon marine mammals has been made with specific reference to the relevant NPS. These are the principal policy documents for Nationally Significant Infrastructure Projects (NSIPs). The following NPS is relevant to the Project and marine mammals:

- NPS for Renewable Energy Infrastructure (EN-3) (Department for Energy Security and Net Zero (DESNZ, 2023); and

17. The specific assessment requirements for marine mammal, as detailed in the NPS, are summarised in Table 12.3 together with an indication of the section of the ES chapter where each is addressed.

Table 12.3 NPS assessment requirements

NPS requirement	NPS reference	ES reference
NPS for Renewable Energy Infrastructure (EN-3)		
Construction activities, including installing wind turbine foundations by pile driving, geophysical surveys, and clearing the site and cable route of unexploded ordinance (UXOs) may reach noise levels which are high enough to cause disturbance, injury, or even death to marine mammals. All marine mammals are protected under Part 3 of the Habitats Regulations (cetaceans within Schedule 2 and seal species within Schedule 4). 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 licence53 to allow the activity to take place.	Paragraphs 2.8.127 - 129	Section 12.3.2 provides an overview of the worst case scenario for potential piling works. Section 12.6.1.1 provides an assessment of pile driving (including noise modelling results). It is anticipated that an application for a European Protected Species (EPS) / licence will be submitted post-consent.
Where necessary, assessment of the effects on marine mammals should include details of: likely feeding areas and impacts on prey species and prey habitat; • known birthing areas/haul out sites for breeding and pupping; • migration routes; • protected sites; • baseline noise levels; • predicted construction and soft start noise levels in relation to mortality, permanent threshold shift (PTS), temporary threshold shift (TTS) and disturbance; • operational noise; • duration and spatial extent of the impacting activities including cumulative/in-combination effects with other plans or projects; • collision risk; • entanglement risk; and • barrier risk.	Paragraph 2.8.131	Section 12.5 and Appendix 12.2 (Document Reference: 3.3.7) provide a description of the existing environment. Section 12.6details the assessment of impacts during construction, including pile driving. Sections 12.6.2.1 and 12.6.2.1.6 provide the assessment of operational noise. Cumulative effects are assessed in Section 12.7 and impacts on protected sites are assessed in the RIAA.
The applicant should discuss any proposed noisy activities with the relevant statutory body and must reference the joint JNCC and SNCB underwater noise guidance, and any successor of this guidance, in relation to noisy activities (alone and in combination with other plans or projects) within SACs, SPAs, and Ramsar sites, in addition to the JNCC mitigation guidelines for piling, explosive use, and geophysical surveys. NRW has a position statement on assessing noisy activities which should also be referenced where relevant.	Paragraph 2.8.133	Section 12.6.1 details the assessment of impacts during construction, including pile driving and mitigation. North Falls have discussed proposed piling activities through the EPP as outlined in Appendix 12.2.
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 2.8.127-2.8.129	Paragraphs 2.8.134 - 135	The Marine Mammal UXO Appendix 12.5 details the impact assessment for UXO clearance. A SIP would be developed as part of the separate

NPS requirement	NPS reference	ES reference
above, the applicant must look at possible alternatives or appropriate mitigation. The applicant should develop a Site Integrity Plan (SIP) or alternative assessments for projects in English and Welsh waters 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.		Marine Licencing process, if it is deemed to be required.
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.	Paragraph 2.8.237	An Offshore Outline PEMP (Document Reference: 7.6) and Draft MMMP (Document Reference: 7.7) are submitted with the DCO application. These plans will be developed in consultation with the relevant Statutory Nature Conservation Bodies (SNCBs) and approved by the MMO post consent and will identify any necessary monitoring requirements.
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 and all potential mitigation options presented as part of the application, having consulted the relevant JNCC mitigation guidelines. .	Paragraph 2.8.238 - 239	A Draft MMMP (Document Reference: 7.7) is submitted with the DCO application which details the marine mammal monitoring requirements during piling.
The Secretary of State should be satisfied that the preferred methods of construction, in particular the construction method needed for the proposed foundations and the preferred foundation type, where known at the time of application, are designed reasonably to minimise significant impacts on marine mammals. Unless suitable noise mitigation measures can be imposed by requirements to any development consent the Secretary of State may refuse the application. The conservation status of cetaceans and seals are of relevance and the Secretary of State should be satisfied that cumulative and in-combination impacts on marine mammals have been considered.	Paragraph 2.8.312 - 314	As outlined in Section 12.3.2, selection of the types of foundations, construction methods and mitigation are designed to reasonably minimise significant effects on marine mammals. The conservation status of relevant marine mammal species is included in Section 12.4.1.5. The cumulative effects and in-combination effects on marine mammals have been assessed in Section 12.7 of the ES and in the RIAA respectively.

Other legislation, policy and guidance

18. In addition to the NPS, there are a number of pieces of legislation, policy and guidance applicable to the assessment of marine mammals. These include:

- Legislation:
    - The UK Marine Strategy Regulations (MSR) 2010;
        - Marine Strategy Part One: UK updated assessment and Good Environmental Status (Defra, 2019)

        - Marine Strategy Part Two: UK updated monitoring programmes (Defra, 2022)
        - Marine Strategy Part Three: UK Programme of Measures (Defra, 2021)
- Policy:
    - The Marine Policy Statement (MPS) (HM Government, 2011); and
    - The East Inshore and East Offshore Marine Plans (HM Government, 2014).

19. The South East Inshore Marine Plan (HM Government, 2021).

20. Further detail is provided in Appendix 12.2 (Document Reference: 3.3.7) and ES Chapter 3 Policy and Legislative Context (Document Reference: 3.1.5).

12.4.1.2 National and international legislation for marine mammals

21. Appendix 12.2 (Document Reference: 3.3.7) provides an overview of national and international legislation in relation to marine mammals.

12.4.1.3 Guidance documents for marine mammals

22. The principal guidance documents used to inform the assessment of potential impacts on marine mammals include, but are not limited to:

- Natural England 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 (Parker et al., 2022).
- The Protection of Marine EPS from Injury and Disturbance: Draft Guidance for the Marine Area in England and Wales and the UK Offshore Marine Area (Joint Nature Conservation Committee (JNCC *et al.,* 2010);
- Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater, Coastal and Marine (Chartered Institute of Ecology and Environmental Management (CIEEM, 2018);
- EIA for offshore renewable energy projects guide (British Standards Institution (BSI, 2015);
- Approaches to Marine Mammal Monitoring at Marine Renewable Energy Developments Final Report (Sea Mammal Research Unit Ltd (SMRU Ltd) on behalf of The Crown Estate, 2010);

23. Guidelines for Data Acquisition to Support Marine Environmental Assessments of Offshore Renewable Energy Projects (Centre for the Environment and Fisheries and Aquaculture Science (Cefas, 2012);

- Guidance for assessing the significance of noise disturbance against Conservation Objectives of harbour porpoise SACs (JNCC, Department of Agriculture, Environment and Rural Affairs (DAERA) and Natural England, 2020);

24. A review of noise abatement systems for Offshore Wind Farm (OWF) construction noise, and the potential for their application in Scottish Waters (Verfuss *et al.,* 2019);

- Reducing Underwater Noise (NIRAS, SMRU Consulting, and The Crown Estate, 2019);
- JNCC guidelines for minimising the risk of injury to marine mammals from using explosives (JNCC, 2010a);
- Draft JNCC guidelines for minimising the risk of injury to marine mammals from explosive use in the marine environment (JNCC, 2023); and
- Statutory Nature Conservation Agency Protocol for Minimising the Risk of Injury to Marine Mammals from Piling Noise (JNCC, 2010b).

12.4.1.4 Protected species and marine wildlife licence regulations

25. All cetacean species are listed as EPS under Annex IV of the Habitats Directive and are therefore protected from the deliberate killing (or injury), capture and disturbance throughout their range. Within the UK, The Habitats Directive is enacted through The Conservation of Habitats and Species Regulations 2017 and the Conservation of Offshore Marine Habitats and Species Regulations 2017. Under these Regulations, it is an offence to:

- deliberately capture, injure or kill any cetacean species;
- to deliberately disturb them; or
- to damage or destroy a breeding site or resting place.

26. Grey and harbour seal are also protected under the Conservation of Habitats and Species Regulations 2017 and The Conservation of Offshore Marine Habitats and Species Regulations 2017, as well as Conservation of Seals Act 1970.

27. Further information is provided in Appendix 12.2 (Document Reference: 3.3.7).

12.4.1.5 Favourable Conservation Status (FCS)

28. Member states report back to the European Union (EU) every six years on the Conservation Status of marine mammals. Table 12.4 provides the current FCS of marine mammals species occurring in UK and adjacent waters, based on the most recent 2013-2018 reporting by JNCC in 2019[4].

Table 12.4 FCS assessment of Annex IV marine mammal species occurring in UK and adjacent waters (JNCC, 2019) relevant to North Falls

Species	Favourable Conservation Status Assessment
Cetaceans	
Harbour porpoise *Phocoena phocoena*	Unknown
Minke whale *Balaenoptera acutorostrata*	Unknown

[4] The fourth UK Habitats Directive Reports for all marine mammal species can be accessed here: https://jncc.gov.uk/our-work/article-17-habitats-directive-report-2019-species/#regularly-occurring-species-vertebrate-species-mammals-marine

Species	Favourable Conservation Status Assessment
Pinnipeds	
Grey seal *Halichoerus grypus*	Favourable
Harbour seal *Phoca vitulina*	Unfavourable-inadequate

12.4.1.6 Good Environmental Status (GES)

29. Publication of the UK Marine Strategy Parts 1-3 (the Strategy) between December 2012 and December 2015 marked a significant step forward in the protection and management of waters around the UK coast. In October 2019 the Marine Strategy was subsequently updated, for the first time, the Strategy set out a comprehensive framework for assessing, monitoring and taking action across seas to achieve the UK's shared vision for clean, healthy, safe, productive and biologically diverse seas (Defra, 2019).

30. The findings of 60 indicator assessments covering marine species and habitats and the key pressures affecting them have enabled the Marine Strategy to assess the extent to which GES has been achieved, helped to identify gaps in knowledge and identify next steps. Table 12.5 provides the current GES of marine mammal species occurring in UK and adjacent waters, based on the most recent reporting by Defra in 2019.

Table 12.5 GES assessment of Annex IV marine mammal species occurring in UK and adjacent waters (Defra, 2019) relevant to North Falls

Species	Good Environmental Status Assessment
Cetaceans	
Harbour porpoise *Phocoena phocoena*	Uncertain
Minke whale *Balaenoptera acutorostrata*	Uncertain
Pinnipeds	
Grey seal *Halichoerus grypus*	Achieved
Harbour seal *Phoca vitulina*	Uncertain

12.4.2 Data sources

Site specific-surveys

31. Site-specific aerial surveys were conducted for both marine mammals and seabirds. HiDef Aerial Surveying Limited ('HiDef') collected high resolution aerial digital still imagery for marine megafauna (combined with ornithology surveys) over the array area, including a 4km buffer. Further detail of the survey method is provided in Appendix 12.2 (Document Reference: 3.3.7).

32. The surveys were conducted monthly; in total 24 months of data has been collected for the array area (further details are provided in Appendix 12.2 (Document Reference: 3.3.7).

12.4.2.1 Other available sources

33. Other sources that have been used to inform the assessment are listed in Table 12.6.

Table 12.6 Other available data and information sources

Data Set	Spatial Coverage	Year	Notes
Estimates of cetacean abundance in the European Atlantic waters (SCANS-IV) data (Gilles *et al.*, 2023)	North Sea and European Atlantic waters	2023	Provides information including abundance and density estimates of cetaceans in European Atlantic waters in summer 2022, including the offshore project area.
Estimates of cetacean abundance in the European Atlantic waters (SCANS-III) data (Hammond *et al.*, 2021)	North Sea and European Atlantic waters	2021	Provides information including abundance and density estimates of cetaceans in European Atlantic waters in summer 2016, including the offshore project area.
Management Units (MUs) for cetaceans in UK waters (Inter-Agency Marine Mammal Working Group (IAMMWG, 2023)	UK waters	2023	Provides information on MU for the offshore project area.
HiDef digital video aerial surveys of seabirds and marine mammals at Five Estuaries. March 2019 to February 2021.	Five Estuaries project area (North Sea)	2021	Aerial survey of the Five Estuaries project area which is in close proximity to North Falls.
UK Offshore Energy Strategic Environmental Assessment (including relevant appendices and technical reports) (Department for Business, Energy & Industrial Strategy (BEIS), 2022 (BEIS, 2022a))	UK waters	2022	Provides information for the wider North Sea.
The identification of discrete and persistent areas of relatively high harbour porpoise density in the wider UK marine area (Heinänen and Skov, 2015)	UK Exclusive Economic Zone (EEZ)	1994-2011	Data was used to determine harbour porpoise SAC sites.
Revised Phase III data analysis of Joint Cetacean Protocol (JCP) data resources (Paxton *et al.*, 2016)	UK EEZ	1994-2011	Provides information on harbour porpoise in the North Sea.
Seasonal habitat-based density models for a marine top predator, the harbour porpoise, in a dynamic environment (Gilles *et al.*, 2016)	UK (SCANS II, Dogger Bank), Belgium, the Netherlands, Germany, and Denmark	2005-2013	Provides information for central and southern North Sea.
Distribution and abundance maps for cetacean species around Europe (Waggitt *et al.* (2019).	North-east Atlantic	1980-2018	Provides information on cetacean species for the wider North Sea.
Distribution of Cetaceans, Seals, Turtles, Sharks and Ocean Sunfish recorded from Aerial Surveys 2001-2008 (The Wildfowl and Wetlands Trust (WWT), 2009)	UK areas of the North Sea	2001-2008	Provides information for species in the North Sea.
Sea Watch Foundation volunteer sightings off eastern England (Sea Watch Foundation, 2021)	East coast of England	2019-2021	Provides information on species sighted along east coast of England.

Data Set	Spatial Coverage	Year	Notes
UK seals at sea relative density estimates and usage maps as provided by *Sympatric Seals, Satellite Tracking and Protected Areas: Habitat-Based Distribution Estimates for Conservation and Management* (Carter *et al.*, 2022)	North Sea	2005-2019	Provides information on abundance and density estimates for seal species.
Seal telemetry data (e.g., Sharples *et al.*, 2008; Russell and McConnell, 2014; Russell, 2016a; Carter *et al.*, 2020)	North Sea	1988-2010; 2015	Provides information on movements and distribution of seal species.
Special Committee on Seals (SCOS) annual reporting of scientific advice on matters related to the management of seal populations (SCOS, 2020; SCOS, 2021; SCOS, 2022).	North Sea	2019, 2020, 2021	Provides information on seal species.

12.4.3 Impact assessment methodology

34. ES Chapter 6 EIA Methodology (Document Reference: 3.1.8) explains the general impact assessment methodology applied to North Falls. The following sections describe the methods used to assess the likely significant effects on marine mammals.

35. A matrix approach is used to guide the assessment of impacts following best practice, EIA guidance and the approach previously agreed with stakeholders for other recent OWFs (including Norfolk Vanguard, Norfolk Boreas and East Anglia ONE North, TWO and THREE).

36. To enable a consistent approach, a definitions matrix will be employed to structure the expert and evidence led assessment of impacts. Receptor sensitivity for each marine mammal species has been defined within the ES, following the definitions set out in Section 12.4.3.1.

12.4.3.1 Definitions

37. The assessment identifies receptors within the study area which are sensitive to each potential impact and implements a systematic approach to understanding the pathways and the level of impacts (i.e., magnitude) on given receptors. The definitions of sensitivity and magnitude for the purpose of the marine mammal assessment are provided in Table 12.7 and Table 12.9.

38. The sensitivity of a receptor is determined through its ability to accommodate change and recover if it is affected (Table 12.7). The sensitivity level of marine mammals to each type of impact is justified within the impact assessment and is dependent on the following factors:

- Adaptability – The degree to which a receptor can avoid or adapt to an effect;
- Tolerance – The ability of a receptor to accommodate temporary or permanent change without a significant adverse effect;
- Recoverability – The temporal scale over and extent to which a receptor will recover following an effect; and
- Value – A measure of the receptor importance, rarity and worth.

39. The sensitivity of marine mammals to impacts from pile driving noise is currently the impact of most concern across the offshore wind sector. The sensitivity to potential impacts of lethality, physical injury, auditory injury or hearing impairment, as well as behavioural disturbance or auditory masking will be considered for each species, using available evidence including published data sources.

Table 12.7 Definition of sensitivity for a marine mammal receptor

Sensitivity	Definition
High	Individual receptor has very limited capacity to avoid, adapt to, tolerate or recover from the anticipated impact.
Medium	Individual receptor has limited capacity to avoid, adapt to, tolerate or recover from the anticipated impact.
Low	Individual receptor has some tolerance to avoid, adapt to, tolerate or recover from the anticipated impact.
Negligible	Individual receptor is generally tolerant to and can tolerate or recover from the anticipated impact.

40. The 'value' of the receptor forms an important element within the assessment, for instance, if the receptor is a protected species. It is important to understand that high value and high sensitivity are not necessarily linked within a particular impact. A receptor could be of high value but have a low or negligible physical/ecological sensitivity to an impact. Similarly, low value does not equate to low sensitivity and is judged on a receptor by receptor basis.

41. Most species of marine mammals are protected by a number of international legislations, as well as European and UK law and policy. All cetaceans in UK waters are EPS and, therefore, are internationally important. Harbour porpoise, minke whale, grey seal and harbour seals are also afforded international protection through the designation of protected sites. As such, all species of marine mammal are considered to be of high value.

42. Table 12.8 provides definitions for the value afforded to a receptor based on its legislative importance. The value will be considered, where relevant, based on expert judgement.

Table 12.8 Definition of value for a marine mammal receptor

Value	Definition
High	Internationally or nationally important Internationally protected species that are listed as a qualifying interest feature of an internationally protected site (i.e., Annex II protected species designated feature of a designated site) and protected species (including EPS) that are not qualifying features of a designated site.
Medium	Regionally important or internationally rare Protected species that are not qualifying features of a designated site but are recognised as a Biodiversity Action Plan (BAP) priority species either alone or under a grouped action plan and are listed on the local action plan relating to the marine mammal study area.
Low	Locally important or nationally rare Protected species that are not qualifying features of a designated site and are occasionally recorded within the study area in low numbers compared to other regions.
Negligible	Not considered to be particularly important or rare

Value	Definition
	Species that are not qualifying features of a designated site and are never or infrequently recorded within the study area in very low numbers compared to other regions.

43. The thresholds for defining the potential magnitude of impact that could occur from a particular impact will be determined using expert judgement, current scientific understanding of marine mammal population biology, and JNCC *et al.* (2010) draft guidance on disturbance to EPS species. The JNCC *et al.* (2010) EPS draft guidance suggests definitions for a 'significant group' of individuals or proportion of the population for EPS species. As such this guidance has been considered in defining the thresholds for magnitude of impacts (Table 12.9).

44. The JNCC *et al.* (2010) draft guidance provides some indication on how many animals may be removed from a population without causing detrimental effects to the population at FCS. The JNCC *et al.* (2010) draft guidance also provides limited consideration of temporary effects, with guidance reflecting consideration of permanent displacement.

45. Temporary effects are considered to be of medium magnitude at greater than 5% of the reference population. JNCC *et al.* (2010) draft guidance considered 4% as the maximum potential growth rate in harbour porpoise, and the 'default' rate for cetaceans. Therefore, beyond natural mortality, up to 4% of the population could theoretically be permanently removed before population growth could be halted. In assigning 5% to a temporary impact in this assessment, consideration is given to uncertainty of the individual consequences of temporary disturbance.

46. Permanent effects with a greater than 1% of the reference population being affected within a single year are considered to be high in magnitude in this assessment. This is based on Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS) and Defra advice (Defra, 2003; ASCOBANS, 2015) relating to impacts from fisheries by-catch (i.e., a permanent effect) on harbour porpoise. A threshold of 1.7% of the relevant harbour porpoise population above which a population decline is inevitable has been agreed with Parties to ASCOBANS, with an intermediate precautionary objective of reducing the impact to <1% of the population (Defra, 2003; ASCOBANS, 2015).

47. To determine the magnitude of an impact for any quantitative impact assessments, the number of individuals that could be impacted is put into the context of the relevant reference population (based on the definitions of magnitude shown in Table 12.9). For all assessments where the results show more than one individual is at risk, the number has been rounded up to a whole number to ensure the result of the assessment is biologically relevant.

Table 12.9 Definition of magnitude for a marine mammal receptor

Magnitude	Definition
High	Permanent irreversible change to exposed receptors or feature(s) of the habitat which are of particular importance to the receptor. Assessment indicates that > 1% of the reference population are anticipated to be exposed to the effect. OR

Magnitude	Definition
	Long-term effect for 10 years or more, but not permanent (e.g., limited to operational phase of the Projects). Assessment indicates that > 5% of the reference population are anticipated to be exposed to the effect. OR Temporary effect (e.g., limited to the construction phase of development) to the exposed receptors or feature(s) of the habitat which are of particular importance to the receptor. Assessment indicates that > 10% of the reference population are anticipated to be exposed to the effect.
Medium	Permanent irreversible change to exposed receptors or feature(s) of the habitat of particular importance to the receptor. Assessment indicates that between 0.01% and 1% of the reference population anticipated to be exposed to effect. OR Long-term effect for 10 years or more, but not permanent (e.g., limited to operational phase of the Projects). Assessment indicates that between 1% and 5% of the reference population are anticipated to be exposed to the effect. OR Temporary effect (e.g., limited to the construction phase of development) to the exposed receptors or feature(s) of the habitat which are of particular importance to the receptor. Assessment indicates that between 5% and 10% of the reference population anticipated to be exposed to effect.
Low	Permanent irreversible change to exposed receptors or feature(s) of the habitat of particular importance to the receptor. Assessment indicates that between 0.001% and 0.01% of the reference population anticipated to be exposed to effect. OR Long-term effect for 10 years or more, but not permanent (e.g., limited to operational phase of the Projects). Assessment indicates that between 0.01% and 1% of the reference population are anticipated to be exposed to the effect. OR Intermittent and temporary effect (e.g., limited to the construction phase of development) to the exposed receptors or feature(s) of the habitat which are of particular importance to the receptor. Assessment indicates that between 1% and 5% of the reference population anticipated to be exposed to effect.
Negligible	Permanent irreversible change to exposed receptors or feature(s) of the habitat of particular importance to the receptor. Assessment indicates that < 0.001% of the reference population anticipated to be exposed to effect. OR Long-term effect for 10 years or more (but not permanent, e.g., limited to lifetime of the Projects). Assessment indicates that < 0.01% of the reference population are anticipated to be exposed to the effect. OR Intermittent and temporary effect (limited to the construction phase of development or Project timeframe) to the exposed receptors or feature(s) of the habitat which are of particular importance to the receptor. Assessment indicates that < 1% of the reference population anticipated to be exposed to effect.

12.4.3.2 Significance of effect

48. The assessment of significance of an effect is a function of the sensitivity of the receptor and the magnitude of the impact (see ES Chapter 6 EIA Methodology (Document Reference: 3.3.8) for further details). The determination of significance is guided by the use of a significance of effect matrix, as shown in Table 12.10 . Definitions of each level of significance are provided in Table 12.11 .

49. Should major or moderate effects be identified within the assessment, these would be regarded within this chapter as significant. Should the assessment indicate any likely significant effect, mitigation measures would be identified, where possible, in consultation with the regulatory authorities and relevant stakeholders. The aim of mitigation measures is to avoid or reduce the overall significance of effect to determine a residual effect upon a given receptor.

Table 12.10 Significance of effect matrix

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

Table 12.11 Definition of effect significance

Significance	Definition
Major	Very large or large change in receptor condition, both adverse or beneficial, which are likely to be important considerations at a regional or district level because they contribute to achieving national, regional or local objectives, or could result in exceedance of statutory objectives and / or breaches of legislation.
Moderate	Intermediate change in receptor condition, which are likely to be important considerations at a local level.
Minor	Small change in receptor condition, which may be raised as local issues but are unlikely to be important in the decision making process.
Negligible	No discernible change in receptor condition.
No change	No impact, therefore, no change in receptor condition.

50. Regarding interpreting significance through population modelling, there are currently no specific potential biological removal limits in place in English waters, therefore there are currently no specific thresholds to determine whether a population level effect would be significant in EIA terms.

51. Evans and Arvela (2012) advise that an annual population decline of more than 1% on average over a 12-year period represents unfavourable conservation status. Booth *et al.,* 2016 undertook a study into the use of the iPCoD model for assessing population level effects of offshore wind farm piling in the North Sea. The study assumed that the harbour porpoise population could already be experiencing an annual decline of 1% (in reference to the Evans and Arvela (2012) threshold noted above), and therefore a threshold of an additional 1%

annual decline could be used to determine whether the construction works of offshore wind would result in a disturbed population.

52. Recent Natural Resources Wales (NRW) guidance on this topic concluded that a significant population level of effect would be present in the case of a continued 1% annual decline within a population (NRW, 2023) for a six year period (in line with FCS reporting periods). In the absence of relevant guidance for English waters, the NRW guidance will be used to determine the potential for a significant population level effect at North Falls, and therefore if the population modelling results show a decline of more than 1% (on average) over the initial six year period, it will be concluded that there is a significant impact at the population level.

12.4.4 Cumulative effect assessment methodology

53. The CEA considers other plans, projects and activities that may result in effects to marine mammal populations in cumulation with North Falls. ES Chapter 6 EIA Methodology (Document Reference: 3.3.8) provides further details of the general framework and approach to the CEA.

54. The marine mammal assessment will present relevant cumulative effects of projects based on their stage of development using the tiered approach as devised by Natural England and Defra (2022), as follows:

- Tier 1: built and operational projects;
- Tier 2: projects under construction;
- Tier 3: projects that have been consented (but construction has not yet commenced);
- Tier 4: projects that have an application submitted to the appropriate regulatory body that have not yet been determined;
- Tier 5: projects that have produced a PEIR and have characterisation data within the public domain;
- Tier 6: projects that the regulatory body are expecting to be submitted for determination (e.g., projects listed under the Planning Inspectorate programme of projects); and
- Tier 7: projects that have been identified in relevant strategic plans or programmes.

55. These tiers are used as they are considered more appropriate in comparison to the tiers in The Planning Inspectorate (2019) Advice Note 17 for the types of projects and plans considered in this assessment, in particular for the OWF stages.

56. The types of plans and projects taken into consideration are:

- Other OWFs;
- Other marine renewables (wave and tidal) developments;
- Aggregate extraction and dredging;
- Licenced disposal sites;

- Construction of subsea cables and pipelines;
- Oil and gas development and decommissioning, including seismic surveys;
- Geophysical surveys;
- Coastal developments; and
- UXO clearance.

57. Commercial fishing and commercial shipping activity is not considered in the CEA. Further information and justification is provided in Section 1.4.12 in Appendix 12.6 (Document Reference: 3.3.11).

58. The CEA is a two-part process in which an initial list of potential projects is identified with the potential to interact with the proposed projects based on the mechanism of interaction and spatial extent of the reference population for each marine mammal species. Following a tiered approach, the list of projects is then refined based on the level of information available for this list of projects to enable further assessment.

59. The plans and projects screened into the CEA are:

- Located in the study area (the relevant marine mammal MUs, defined for individual species in Section 12.3.1);
- Offshore projects and developments, if there is the potential for cumulative impacts during the construction, operation or decommissioning of the proposed projects; and
- Offshore wind farm developments, if the construction and/or piling period could overlap with the proposed construction and/or piling period of the other projects, based on best available information on when the developments are likely to be constructed and piling.

60. The CEA will consider projects, plans and activities which have sufficient information available to undertake the assessment. Insufficient information will preclude a meaningful quantitative assessment, and it is not appropriate to make assumptions about the detail of future projects in such circumstances.

61. Given the fast-moving nature of offshore development, it is likely that new projects will arise through the application period. In order to finalise an assessment, it was therefore necessary to have a cut-off period after which no more projects will be considered (or after which no new project specific information will be included). A six-month cut-off date, prior to DCO submission, was therefore agreed through the ETG process.

62. The project tiers considered in the CEA for marine mammals are outlined in Table 12.12 and the CEA screening is provided in Appendix 12.6 (Document Reference: 3.3.11).

Table 12.12 Tiers in relation to project category which have been included in CEA project screening

Project Category	UK	Outside of the UK
Other OWFs	Tier 1, 2, 3, 4, 5, 6, 7	Screened for tier 1, 2, 3, 4, 5, 6, 7
Other renewable developments (tidal and wave)	Tier 1, 2, 3, 4, 5, 6	Screened for tier 1, 2, 3

Project Category	UK	Outside of the UK
Aggregate extraction and dredging	Tier 1, 2, 3, 4	Screened out
Oil and gas installations (including surveying)	Tier 1, 2, 3, 4	Screened out
Shipping	Screened out	Screened out
Planned construction of subsea cables and pipelines	Tier 1, 2, 3, 4, 5, 6	Screened out
Gas storage, offshore mines, and carbon capture projects	Tier 1, 2, 3, 4, 5	Screened out
Coastal developments	Tier 1, 2, 3, 4, 5	Screened out

12.4.5 Transboundary effect assessment methodology

63. The transboundary assessment considers the potential for transboundary effects to occur on marine mammal receptors as a result of North Falls; either those that might arise within the EEZ of European Economic Area (EEA) states, or arising on the interests of EEA states e.g., a European OWF development close to the boundary of the UK EEZ may generate underwater noise effects within UK waters, and vice versa. ES Chapter 6 EIA Methodology (Document Reference: 3.1.8) provides further details of the general framework and approach to the assessment of transboundary effects.

64. For marine mammals, the potential for transboundary impacts has been addressed by considering the reference populations (MUs) and potential linkages to other countries (for example, as identified through seal telemetry studies).

65. The assessment of effects on transboundary Designated Sites is presented in the RIAA (Document Reference: 7.1).

12.4.6 Assumptions and limitations

66. Due to the large amount of data that has been collected for this and other nearby OWFs, as well as other available data for marine mammals within the region, there is a good understanding of the existing environment. There are, however, some limitations to data collected by marine mammal surveys, primarily due to the highly mobile nature of marine mammals and therefore the potential variability in usage of the site; each survey provides only a snapshot. The majority of the surveys, such as SCANS, are typically carried out in summer months which can result in seasonal gaps. However, the site specific surveys were conducted every month during the two year survey period (Appendix 12.2 (Document Reference: 3.3.7)). However, the surveys in the species specific MUs over the last decade show relatively consistent results and taking into account the site-specific survey and data from other surveys, such as nearby OWFs for different months, seasons and years, there is good coverage to provide information on the species likely to be present in the area.

67. There are also limitations in the detectability of marine mammals from aerial surveys, such as not being able to detect those individuals that are submerged.

Appendix 12.2 (Document Reference: 3.3.7) seeks to address these limitations by estimating a correction factor in order to determine estimated absolute density estimates from the site specific aerial surveys.

68. As a precautionary approach, density estimates for each marine mammal species used in the assessments are based on the highest for the area, see Section 12.5.5.Overall, the confidence in the assessment is high as it is deemed precautionary, to comfortably encompass the likely uncertainty and variability. Throughout the assessment it is made clear where multiple and compounding precautionary assumptions have been made.

12.5 Existing environment

69. As outlined in Section 12.2, the marine mammal species considered in this assessment are:

- Harbour porpoise;
- Minke whale;
- Grey seal; and
- Harbour seal.

70. Appendix 12.2 (Document Reference: 3.3.7) provides detailed information for each of the species, including details from the site-specific surveys, density estimates, abundance estimates, distribution, diet and seal haul-out sites, that are relevant for the assessments.

12.5.1 Harbour porpoise

71. Within the southern North Sea area, harbour porpoise are the most common marine mammal species. Heinänen and Skov (2015) identified that within the North Sea, water depth and hydrodynamic variables are the most important factors in harbour porpoise densities in species areas, in both winter and summer seasons. The seabed sediments also play an important role in determining areas of high harbour porpoise density, as well as the number of vessels present in the area.

12.5.1.1 Desk based density estimates

72. Distribution and abundance maps have been developed by Waggitt *et al.* (2019) for cetacean species around Europe. These maps were generated based on a collation of survey effort across the north-east Atlantic between 1980 and 2018, with a total of 1,790,375km of survey effort for cetaceans. All survey data was standardised to generate distribution maps at 10km resolution, with maps generated for each species included for each month of the year.

73. For harbour porpoise, the distribution maps show a clear pattern of high harbour porpoise density in the southern North Sea, and the coasts of south east England, for both January and July (Waggitt *et al.,* 2019). Examination of this data, including all 10km grids that overlap with North Falls, indicates an average annual density estimate of:

- 0.368 individuals per km^2 for the North Falls array area; and
- 0.393 individuals per km^2 for the North Falls offshore cable corridor.

74. Results from the SCANS-IV survey (undertaken in summer 2022; Gilles *et al.,* 2023) also indicate that the occurrence of harbour porpoise is greater in the central and southern areas of the North Sea compared to the northern North Sea. The offshore project area is located in SCANS IV survey block NS-B (see Appendix 12.2 (Document Reference: 3.3.7) where:

- Abundance estimate = 7,982 harbour porpoise (95% Confidence Limit (CL) = 4,865 – 13,033); and
- Density estimate = 0.3096 harbour porpoise/km^2 (Coefficient of Variation (CV) = 0.239).

12.5.1.2 Site specific survey data

75. Data from the North Falls site specific surveys have also been used to generate abundance and density estimates for the array area with a 4km buffer (see Appendix 12.2 (Document Reference: 3.3.7)).

76. Harbour porpoise was the most commonly sighted marine mammal species during the surveys, with a total of 702 individuals recorded through the 24 survey dates. A seasonal pattern of harbour porpoise abundance within North Falls is indicated within the results, with the highest numbers generally recorded in the winter months, while lower numbers were recorded during summer. The highest numbers recorded in a single month were 75 in February 2020 and 55 in November 2020. The lowest number recorded in a survey month was during May 2019 (with just one individual).

77. The average of the winter months, summer months, and annual density has then been calculated based on the maximum calculated for each month. Table 12.13 shows the densities for harbour porpoise, based on all individuals that have the potential to be harbour porpoise. See Appendix 12.2 (Document Reference: 3.3.7) for more information on how these density estimates were derived.

Table 12.13 Maximum harbour porpoise summer, winter and annual density estimates for North Falls

Season	Maximum density estimate (corrected) for whole survey area (harbour porpoise per km^2)
Average winter	3.217
Average summer	1.665
Average annual	2.441

78. It is not currently known at what time of year any activities associated with North Falls will take place, and therefore, as a precautionary approach, the worst case average winter density estimate of harbour porpoise from the site specific surveys (Table 12.13) have been used in the impact assessments. The worst case summer and annual average densities have also been used within the additional assessments for underwater noise related effects; presented in Appendix 12.4 (Document Reference: 3.3.9).

79. In addition to the density estimates, abundance estimates of harbour porpoise at North Falls have been derived from the site surveys. The abundance estimates indicate a clear seasonal pattern in the abundance of harbour porpoise within the entire survey area, with higher numbers present in the winter months. For the winter months, there is an estimated average abundance of

186 per month (for the period of October to March), and for the summer months, there is an average abundance of 116 harbour porpoise within the survey area per month (for the period of April to September).

80. The distribution of harbour porpoise within North Falls is varied, with individuals present across the survey area. There is no evident pattern of harbour porpoise distribution within the survey area, with no indication of a particular area of importance.

12.5.1.3 Population estimates

81. IAMMWG defined three MUs for harbour porpoise: NS; West Scotland; and the Celtic and Irish Sea. The offshore project area is located in the NS MU. The most recent estimate of harbour porpoise abundance in the North Sea MU is provided by Gilles *et al*. (2023), with a population estimate of 338,918 (95%; CL = 243,063 – 476,203; Gilles *et al*., 2023). This is the reference population for harbour porpoise, which any potential impacts will be assessed against.

12.5.2 Minke whale

82. The JCP Phase III Report (Paxton *et al.,* 2016) identified a total of 1,860 minke whale sightings within the UK offshore area. The density of minke whale was predicted to be highest along the northern coast of the UK, from Yorkshire north to the Kintyre Peninsula. The resultant density maps produced in the JCP Phase III Report (Paxton *et al.,* 2016) shows a minke whale density of <0.04 per km^2 for the southern North Sea (97.5% CI = 0-0.02 – 0.08 per km^2), below the Humber Estuary and Flamborough Head.

12.5.2.1 Desk based density estimates

83. For minke whale, the distribution maps (Waggitt *et al.,* 2019) show a clear pattern of higher density in the northern North Sea, and around the coasts of Scotland, Ireland and within the Celtic and Irish Seas, with decreasing densities southwards of Scotland along the east coast of England. There is a clear seasonal difference in the densities of minke whale, with higher densities in July, which is particularly evident in the north of their range (Waggitt *et al.,* 2019). Examination of this data, including all 10km grids that overlap with the offshore project area indicates the following density estimates:

- 0.0011 individuals per km^2 for the array area; and
    - 0.0015 individuals per km^2 within the summer season (April to September)
    - 0.0008 individuals per km^2 within the winter season (October to March)
- 0.001 individuals per km^2 for the offshore cable corridor.
    - 0.0014 individuals per km^2 within the summer season (April to September)
    - 0.0007 individuals per km^2 within the winter season (October to March)

84. For the entire SCANS-IV survey area, minke whale abundance in the summer of 2022 was estimated to be 12,417 with an overall estimated density of 0.0085/km^2 (CV = 0.361; 95% CL = 7,038-26,943; Gilles *et al*., 2023).

85. The offshore project area is located in SCANS-IV survey block NS-B, but as there were no recordings within Block NS-B, the adjacent block NS-H estimates will be used (Gilles *et al.,* 2023)[5]:

- Abundance estimate = 1,061 minke whale (95% CL = 231-2,771); and
- Density estimate = 0.0153 minke whale/km^2 (CV=0.552).

86. The impact assessments for minke whale are based on the SCANS-IV survey density estimate for survey block NS-H of 0.0153 minke whale/km^2 (Gilles *et al.,* 2023), as a worst case. Additional assessments based on the site specific Waggitt *et al.* (2019) densities are also used to inform an assessment within Appendix 12.4 (Document Reference: 3.3.9) for underwater noise related effects, to be referred to for information purposes only.

12.5.2.2 Site specific survey data

87. During the North Falls site specific aerial surveys (24 surveys undertaken between March 2019 and February 2021), a single minke whale was identified in September 2019.

12.5.2.3 Population estimates

88. There is a single MU for minke whale; the CGNS MU (see Appendix 12.2 (Document Reference: 3.3.7)). The reference population for minke whales in the CGNS MU is 20,118 animals (CV = 0.18; 95% Confidence Interval (CI) = 14,061 – 28,786; IAMMWG, 2023).

12.5.3 Grey seal

12.5.3.1 Movement and haul-outs

89. There is a considerable amount of movement of grey seals that occurs (as observed from telemetry data; see Appendix 12.2 (Document Reference: 3.3.7)) among the different areas and regional subunits of the North Sea, and no evidence to suggest that grey seals on the North Sea coasts of Denmark, Germany, the Netherlands or France are independent from those in the UK (SCOS, 2022).

90. Compared with other times of the year, grey seals in the UK spend longer hauled out during their annual moult (between December and April) and during their breeding season, in eastern England, pupping occurs mainly between early November and mid-December (SCOS, 2022).

91. The array area is located approximately 40km offshore (at the closest point to shore).

92. In 2021, the ZSL conducted a seal population survey in the outer Thames Estuary (SCOS, 2021; Cox, 2021). A total of 749 grey seal were counted during

[5] The SCANS-IV survey block NS-H was used instead of other adjacent blocks due to having the worst case density estimate

the 2021 survey, which results in a population estimate of 3,134 grey seals (95% CI 2,619 – 3,901) (Cox, 2021).

93. A number of seal haul-out sites are located within the outer Thames estuary, where seals use sandbanks to haul-out. These are intertidal haul-out sites and not always available to seals, and therefore are unlikely to be used as pupping sites. See Appendix 12.2 (Document Reference: 3.3.7) for a full review of the nearby grey seal sites.

94. The closest of these sites is Kentish Knock, approximately 16km at closest point to the offshore project area, with approximately 200 seal species recorded at the site in 2021 (Cox, 2021). Other nearby haul-sites for grey seal include Sunk and Knock John, with up to 40 grey seals counted in 2021 (approximately 25km from the offshore project area; Cox, 2021) and the Margate Sands and Pan Sands Ridge sites, approximately 43.5km from the offshore project area, and with approximately 280 grey seal recorded in 2021 (Cox, 2021).

12.5.3.2 Site specific survey data

95. A relatively low number of grey seal were recorded during the site-specific aerial surveys, with a total of 13 individuals recorded during the 24 surveys, however, in addition a total of 23 unidentified seal species were recorded, as well as 17 seal / small cetacean species, a proportion of which are expected to be grey seal.

96. Throughout the surveys the numbers of grey seal, or individuals that could be grey seal (i.e., seal species and seal / small cetacean species) were relatively similar year-round, with no clear change seasonally. Due to the low number of grey seal sightings, absolute density and abundance estimates were not possible to derive from the site-specific surveys.

12.5.3.3 Desk based density estimates

97. Carter *et al*. (2022) provides habitat-based predictions of at sea distribution for seals around the British Isles. The habitat preference approach predicted distribution maps provide estimates per species, on a 5km by 5km grid, of relative at sea density for seals hauling-out in the British Isles (Figure 12.1 (Document Reference: 3.2.8)). It is important to note that Carter *et al.* (2022) provides relative density (i.e., percentage of the total at sea population in each grid at any one time), whereas previous usage maps (Russell *et al.,* 2017) have presented absolute density (i.e., number of animals within each grid at any one time). See Appendix 12.2 (Document Reference: 3.3.7) for more information.

98. The grey seal density estimates for North Falls have been calculated from the seal at sea usage maps (Carter *et al.,* 2022) based on the 5km x 5km grids that overlap with the offshore project area (see Appendix 12.2 (Document Reference: 3.3.7)). The total grey seal population in the British Isles, at sea, is approximately 153,591 individuals, based on the corrected values and most recent haul-out counts for the UK (SCOS, 2022). This is the population estimate used with the Carter *et al.* (2022) data to calculate density estimates for North Falls.

99. The mean at sea relative density estimates for these areas have been calculated from Carter *et al.* (2022);

- 0.07 individuals per km^2 for the total array area; and

- 0.19 individuals per km^2 for the total export cable area.

12.5.3.4 Population estimates

100. The reference population extent for grey seal incorporates the SE England MU and NE England MU (IAMMWG, 2013; SCOS, 2022), to take into account the wide ranging movement of grey seal as indicated by tagging studies (see Appendix 12.2 (Document Reference: 3.3.7)).

101. These have also been corrected to take account of the number of seals not available to count during the surveys. Approximately 0.2515 grey seals are available to count within the August surveys (i.e., are hauled-out; SCOS, 2022), and therefore this has been used as a correction factor, to derive total grey seal numbers within each MU, rather than the number counted within each MU.

102. The reference population for grey seal is therefore currently based on the most recent estimates as shown in Table 12.14.

Table 12.14 Grey seal counts and population estimates

Population area	Grey seal haul-out count	Source of haul-out count data	Correction factor for seals not available to count	Grey seal total population
SE England MU	7,694	SCOS 2022	0.2515	30,592
NE England MU	6,517	SCOS 2022	0.2515	25,913
Total wider reference population	**14,211**	**-**	**0.2515**	**56,505**

103. The SE MU population is used as the reference population in all assessments; which is 30,592 grey seals. The assessments will also be put into context of the wider reference population (of 56,505). As a worst case it is assumed that all seals are from the nearest MU, the SE England MU, although the more realistic assessment is based on wider reference population which takes into account the movement of seals.

12.5.4 Harbour seal

12.5.4.1 Movement and haul-outs

104. The array area is located approximately 40km offshore at the closest point to shore.

105. In the 2021 ZSL seal population survey, a total of 498 harbour seal were counted, with a resulting population estimate of 692 harbour seal (95% CI = 566 – 922) (Cox, 2021). A number of seal haul-out sites are located within the outer Thames estuary, with seals using sandbanks to haul-out. These are intertidal haul-out sites and not always available to seals, and therefore are unlikely to be used as pupping sites. See Appendix 12.2 (Document Reference: 3.3.7) for a full review of the nearby harbour seal sites.

106. The closest of these sites is Hamford Water, at approximately 8km from the offshore project area, with between 11 and 20 harbour seal recorded in 2021 (Cox, 2021), and Buxey Sand North at approximately 11km from the offshore project area, with up to 10 harbour seal counted in 2021 (Cox, 2021). Other nearby haul-sites for harbour seal include Sunk and Knock John, with up to 30 harbour seal counted in 2021 (approximately 25km from the offshore project

area; Cox, 2021), Kentish Knock at approximately 16km at closest point to the offshore project area, with approximately 200 seal species recorded at the site in 2021 (Cox, 2021). and the Margate Sands sites, approximately 43.5km from the offshore project area, and with approximately 140 harbour seal recorded in 2021 (Cox, 2021).

12.5.4.2 Site specific survey data

107. No harbour seal sightings were confirmed during the site-specific aerial surveys, however there was a total of 23 individuals within unidentified seal species and 17 individuals within the seal/ small cetacean group recorded through the 24 survey dates, a proportion of which could be harbour seal (although the majority are expected to be grey seal).

12.5.4.3 Desk based density estimates

108. Impact assessments will be based on densities as derived from desk-based sources. As outlined in Section 12.5.3, Carter *et al.* (2022) provides habitat-based predictions of at sea distribution for harbour seal around the British Isles. The habitat preference approach predicted distribution maps provide estimates per species, on a 5km by 5km grid, of relative at sea density for seals hauling-out in the British Isles (Figure 12.2 (Document Reference: 3.2.8)).

109. The harbour seal density estimates for North Falls have been calculated from the latest seal at sea maps produced by SMRU (Carter *et al.,* 2022), based on the 5km x 5km grids that overlap with each area (see Appendix 12.2 (Document Reference: 3.3.7). The total harbour seal population in the British Isles, at sea, is approximately 39,878 individuals, based on the corrected values and most recent haul-out counts for the UK (SCOS, 2022). This is the population estimate used with the Carter *et al.* (2022) data to calculate density estimates for North Falls.

110. The mean at sea density estimates for these areas have been used in the assessment:

- 0.00048 individuals per km^2 for the total array area; and
- 0.11 individuals per km^2 for the export cables.

12.5.4.4 Population estimates

111. The reference population extent for harbour seal will incorporate the SE England MU (IAMMWG, 2013; SCOS, 2022).

112. These have also been corrected to take account of the number of seals not available to count during the surveys. Approximately 0.72 harbour seals (Lonergan *et al*., 2013) are available to count within the August surveys (i.e., are hauled-out), and therefore this has been used as a correction factor, to derive total harbour seal numbers within each MU, rather than the number counted within each MU.

113. The reference population for harbour seal is therefore currently based on the most recent estimate as shown in Table 12.15.

Table 12.15 Harbour seal counts and population estimates

Population area	Harbour seal haul-out count	Source of haul-out count data	Correction factor for seals not available to count	Harbour seal total population
South East (SE) England MU	3,505	SCOS 2022	0.72	4,868

114. The total reference population for the assessment is 4,868 harbour seal. As a worst case it is assumed that all seals are from the nearest MU; the SE England MU.

115. As outlined in Appendix 12.2 (Document Reference: 3.3.7), there are indications of a current decline in the numbers of harbour seal in The Wash. The assessments are based on the current harbour seal counts at the time of writing, however any assessments will be based on the latest harbour seal counts at that time to take account of any changes.

12.5.5 Summary of marine mammal densities and reference populations for assessments

116. Table 12.16 and Table 12.17 provide a summary of the reference populations and the density estimates for the marine mammal species used in the impact assessment. For both seal species, the density used is dependent on the spatial area of the impact itself (i.e. for all activities within the array area, only the array area density has been used, and for activities within either the array area or the cable corridor, both densities have been used).

Table 12.16 Summary of marine mammal reference populations used in the impact assessments

Species	Reference population extent	Population	Source
Harbour porpoise	NS MU	338,918	SCANS IV (Gilles et al., 2023)
Minke whale	CGNS MU	20,118	IAMMWG (2023)
Grey seal	SE England MU	30,592	Corrected from haul-out count in SCOS (2022)
	Wider reference population = (SE England MU and NE England MU)	56,505 (30,592; 25,913)	Corrected from haul-out counts in SCOS (2022)
Harbour seal	SE England MU	4,868	Corrected from haul-out counts in SCOS (2022)
	Wider reference population = (SE England MU)	4,868	Corrected from haul-out counts in SCOS (2022)

Table 12.17 Summary of marine mammal density estimates (those shown in bold have been used to inform the effect assessments within this chapter, all other density estimates have been used within

assessments provided in Appendix 12.4 (Document Reference: 3.3.9), to be referred as additional information only)

Species	Area of density estimate	Density estimate (individuals per km^2)	Source
Harbour porpoise	**Array area (winter season, as worst case)**	**3.217**	Site-specific surveys
	Array area (summer season)	1.665	
	Array area (annual estimate)	2.441	
	SCANS IV Block	0.3096	Gilles *et al*. (2023)
Minke whale	**SCANS IV Block**	**0.0153**	
	Array area (annual estimate)	0.0011	Waggitt *et al*. (2019)
	Array area (summer season, as worst case)	0.0015	
Grey seal	**Array area (average density)**	**0.07**	Carter *et al*. (2022)
	Offshore cable area	**0.19**	
Harbour seal	**Array area (average density)**	**0.00048**	
	Offshore cable area	**0.11**	

12.5.6 Future trends in baseline conditions

117. In the event that North Falls is not developed, an assessment of the future conditions for marine mammals has been carried out and is described within this section.

118. The existing baseline conditions for marine mammals are considered to be relatively stable, for most species. The baseline environment of the southern North Sea has been influenced by the oil and gas industry since the 1960s, fishing by various methods for hundreds of years and the construction and operation of OWFs for over ten years (Kentish Flats in 2005; Lynn and Inner Dowsing in 2009). In January 2024, the Department for Environment, Food & Rural Affairs (DEFRA) announced a permanent closure of the sandeel fisheries in English waters of the North Sea from April (2024). Sandeels are a vital food source for marine mammals, therefore one of the benefits of the closure is likely to be the recovery and improvement of a key prey harbour porpoise prey species.

119. The baseline will continue to evolve as a result of global trends which include the impacts of climate change. The potential impacts of climate change on marine mammals can be direct, such as the impacts of rising sea levels on seal haul-out sites, or species tracking a specific range of water temperatures in which they can physically survive. Indirect impacts of climate change include changes in prey resources affecting distribution, abundance and migration patterns, community structure, susceptibility to disease and contaminants. Ultimately, these can impact on the reproductive success and survival of marine mammals and, hence, have consequences for populations (Learmonth *et al.,* 2006).

120. As reviewed in BEIS (2022b), significant change has been documented in many aspects of the UK marine environment, likely due to an array of factors including climatic influences, nutrient inputs and anthropogenic factors, such as fishing. These changes include rising sea temperatures, biogeographical shifts in many zooplankton assemblages, with a northward extension of warm-water species, changes in the distribution and abundance of fish species, with southern species becoming more prominent.

12.5.6.1 Harbour porpoise

121. Despite no overall change in population size, large scale changes in the distribution of harbour porpoise were observed between SCANS-I in 1994 and SCANS-II in 2005, with the main concentration shifting from north-eastern UK and Denmark to the southern North Sea. Such large-scale changes in the distribution of harbour porpoise are likely the result of changes to the resources of their principal prey species, such as sandeel, within the North Sea (SCANS-II, 2008).

122. The observed distribution of harbour porpoises from the SCANS-III survey in summer 2016 was similar to that observed in SCANS-II in 2005 (Hammond *et al.,* 2013). Although, one notable difference is that more sightings were made throughout the English Channel (block C) in 2016 than previous surveys (Hammond *et al.,* 2021). The progressive spread of sightings into most of the Channel over the past two decades indicates that harbour porpoise distribution has expanded, probably from the North Sea and the Celtic Sea, and now encompasses the entire Channel, at least in summer (Hammond *et al.,* 2021; Lacey *et al*., 2022).

123. During the SCANS-IV survey (undertaken in summer 2022), the distribution of harbour porpoises is shown to be similar to that of SCANS-III (for summer 2016), suggesting very little change. However, in line with the differences observed between SCANS-II and III as described above, the number harbour porpoise in the English Channel has steadily increased, and has been since 1994, indicating a long-term shift in harbour porpoise distributions (Gilles *et al*., 2023).

124. The overall abundance estimate for the North Sea in 2022 is comparable to estimates in 2016 and 2005, suggesting no significant change in harbour porpoise abundance in the North Sea (Gilles *et al*., 2023).

125. The impacts of climate change on harbour porpoise populations are still relatively unknown, however, it is expected that there will be impacts to the population through prey depletion and range shifts. Harbour porpoise habitat and population range is determined from their preferred prey resources, and therefore a change in prey range has the potential to cause a change in the distribution of harbour porpoise (Evans and Bjorge, 2013; Ransijn *et al.,* 2019). As outlined above, a shift southward of harbour porpoise has been noted within the North Sea (Hammond *et al.,* 2021), and it is possible that this was due to a loss of sandeel resources in the northern parts of the North Sea (Evans and Bjorge, 2013).

12.5.6.2 Minke whale

126. SCANS found no evidence of a trend in abundance of minke whale in the North Sea since the mid-1990s (Hammond *et al.,* 2021). However, a decade of

acoustic observations in the western North Atlantic have shown important distributional changes over the range of baleen whales, mirroring known climatic shifts (Davies *et al.,* 2020).

127. Based on the modelled density maps for the SCANS-III survey (Lacey *et al.,* 2022), minke whales have the highest density in the central and northeastern North Sea, which is similar to distributions seen in 1994 and 2005-2007, with the exception of a high density in the Celtic Sea present in previous years. Gilles *et al.* (2023) reported a southward shift in the distribution of minke whales in the North Sea between SCANS-I (1994) and SCANS-II (2005), with a similar distribution in SCANS-III (2016). The 2022 SCANS-IV survey demonstrates a shift southwards, which suggests a potential extension of their range in summer.

128. For minke whale, the overall abundance estimate for 2022 in the North Sea was similar to previous SCANS estimates, although lower than the Norwegian survey in 2018. Population trend analysis since 1989 shows no evidence of a significant change in minke whale abundance in the North Sea (Gilles *et al*., 2023).

12.5.6.3 Grey seal

129. There has been a continual increase in the total UK grey seal pup production since regular surveys began in the 1960s (SCOS, 2022). While grey seal pup production at colonies in the North Sea increased rapidly up to 2016, with an annual increase of 7.5% per year from 2014 to 2018, there has more recently been a stable but declining trend in pup production in north Scotland and Orkney (SCOS, 2022). The majority of the increase in the North Sea has been due to the continued rapid expansion of newer colonies on the mainland coasts in Berwickshire, Lincolnshire, Norfolk and Suffolk. Interestingly, these colonies are all at easily accessible sites on the mainland, where grey seals have probably not bred in significant numbers since before the last ice age (SCOS, 2020).

130. In the southern North Sea, the rates of increase in pup production from 2010 to 2014 by an average of 22% per year suggests that there must be some immigration from colonies further north (SCOS, 2019). The colonies in the southern North Sea are still increasing in population size, but the rate has been much lower in the last three years, giving an early indication that they may be reaching carrying capacity (SCOS 2022) as recorded with grey seal populations in other areas such as Orkney (SCOS, 2022).

12.5.6.4 Harbour seal

131. Overall, the UK population of harbour seal has increased since the late 2000s and is close to the previous high observed during the 1990s (SCOS, 2020). However, there are significant differences in the population dynamics between seal management units, with general declines in counts of harbour seals in several regions around Scotland and more recently in east England. Recent trends, i.e., those that incorporate the last 10 years show significant growth in both MUs on the east coast of England up to 2018, but the 2019 count was approximately 27.6% lower than the mean of the previous 5 years in the SE England MU (SCOS, 2020). The most recent estimate from 2021 is 3,659, marking a 25% decrease from the totals in 2016-2018 and representing the lowest count in around a decade (SCOS, 2022).

132. In The Wash between 2006 and 2012 the counts of harbour seal approximately doubled and increased by 50% for East Anglia as a whole. Since 2012 the counts in these areas have been almost constant. The 2018 count was the second highest ever recorded in The Wash and was consistent with the pattern of relatively stable population since 2010. However, the 2019 count was 27% lower than the 2012 to 2018 mean count (SCOS, 2021). Along the East Anglian coast, the 2018 count was 17% higher than the 2017 count and similar to the average for the preceding five years.

133. This continues the pattern of high inter annual variability (SCOS, 2021). As outlined in SCOS (2021), these wide fluctuations are not unusual in the long-term time series and despite the apparently wide inter-annual variation, the pup production has increased at around 5.6% per year since surveys began in 2001, although the rate of increase may have slowed and may be reaching an asymptote (SCOS, 2021). The count for The Wash and North Norfolk SAC has decreased by approximately 19% over the same time periods, while Donna Nook and Scroby Sands showed a 38% decrease (SCOS, 2022). The harbour seal decline is evident at all sites and appears to have affected all sub-sections of The Wash & North Norfolk SAC (SCOS, 2022).

134. Harbour seal counts in 2019 to 2022 that were carried out during the harbour seal moult, when the highest numbers are hauled out, over all were much lower, indicating a decline of 20 to 30%.

135. It is unsure what factors is driving the decline, but the most likely main drivers could be increased competition with grey seal, anthropogenic activities, disease or toxins or interactions therein (SCOS, 2022). This decline is a clear cause for concern and emergency funding for additional surveys has been provided by Defra. A proposed programme of research to investigate the causes of this decline is being developed (SCOS, 2022).

12.5.6.5 Summary

136. For marine mammals, there are some evident climate change related trend variations and it is reasonable to expect further shifts in the future and over the lifetime of North Falls. However, the latest changes in population distribution and abundance have been considered in the assessments that have been undertaken.

12.6 Assessment of significance

137. Potential impacts for consideration and the applicable assessment methodologies were agreed with the stakeholders at the first ETG meeting (3rd December 2019) and through the scoping process.

12.6.1 Likely effects during construction

138. Potential construction effects may arise through the installation of offshore infrastructure. Amongst these, generation of underwater noise during piling, as well as disturbance associated with underwater noise from other construction activities and the presence of vessels offshore, are considered. Potential displacement from important habitat areas and impacts on prey species are also considered.

139. The potential impacts during construction assessed for marine mammals are:

- Impact 1: Auditory injury and disturbance or behavioural effects resulting from underwater noise during piling, and due to Acoustic Deterrent Device (ADD) activation prior to piling;
    - Impact 1a: Permanent auditory injury (PTS) due to impact piling.
    - Impact 1b: Temporary auditory injury (TTS) due to impact piling.
    - Impact 1c: Disturbance due to impact piling.
    - Impact 1d: Disturbance due to ADD activation prior to piling.
- Impact 2: Auditory injury and disturbance or behavioural effects resulting from underwater noise during other construction activities, including seabed preparations, rock placement and cable installation;
    - Impact 2a: Permanent auditory injury (PTS) due to other construction activities.
    - Impact 2b: Temporary auditory injury (TTS) due to other construction activities.
    - Impact 2c: Disturbance due to other construction activities.
- Impact 3: Underwater noise and disturbance from construction vessels;
    - Impact 3a: Permanent auditory injury (PTS) due to construction vessels.
    - Impact 3b: Temporary auditory injury (TTS) due to construction vessels.
    - Impact 3c: Disturbance due to construction vessels.
- Impact 4: Barrier effects from underwater noise during construction;
- Impact 5: Increased risk of collision with vessels during construction;
- Impact 6: Disturbance at seal haul-out sites;
- Impact 7: Changes to water quality; and
- Impact 8: Changes to prey resource.

140. The realistic worst case scenario on which the assessments are based is outlined in Table 12.1.

141. A separate Marine Licence (ML) application for UXO clearance will be submitted post-consent, once detailed information on the locations and extent of UXO required to be cleared is known. An assessment of the potential impacts from UXO clearance at North Falls is provided in Appendix 12.5 (Document Reference: 3.3.10) for information purposes only. The potential cumulative impacts from UXO clearance at other OWFs during piling North Falls are assessed in Section 12.9.3.1.3.

12.6.1.1 Impact 1: Effects of underwater noise associated with piling

142. A range of foundation options are being considered for North Falls, including monopiles, jackets (with pin piles), suction buckets for both monopiles and jacket pin piles, and gravity-based for both monopiles and jacket pin piles (see Section 12.3.2). Of these, monopiles and jackets (with pin piles) may require

piling. As a worst case scenario for underwater noise, it has been assumed that all foundations could be piled, although drive-drill-drive installation may be used.

143. Impact piling is a source of high-level underwater noise, which can cause both physiological (e.g., lethal, physical injury and auditory injury) and behavioural (e.g., disturbance and masking of communication) impacts on marine mammals.

144. Should a marine mammal be very close to the source, the high peak pressure sound levels have the potential to cause death or physical injury, with any severe injury potentially leading to death, if no adequate mitigation is in place. High exposure levels from underwater noise sources can cause auditory injury or hearing impairment, taking the form of a permanent loss of hearing sensitivity (PTS), or a temporary loss in hearing sensitivity (TTS). The potential for auditory injury is not just related to the level of the underwater sound and its frequency relative to the hearing bandwidth of the animal, but is also influenced by the duration of exposure. The level of impact on an individual is a function of the Sound Exposure Level (SEL) that an individual receives as a result of underwater noise.

145. The potential impact of underwater noise will depend on a number of factors which include, but are not limited to:

- The source levels of noise;

146. Frequency relative to the hearing bandwidth of the animal (dependent upon species);

- Propagation range, which is dependent upon;
  - Sediment/sea floor composition; and
  - Water depth;
- Duration of exposure;
- Distance of the animal to the source; and
- Ambient noise levels.

12.6.1.1.1 Underwater noise modelling

147. Underwater noise modelling was undertaken by Subacoustech Environmental Ltd to estimate the noise levels likely to arise during noisy activities (Appendix 12.3 (Document Reference: 3.3.8)), and determine the potential impacts on marine mammals. Key information on the methodology of underwater noise modelling, and the full results of the assessments for marine mammals, is provided in Appendix 12.4 (Document Reference: 3.3.9).

148. Underwater noise modelling was undertaken against the currently recommended marine mammal injury thresholds presented in Southall *et al*., 2019.

12.6.1.1.2 Impact 1a: Permanent auditory injury (PTS) due to impact piling

Sensitivity of marine mammals

149. All species of cetaceans rely on sonar for navigation, finding prey and communication; they are therefore highly sensitive to permanent hearing

damage (Southall *et al.,* 2007). As such, sensitivity to PTS from pile driving noise is assessed as high for all cetacean species. However, when considering the impact that any auditory injury has on an individual, the frequency range over which the auditory injury occurs must be considered. PTS would normally only be expected in the critical hearing bands in and around the critical band of the fatiguing sound (Kastelein *et al.,* 2012). Auditory injury resulting from sound sources like piling (where most of the energy occurs at lower frequencies) is unlikely to negatively affect the ability of high-frequency cetaceans to communicate or echo-locate. PTS would not result in an individual being unable to hear but could result in some permanent change to hearing sensitivity.

150. Pinnipeds use sound both in air and water for social and reproductive interactions (Southall *et al.,* 2007), but not for finding prey. Therefore, Thompson *et al.* (2012) suggest damage to hearing in pinnipeds may not be as sensitive as it could be in cetaceans. Pinnipeds also have the ability to hold their heads out of the water during exposure to loud noise, and potentially avoid PTS during piling. As such, sensitivity to PTS in harbour and grey seal is expected to be lower than cetacean species such as harbour porpoise, with the individual showing some tolerance to avoid, adapt to or accommodate or recover from the impact (for example, Russell *et al.,* 2016b), but as a precautionary approach they are also considered as having high sensitivity in this assessment.

151. Any PTS would be permanent, and marine mammals within the potential impact area are considered to have very limited capacity to avoid such impacts, and unable to recover from the impacts.

152. PTS can occur instantaneously from acute exposure to high noise levels, such as single strike (SPL_{peak}) of the maximum hammer energy applied during piling. PTS can also occur as a result of prolonged exposure to increased noise levels, such as during the duration of pile installation (SEL_{cum}).

153. All marine mammal species are assessed as having high sensitivity to PTS.

Magnitude of impact

PTS from a single strike

154. The full underwater noise modelling results and assessments are provided in Appendix 12.4 (Document Reference: 3.3.9) for the potential for PTS due to a single strike at either the starting or the maximum hammer energy.

155. Table 12.18 and Figure 12.3 (Document Reference: 3.2.8) present the underwater noise modelling results for the predicted impact ranges and areas for PTS from a single strike of both a single strike and the maximum hammer energy for the worst case location. The potential impact range for PTS is highest for harbour porpoise for both monopiles and jacket pin piles, with a potential PTS range of 680m and 630m respectively.

156. The worst-case for a single hammer strike is for full hammer energy, and therefore this has been used to inform the following assessments. An assessment of the potential impact from a single strike at the starting hammer energy has been provided in Appendix 12.4 (Document Reference: 3.3.9).

Table 12.18 The predicted impact ranges for PTS in all marine mammal species, at the worst case modelling location, for the maximum hammer energies of both monopiles and pin piles

Marine mammal species	Potential impact ranges (and areas) for PTS from a single strike	
	Monopile	Jacket pin pile
Single strike from the starting hammer energy	**900kJ**	**660kJ**
Harbour porpoise	310m (0.29km^2)	240m (0.17km^2)
Minke whale	<50m (0.01km^2)	<50m (<0.01km^2)
Grey seal	<50m (0.01km^2)	<50m (0.01km^2)
Harbour seal		
Single strike from the maximum hammer energy	**6,000kJ**	**4,400kJ**
Harbour porpoise	680m (1.40km^2)	630m (1.2km^2)
Minke whale	<50m (0.01km^2)	<50m (<0.01km^2)
Grey seal	60m (0.01km^2)	50m (0.01km^2)
Harbour seal		

157. An assessment of the maximum number of individuals that could be at risk of instantaneous PTS, due to a single strike at the maximum hammer energy, for both monopiles and jacket pin piles, is presented in Table 12.19, based on the impact areas as presented in Table 12.18. An assessment against all marine mammal densities is provided in Appendix 12.4 (Document Reference: 3.3.9), including the summer seasonal density for harbour porpoise.

158. The magnitude of impact is assessed as low for harbour porpoise and negligible for all other species, for either monopiles or jacket pin piles (Table 12.19).

Table 12.19 Assessment of the potential for instantaneous PTS due to a single strike of the maximum hammer energy for a monopile and jacket pin pile (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Marine mammal species	Assessment of impact	Magnitude of impact
PTS due to a single strike of a monopile at maximum hammer energy (SPL_{peak})		
Harbour porpoise	5 harbour porpoise (0.0013% of the NS MU reference population).	Low
Minke whale	0.0002 minke whale (0.000001% of the CGNS MU reference population).	Negligible
Grey seal	0.001 grey seal (0.000002% of the SE England MU reference population; or (0.000001% of the wider reference population).	Negligible
Harbour seal	0.000005 harbour seal (0.0000001% of the SE E MU reference population).	Negligible
PTS due to a single strike of a jacket pin pile at maximum hammer energy (SPL_{peak})		
Harbour porpoise	4 harbour porpoise (0.0011% of the NS MU reference population).	Low
Minke whale	0.0002 minke whale (0.000001% of the CGNS MU reference population).	Negligible

Marine mammal species	Assessment of impact	Magnitude of impact
Grey seal	0.001 grey seal (0.000002% of the SE England MU reference population, or 0.000001% of the wider reference population).	Negligible
Harbour seal	0.000005 harbour seal (0.000001% of the SE England MU reference population).	Negligible

PTS from cumulative exposure

159. The Cumulative Sound Exposure Level (SEL_{cum}) is a measure of the total received noise over the whole piling operation. The SEL_{cum} range indicates the distance from the piling location that if the receptor were to start fleeing in a straight line from the noise source starting at a range closer than the modelled range it would receive a noise exposure in excess of the criteria threshold, and if the receptor were to start fleeing from a range further than the modelled range it would receive a noise exposure below the criteria threshold (see Appendix 12.3 (Document Reference: 3.3.8) and Appendix 12.4 (Document Reference: 3.3.9) for further details).

160. The full underwater noise modelling results and assessments are provided in Appendix 12.4 (Document Reference: 3.3.9) for the potential for PTS due to the cumulative exposure of both monopile and jacket pin pile installations.

161. Table 12.20 presents the underwater noise modelling results for the predicted impact ranges and areas for PTS due to the cumulative exposure of monopiles and jacket pin piles at the worst case location. The potential impact range for PTS is highest for minke whale for both jacket pin piles and monopiles, with a potential cumulative PTS range of 6.9km and 7km respectively, for multiple piles in a 24 hour period. The potential cumulative impact ranges are the same for either one or three sequential monopiles, or for one or six sequential jacket pin piles, with the exception of harbour porpoise cumulative exposures from jacket pin piles, with a PTS impact range of 3.3km for one jacket pin pile, and an impact range of 3.4km for six sequential installations.

162. It should be noted that there is a lot of variation in the potential impact ranges for SEL_{cum} at each location and between locations (Appendix 12.3 (Document Reference: 3.3.8)). For example, for harbour porpoise, the PTS impact range for three sequential monopile installations is 3.3km at the East location, and 2.2km at the West location, and therefore while the assessment is based on the worst-case ranges at the East location, many of the piling locations would have lower impact ranges. It should be noted, the maximum hammer energy is only likely to be required at a few of the piling installation locations and for shorter periods of time.

Table 12.20The predicted impact ranges for PTS in all marine mammal species, at the worst case modelling location, for the cumulative exposure of both monopiles and pin piles

Marine mammal species	Potential impact ranges (and areas) for PTS due to cumulative exposure	
	Monopile (6,000kJ)	Jacket pin pile (**4,400kJ**)
Single pile installation in a 24 hour period	**One monopile**	**One jacket pin pile**

Marine mammal species	Potential impact ranges (and areas) for PTS due to cumulative exposure	
	Monopile (6,000kJ)	Jacket pin pile (**4,400kJ**)
Harbour porpoise	3.30km (22.0km^2)	3.30km (22.0km^2)
Minke whale	7.0km (94.0km^2)	6.9km (85.0km^2)
Grey seal	100m (0.10km^2)	<100m (<0.10km^2)
Harbour seal		
Multiple sequential pile installations in a 24 hour period	**Three sequential monopiles**	**Six sequential jacket pin piles**
Harbour porpoise	3.30km (22.0km^2)	3.40km (23.0km^2)
Minke whale	7.0km (94.0km^2)	6.90km (85.0km^2)
Grey seal	100m (0.10km^2)	<100m (<0.10km^2)
Harbour seal		

163. Assessments for the modelling of a single pile in 24 hours are provided in Appendix 12.5 (Document Reference: 3.3.10), and the assessments for three sequential monopiles or six sequential pin piles in a 24 hour period are provided below, as the worst case.

164. An assessment of the maximum number of individuals that could be at risk of cumulative PTS, for both sequential monopiles and jacket pin piles, is presented in Table 12.21, based on the impact areas as presented in Table 12.20. An assessment against all marine mammal densities is provided in Appendix 12.4 (Document Reference: 3.3.9), including the summer seasonal density for harbour porpoise.

165. The magnitude of impact is assessed as medium for harbour porpoise, low for minke whale, and negligible for grey seal and harbour seal for both monopiles and jacket pin piles (Table 12.21).

Table 12.21 Assessment of the potential for PTS due to the cumulative exposure of sequential monopiles or jacket pin piles in a 24 hour period (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Marine mammal species	Assessment of impact	Magnitude of impact
PTS due to the cumulative exposure of three sequential monopiles in a 24 hour period (SEL_{cum})		
Harbour porpoise	71 harbour porpoise (0.02% of the NS MU reference population).	Medium
Minke whale	2 minke whale (0.01% of the CGNS MU reference population).	Low
Grey seal	0.007 grey seal (0.00002% of the SE England MU reference population, or 0.00001% of the wider reference population).	Negligible
Harbour seal	0.00005 harbour seal (0.000001% of the SE England MU reference population).	Negligible
PTS due to the cumulative exposure of six sequential jacket pin piles in a 24 hour period (SEL_{cum})		
Harbour porpoise	74 harbour porpoise (0.02% of the NS MU reference population).	Medium
Minke whale	2 minke whale (0.01% of the CGNS MU reference population).	Low

Marine mammal species	Assessment of impact	Magnitude of impact
Grey seal	0.007 grey seal (0.00002% of the SE England MU reference population; or 0.00001% of the wider reference population).	Negligible
Harbour seal	0.00005 harbour seal (0.000001% of the SE England MU reference population).	Negligible

PTS from cumulative exposure from multiple piling locations

166. The simultaneous piling scenario assumes that animals are within potential impact ranges for a much longer period (i.e., they would be travelling from one pile location to another which piling is ongoing), and therefore cumulative impact ranges are much larger than for the cumulative exposure ranges of one pile at a time. See Appendix 12.3 (Document Reference: 3.3.8) and Appendix 12.4 (Document Reference: 3.3.9) for further information.

167. The potential impact ranges are not practicable to model under this scenario, as there are two starting points for receptors, and it is not possible to determine the potential range at which they need to be in order to not be at risk of impact. Therefore, the following assessment is based on the potential areas of impact only.

168. Where the potential impact areas are not large enough to interact with each other (i.e., they do not meet), the results for the respective locations and scenarios are used (the results of the modelling for the South and East locations are used to inform the assessment, to align with the modelling locations used for the simultaneous modelling.

169. The full underwater noise modelling results and assessments are provided in Appendix 12.4 (Document Reference: 3.3.9) for the potential for PTS due to the cumulative exposure of multiple monopile and jacket pin pile installations at the same time.

170. Table 12.22 presents the underwater noise modelling results for the predicted impact ranges and areas for PTS due to the cumulative exposure of simultaneous monopiles and jacket pin piles at the East and South modelling locations. These locations were chosen as they have the potential for the largest 'spread' in terms of underwater noise propagation (as they are the two furthest apart locations).

171. The simultaneous modelling includes three monopiles being installed sequentially at each location at the same time, or six jacket pin piles being installed sequentially at each location at the same time.

172. The potential impact range for PTS is highest for minke whale for both monopiles and jacket pin piles, with a potential cumulative PTS impact area of 390km^2 and 380km^2 respectively, for multiple simultaneous piles. For harbour porpoise and minke whale, the cumulative PTS is significantly higher for simultaneous piling than it is for a single piling location at any one time, however, for grey seal and harbour seal, the potential PTS ranges are significantly smaller, and do not interact with each other where there are simultaneous piling events at the same time (Table 12.22).

173. For harbour porpoise and minke whale, the results of the modelling for simultaneous piling for both monopiles and jacket pin piles are used in the assessments. For both grey and harbour seal, there is no potential for modelled impact ranges (from both locations at the same time) to interact due to their smaller distances, therefore, for grey and harbour seals the assessments are based on the sequential piling results of the modelling at the South and East locations, added together.

Table 12.22 The predicted impact areas for PTS in all marine mammal species at the North and South modelling locations, for the cumulative exposure of multiple monopiles and pin pile installations at the same time (impact areas in bold used within the assessments for sequential piling)

Marine mammal species	Potential impact areas for PTS due to cumulative exposure of simultaneous pile installations	
	Monopile (6,000kJ)	Jacket pin pile (**4,400kJ**)
Multiple sequential pile installations in a 24 hour period (for the East and South modelling locations together)	**Three sequential monopiles at the East location and three sequential monopile at the South location at the same time**	**Six sequential jacket pin piles at the East location and six sequential jacket pin piles at the South location at the same time**
Harbour porpoise	East alone = 22km^2 South alone = 16km^2 **Total together = 210km^2**	East alone = 23km^2 South alone = 17km^2 **Total together = 230km^2**
Minke whale	East alone = 94km^2 South alone = 68km^2 **Total together = 390km^2**	East alone = 85km^2 South alone = 57km^2 **Total together = 380km^2**
Grey seal Harbour seal	East alone = <0.1km^2 South alone = <0.1km^2 **Total together = no overlap, therefore maximum simultaneous impact area is 0.2km^2.**	East alone = <0.1km^2 South alone = <0.1km^2 **Total together = no overlap, therefore maximum simultaneous impact area is 0.2km^2.**

174. An assessment of the maximum number of individuals that could be at risk of cumulative PTS, for simultaneous monopiles and jacket pin piles is presented in Table 12.23, based on the impact areas as presented in Table 12.22. The worst-case for a single hammer strike is for full hammer energy, and therefore this has been used to inform the following assessments. An assessment of the potential impact from a single strike at the starting hammer energy has been provided in Appendix 12.4 (Document Reference: 3.3.9).

175. An assessment against all marine mammal densities is provided in Appendix 12.4 (Document Reference: 3.3.9), including the summer seasonal density for harbour porpoise.

176. The magnitude of impact is assessed as medium for harbour porpoise and minke whale, and as negligible for grey seal and harbour seal, due to simultaneous monopiles and jacket pin pile installations (Table 12.23).

Table 12.23 Assessment of the potential for PTS due to the cumulative exposure of simultaneous monopiles or jacket pin piles at the same time (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Marine mammal species	Assessment of impact	Magnitude of impact
PTS due to the cumulative exposure of simultaneous monopile installations (SEL_{cum})		

Marine mammal species	Assessment of impact	Magnitude of impact
Harbour porpoise	676 harbour porpoise (0.20% of the NS MU reference population).	Medium
Minke whale	6 minke whale (0.03% of the CGNS MU reference population).	Medium
Grey seal	0.014 grey seal (0.00004% of the SE England MU reference population; or 0.00002% of the wider reference population).	Negligible
Harbour seal	0.0002 harbour seal (0.000002% of the SE England MU reference population).	Negligible
PTS due to the cumulative exposure of simultaneous jacket pin pile installations (SEL_{cum})		
Harbour porpoise	740 harbour porpoise (0.22% of the NS MU reference population).	Medium
Minke whale	6 minke whale (0.03% of the CGNS MU reference population).	Medium
Grey seal	0.014 grey seal (0.00004% of the SE England MU reference population; or 0.00002% of the wider reference population).	Negligible
Harbour seal	0.0002 harbour seal (0.000002% of the SE England MU reference population).	Negligible

Significance of effect

177. The assessment for the effect of PTS from monopile and jacket pin pile installation in marine mammals is provided in Table 12.24, taking into account the high marine mammal sensitivity and the potential magnitude of impact (i.e. number of individuals as a percentage of the reference population; Table 12.19, Table 12.21 and Table 12.23).

178. The effect significance for permanent changes in hearing sensitivity (PTS) from a single strike of the maximum hammer energy for either monopiles or jacket pin piles (without additional mitigation) has been assessed as moderate adverse for harbour porpoise and minor adverse for all other marine mammals (Table 12.24).

179. For the potential PTS from cumulative exposure for sequential monopile or jacket pin pile installations (without additional mitigation), the effect significance has been assessed as major adverse for harbour porpoise, moderate adverse for minke whale, and minor adverse for grey seal and harbour seal (Table 12.24).

180. For the potential PTS from cumulative exposure for simultaneous monopile or simultaneous jacket pin pile installations (without additional mitigation), the effect significance has been assessed as major adverse for harbour porpoise and minke whale, and as minor adverse for grey seal and harbour seal (Table 12.24).

Table 12.24 Assessment of effect significance for the potential for PTS due to piling of monopiles and jacket pin piles

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual effect
PTS due to a single strike of a monopile at maximum hammer energy					

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual effect
Harbour porpoise	High	Low	Moderate adverse	MMMP for piling will significantly reduce any potential for marine mammals to be within the PTS effect area (see paragraphs 182-185).	Minor adverse
Minke whale, grey seal and harbour seal		Negligible	Minor adverse		Minor adverse
PTS due to a single strike of a jacket pin pile at maximum hammer energy					
Harbour porpoise	High	Low	Moderate adverse	MMMP for piling will significantly reduce any potential for marine mammals to be within the PTS effect area (see paragraphs 182-185).	Minor adverse
Minke whale, grey seal and harbour seal		Negligible	Minor adverse		Minor adverse
PTS due to the cumulative exposure of three sequential monopiles in a 24 hour period					
Harbour porpoise	High	Medium	Major adverse	MMMP for piling will significantly reduce any potential for marine mammals to be within the PTS effect area (see paragraphs 182-185).	Minor adverse
Minke whale		Low	Moderate adverse		Minor adverse
Grey seal and harbour seal		Negligible	Minor adverse		Minor adverse
PTS due to the cumulative exposure of six sequential jacket pin piles					
Harbour porpoise	High	Medium	Major adverse	MMMP for piling will significantly reduce any potential for marine mammals to be within the PTS effect area (see paragraphs 182-185).	Minor adverse
Minke whale		Low	Moderate adverse		Minor adverse
Grey seal and harbour seal		Negligible	Minor adverse		Minor adverse
PTS due to the cumulative exposure of simultaneous monopile installations					
Harbour porpoise and minke whale	High	Medium	Major adverse	MMMP for piling will reduce any potential for marine mammals to be within the PTS effect area (see paragraphs 182-185).	Minor adverse
Grey seal and harbour seal		Negligible	Minor adverse		Minor adverse
PTS due to the cumulative exposure of simultaneous jacket pin pile installations					
Harbour porpoise and minke whale	High	Medium	Major adverse	MMMP for piling will reduce any potential for marine mammals to be within the PTS effect area (see paragraphs 182-185).	Minor adverse
Grey seal and harbour seal		Negligible	Minor adverse		Minor adverse

Additional mitigation

181. A MMMP for piling (Section 12.8) in accordance with the Draft MMMP (Document Reference: 7.7) would reduce the risk of PTS from a single strike of both monopiles and jacket pin piles, at the maximum hammer energy, and from

the cumulative exposure of one monopile and one jacket pin pile. Mitigations will be undertaken for each pile, and therefore should be designed to ensure they cover for the potential impact of the installation either one monopile or one jacket pin pile, as required (as well as for any simultaneous piling events).

182. The MMMP for piling will be developed post-consent in consultation with the Marine Management Organisation (MMO) and other relevant stakeholders (including Natural England), and will be based on the latest information, scientific understanding and guidance and detailed project design at the time.

183. The final MMMP is expected to be based on the standard JNCC guidance (JNCC, 2010), and include the mitigation as follows;

- A monitoring zone of at least 700m, where soft-start cannot commence until the monitoring zone is clear of marine mammals;
- Soft-start piling as defined by the embedded mitigation and the underwater noise modelling (comprised of a period of low-energy blows at the starting hammer energy, followed by a gradual ramp-up to full hammer energy); and
- ADDs to deter marine mammals from the piling location, to a distance that is greater than the PTS range for the cumulative exposure of one pile installation.

184. ADDs have proven to be effective mitigation for harbour porpoise, minke whale, grey and harbour seal (Sparling *et al.,* 2015; McGarry *et al.,* 2017, 2020). ADDs have been widely used as mitigation to deter marine mammals during OWF piling.

Residual effect

185. As noted above and shown by Table 12.24, there is the potential for a significant effect due to PTS onset from piling for harbour porpoise and minke whale (for both monopiles and jacket pin piles). The mitigation provided through the MMMP (as described above) would significantly reduce the number of all marine mammal species at risk of PTS, by deterring individuals from within the PTS effect areas prior to piling. This would effectively and significantly reduce the number of marine mammals at risk of PTS onset, and therefore the residual magnitude of effect would be negligible in all cases.

186. Therefore, the residual effect significance for the potential for PTS onset due to piling (taking into account the high sensitivity of all marine mammals) would be minor adverse.

12.6.1.1.3 Impact 1b: Temporary auditory injury (TTS) due to impact piling

Sensitivity of marine mammals

187. TTS can occur instantaneously from acute exposure to high noise levels, such as single strike (SEL_{ss}) of the maximum hammer energy applied during piling. TTS can also occur as a result of prolonged exposure to increased noise levels, such as during the duration of pile installation (SEL_{cum}).

188. All marine mammal species are assessed as having medium sensitivity to TTS. A fleeing response is assumed to occur at the same noise levels as TTS. The response of individuals to a noise stimulus will vary and not all individuals will

respond, however, for the purpose of this assessment, it is assumed that 100% of the individuals exposed to the noise stimulus will respond and flee the area.

189. Any TTS would be temporary, and individuals would recover from any temporary changes in hearing sensitivity after the noise source has ceased. However, as a precautionary approach, medium sensitivity to TTS assumes an individual has limited capacity to avoid, adapt to, tolerate or recover from the anticipated impact.

Magnitude of impact

TTS from a single strike

190. The full underwater noise modelling results and assessments are provided in Appendix 12.4 (Document Reference: 3.3.9) for the potential for TTS due to a single strike at either the starting or the maximum hammer energy.

191. Table 12.25 presents the underwater noise modelling results for the predicted impact ranges and areas for TTS from a single strike for the worst case location, for both monopiles (shown in Figure 12.5 (Document Reference: 3.2.8)) and jacket pin piles (Figure 12.6 (Document Reference: 3.2.8)). The potential impact range for TTS is highest for harbour porpoise for both monopiles and jacket pin piles, with a potential TTS range of 1.7km and 1.6km respectively.

Table 12.25 The predicted impact ranges for TTS in all marine mammal species, at the worst case modelling location, for the maximum hammer energies of both monopiles and pin piles

Marine mammal species	Potential impact ranges (and areas) for TTS from a single strike	
	Monopile	Jacket pin pile
Single strike from the starting hammer energy	**900kJ**	**660kJ**
Harbour porpoise	790m (1.9km^2)	610m (1.1km^2)
Minke whale	60m (0.01km^2)	<50m (0.01km^2)
Grey seal	70m (0.01km^2)	50m (0.01km^2)
Harbour seal		
Single strike from the maximum hammer energy	**6,000kJ**	**4,400kJ**
Harbour porpoise	1.70km (8.20km^2)	1.60km (7.1km^2)
Minke whale	120m (0.05km^2)	110m (0.04km^2)
Grey seal	140m (0.06km^2)	130m (0.05km^2)
Harbour seal		

192. An assessment of the maximum number of individuals that could be at risk of instantaneous TTS, due to a single strike at the maximum hammer energy, for both monopiles and jacket pin piles, is presented in Table 12.26, based on the potential impact ranges as presented in Table 12.25. An assessment against all marine mammal densities is provided in Appendix 12.4 (Document Reference: 3.3.9), including the summer seasonal density for harbour porpoise.

193. The magnitude of impact is assessed as negligible for all species, for a single strike of either a monopile or a jacket pin pile (Table 12.26).

Table 12.26 Assessment of the potential for instantaneous TTS due to a single strike of the maximum hammer energy for a monopile and jacket pin pile (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Marine mammal species	Assessment of impact	Magnitude of impact
TTS due to a single strike of a monopile at maximum hammer energy (SPL_{peak})		
Harbour porpoise	27 harbour porpoise (0.008% of the NS MU reference population).	Negligible
Minke whale	0.0008 minke whale (0.000004% of the CGNS MU reference population).	Negligible
Grey seal	0.004 grey seal (0.00001% of the SE E MU reference population, or 0.000007% of the wider reference population).	Negligible
Harbour seal	0.00003 harbour seal (0.0000006% of the SE England MU reference population).	Negligible
TTS due to a single strike of a jacket pin pile at maximum hammer energy (SPL_{peak})		
Harbour porpoise	23 harbour porpoise (0.007% of the NS MU reference population).	Negligible
Minke whale	0.006 minke whale (0.000003% of the CGNS MU reference population).	Negligible
Grey seal	0.004 grey seal (0.00001% of the SE England MU reference population, or (0.000006% of the wider reference population).	Negligible
Harbour seal	0.0002 harbour seal (0.0000005% of the SE England MU reference population).	Negligible

TTS from cumulative exposure from a single piling location

194. As outlined for PTS from cumulative exposure, the ranges indicate the distance that an individual would need to be from the noise source at the start of the piling sequence to prevent a cumulative noise exposure which could lead to TTS. This is highly conservative as the assessment assumes the worst case exposure levels for an animal in the water column, and does not take account of periods where exposure will be reduced, for example in seals when their heads are out of the water; or that the cumulative noise dose received by the marine mammal will be largely dependent on the swimming speed, and whether the animal moves away from the noise source rapidly as a flee response. The cumulative SEL dose does not take account of this and therefore is likely to overestimate the received noise levels.

195. The full underwater noise modelling results and assessments are provided in Appendix 12.4 (Document Reference: 3.3.9) for the potential for TTS due to the cumulative exposure of both monopile and jacket pin pile installations.

196. Table 12.27 presents the underwater noise modelling results for the predicted impact ranges and areas for TTS due to the cumulative exposure of monopiles and jacket pin piles at the worst case location. The potential impact range for TTS is highest for minke whale for both monopiles and jacket pin piles, with a potential cumulative TTS range of 30km and 31km respectively, for multiple piles in a 24 hour period.

197. The potential cumulative impact ranges are the same for either one or three sequential monopiles, or for one or six sequential jacket pin piles, with the

exception of grey and harbour seal for jacket pin piles, with a slight increase for six sequential pin pile installations compared to one jacket pin pile (Table 12.27).

Table 12.27 The predicted impact ranges for TTS in all marine mammal species, at the worst case modelling location, for the cumulative exposure of both monopiles and pin piles

Marine mammal species	Potential impact ranges (and areas) for TTS due to cumulative exposure	
	Monopile (6,000kJ)	Jacket pin pile (3,000kJ)
Single pile installation in a 24 hour period	**One monopile**	**One jacket pin pile**
Harbour porpoise	24.0km (1,000.0km^2)	24.0km (1,100.0km^2)
Minke whale	30.0km (1,600.0km^2)	31.0km (1,500.0km^2)
Grey seal	9.0km (160.0km^2)	9.3km (180.0km^2)
Harbour seal		
Multiple sequential pile installations in a 24 hour period	**Three sequential monopiles**	**Six sequential jacket pin piles**
Harbour porpoise	24.0km (1,000.0km^2)	24.0km (1,100.0km^2)
Minke whale	30.0km (1,600.0km^2)	31.0km (1,500.0km^2)
Grey seal	9.0km (160.0km^2)	9.5km (180.0km^2)
Harbour seal		

198. Assessments for the modelling of a single pile in 24 hours are provided in Appendix 12.4 (Document Reference: 3.3.9), and the assessments for three sequential monopiles and six sequential pin piles in a 24 hour period are provided below, as the worst case.

199. An assessment of the maximum number of individuals that could be at risk of cumulative TTS, for both sequential monopiles and jacket pin piles, is presented in Table 12.28, based on the impact areas as presented in Table 12.27. An assessment against all marine mammal densities is provided in Appendix 12.4 (Document Reference: 3.3.9), including the summer seasonal density for harbour porpoise.

200. The magnitude of impact is assessed as negligible for all species for sequential monopiles. For sequential jacket pin piles harbour porpoise has been assessed as a low magnitude of impact, and as negligible for all other species (Table 12.28).

Table 12.28 Assessment of the potential for TTS due to the cumulative exposure of sequential monopiles or jacket pin piles in a 24 hour period (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Marine mammal species	Assessment of impact	Magnitude of impact
TTS due to the cumulative exposure of three sequential monopiles in a 24 hour period (SEL_{cum})		
Harbour porpoise	3,217 harbour porpoise (0.95% of the NS MU reference population).	Negligible
Minke whale	25 minke whale (0.12% of the CGNS MU reference population).	Negligible

Marine mammal species	Assessment of impact	Magnitude of impact
Grey seal	12 grey seal (0.04% of the SE England MU reference population, or 0.02% of the wider reference population).	Negligible
Harbour seal	0.08 harbour seal (0.002% of the SE England MU reference population).	Negligible
TTS due to the cumulative exposure of six sequential jacket pin piles in a 24 hour period (SEL_{cum})		
Harbour porpoise	3,539 harbour porpoise (1.04% of the NS MU reference population).	Low
Minke whale	23 minke whale (0.11% of the CGNS MU reference population).	Negligible
Grey seal	13 grey seal (0.04% of the SE England MU reference population, or 0.02% of the wider reference population).	Negligible
Harbour seal	0.09 harbour seal (0.002% of the SE England MU reference population).	Negligible

TTS from cumulative exposure from multiple piling locations

201. As described above for PTS, the simultaneous piling scenario assumes that animals are within potential impact ranges for a much longer period (i.e., they would be travelling from one pile location to another which piling is ongoing), and therefore cumulative impact ranges are much larger than for the cumulative exposure ranges of one pile at a time. See Appendix 12.3 (Document Reference: 3.3.8) and Appendix 12.4 (Document Reference: 3.3.9) for further information.

202. The full underwater noise modelling results and assessments are provided in Appendix 12.4 (Document Reference: 3.3.9) for the potential for TTS due to the cumulative exposure of multiple monopile and jacket pin pile installations at the same time. The modelling includes three monopiles being installed sequentially at each location at the same time, and six jacket pin piles being installed sequentially at each location at the same time.

203. Table 12.29 presents the underwater noise modelling results for the predicted impact ranges and areas for TTS due to the cumulative exposure of simultaneous monopiles and jacket pin piles at the East and South modelling locations.

204. The potential impact range for TTS is highest for minke whale for both monopiles and jacket pin piles, with a potential cumulative TTS impact area of 2,400km^2 for both, for multiple simultaneous piles.

205. For both seal species assessed, the cumulative TTS is significantly higher for simultaneous piling than it is for a single piling location at any one time (Table 12.29). However, in the case of three sequential monopiles installed at the same time, and for six sequential jacket pin piles installed at two locations at the same time, for both harbour porpoise and minke whale, the area of impact for TTS onset from simultaneous piling is smaller than that of the two locations if they were piled alone. This is due to the distance between the two locations being such that the noise contours overlap, reducing the overall area of TTS onset in the case of both locations being piled together.

Table 12.29 The predicted impact ranges for TTS in all marine mammal species at the East and South modelling locations, for the cumulative exposure of multiple monopiles and pin pile installations at the same time (impact areas in bold used within the assessments for sequential piling)

Marine mammal species	Potential impact areas for TTS due to cumulative exposure of simultaneous pile installations	
	Monopile (6,000kJ)	Jacket pin pile (3,000kJ)
Multiple sequential pile installations in a 24 hour period (for the East and South modelling locations together)	**Three sequential monopiles at the East location and three sequential monopiles at the South location at the same time**	**Six sequential jacket pin piles at the East location and six sequential jacket pin piles at the South location at the same time**
Harbour porpoise	East alone = 1,000km^2 South alone = 840km^2 **Total together = 1,800.0km^2**	East alone = 1,100km^2 South alone = 880km^2 **Total together = 1,800.0km^2**
Minke whale	East alone = 1,600km^2 South alone = 1,300km^2 **Total together = 2,400.0km^2**	East alone = 1,500km^2 South alone = 1,200km^2 **Total together = 2,400.0km^2**
Grey seal Harbour seal	East alone = 160km^2 South alone = 120km^2 **Total together = 530.0km^2**	East alone = 180km^2 South alone = 140km^2 **Total together = 580.0km^2**

206. An assessment of the maximum number of individuals that could be at risk of cumulative TTS, for simultaneous monopiles and jacket pin piles, is presented in Table 12.30, based on the impact areas as presented in Table 12.29. An assessment against all marine mammal densities is provided in Appendix 12.4 (Document Reference: 3.3.9), including the summer seasonal density for harbour porpoise.

207. The magnitude of impact is assessed as low for harbour porpoise, and negligible for minke whale, grey seal and harbour seal, due to either simultaneous monopiles or jacket pin pile installations (Table 12.30).

Table 12.30 Assessment of the potential for TTS due to the cumulative exposure of simultaneous monopiles or jacket pin piles at the same time (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Marine mammal species	Assessment of impact	Magnitude of impact
TTS due to the cumulative exposure of simultaneous monopile installations (SEL_{cum})		
Harbour porpoise	5,791 harbour porpoise (1.71% of the NS MU reference population).	Low
Minke whale	37 minke whale (0.18% of the CGNS MU reference population).	Negligible
Grey seal	38 grey seal (0.12% of the SE England MU reference population, or (0.07% of the wider reference population).	Negligible
Harbour seal	0.3 harbour seal (0.005% of the SE England MU reference population).	Negligible
TTS due to the cumulative exposure of simultaneous jacket pin pile installations (SEL_{cum})		
Harbour porpoise	5,791 harbour porpoise (1.71% of the NS MU reference population).	Low

Marine mammal species	Assessment of impact	Magnitude of impact
Minke whale	37 minke whale (0.18% of the CGNS MU reference population).	Negligible
Grey seal	41 grey seal (0.13% of the SE England MU reference population, or 0.07% of the wider reference population).	Negligible
Harbour seal	0.3 harbour seal (0.006% of the SE England MU reference population).	Negligible

Significance of effect

208. The assessment for the effect of TTS from monopile and jacket pin piles installation on marine mammals is provided in Table 12.31, taking into account the medium marine mammal sensitivity and the potential magnitude of impact (i.e. number of individuals as a percentage of the reference population; Table 12.26, Table 12.28 and Table 12.30).

209. The effect significance for temporary changes in hearing sensitivity (TTS) from either a single strike of the maximum hammer energy for monopiles, or the cumulative exposure of either sequential or simultaneous monopiles, has been assessed as minor adverse for harbour porpoise, minke whale, grey seal and harbour seal (Table 12.31).

Table 12.31 Assessment of effect significance for the potential for TTS due to piling of monopiles and jacket pin piles

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual effect
TTS due to a single strike of a monopile at maximum hammer energy					
Harbour porpoise, minke whale, grey seal and harbour seal	Medium	Negligible	Minor adverse	None required, however, MMMP for piling may minimise TTS effects.	Minor adverse
TTS due to a single strike of a jacket pin pile at maximum hammer energy					
Harbour porpoise, minke whale, grey seal and harbour seal	Medium	Negligible	Minor adverse	None required, however, MMMP for piling may minimise TTS effects.	Minor adverse
TTS due to the cumulative exposure of three sequential monopiles in a 24 hour period					
Harbour porpoise, minke whale, grey seal and harbour seal	Medium	Negligible	Minor adverse	None required, however, MMMP for piling may minimise TTS effects	Minor adverse
TTS due to the cumulative exposure of six sequential jacket pin piles in a 24 hour period					

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual effect
Harbour porpoise	Medium	Low	Minor adverse	None required, however, MMMP for piling may minimise TTS effects	Minor adverse
Minke whale, grey seal and harbour seal		Negligible	Minor adverse	None required, however, MMMP for piling may minimise TTS effects	Minor adverse
TTS due to the cumulative exposure of simultaneous monopile installations at the same time					
Harbour porpoise	Medium	Low	Minor adverse	None required, however, MMMP for piling may minimise TTS effects	Minor adverse
Minke whale, grey seal and harbour seal	Medium	Negligible	Minor adverse	None required, however, MMMP for piling may minimise TTS effects	Minor adverse
TTS due to the cumulative exposure of simultaneous jacket pin pile installations					
Harbour porpoise	Medium	Low	Minor adverse	None required, however, MMMP for piling may minimise TTS effects	Minor adverse
Minke whale, grey seal and harbour seal		Negligible	Minor adverse	None required, however, MMMP for piling may minimise TTS effects	Minor adverse

Mitigation

210. While no mitigation is required for the potential for TTS in marine mammals, the mitigation in the Draft MMMP (Document Reference: 7.7) to reduce the risk of PTS could also reduce the number of marine mammals at risk of TTS.

12.6.1.1.4 Impact 1c: Disturbance effects due to impact piling

211. The range of possible behavioural reactions that may occur as a result of exposure to noise include orientation or attraction to a noise source, increased alertness, modification of characteristics of their own sounds, cessation of feeding or social interaction, alteration of movement / diving behaviour, temporary or permanent habitat abandonment and, in severe cases, panic, or stranding, sometimes resulting in injury or death (Southall *et al.,* 2007).

212. There are currently no agreed thresholds or criteria for the behavioural response and disturbance of marine mammals, therefore it is not practicable to conduct underwater noise modelling to predict impact ranges.

213. Disturbance from construction activities (including piling) may have behavioural consequences on marine mammals in the study area, including reduced time spent foraging at sea as animals move away from sources of noise, displacement from vessels, etc. Repeated disruptions can have cumulative negative impacts on the bioenergetic budget of marine species, with the potential for long-term impacts on survival and reproductive rates (Christiansen *et al.*, 2013).

Sensitivity of marine mammals

214. Marine mammals may exhibit varying intensities of behavioural response at different noise levels. The response can vary due to exposure level, the hearing sensitivity of the individual, context, previous exposure history or habituation, motivation and ambient noise levels (e.g., Southall *et al.,* 2007).

215. The response of individuals to a noise stimulus will vary and not all individuals will respond; though for the purpose of this assessment, it is assumed that at the disturbance range, 100% of the individuals exposed to the noise stimulus will respond and be displaced from the area. However, 100% displacement is highly unlikely, therefore this a very precautionary approach.

216. Marine mammals within the potential disturbance area are considered to have limited capacity to avoid such impacts, although any disturbance to marine mammals would be temporary and they would be expected to return to the area once the disturbance had ceased.

217. Harbour porpoise have relatively high daily energy demands and need to consume between 4% and 9.5% of their body weight in food per day (Kastelein et al., 1997). If a harbour porpoise does not capture enough prey to meet its daily energy requirements it can rely on stored energy (primarily blubber) for an estimated three to five days, depending on body condition (Kastelein et al., 1997). Should harbour porpoise be excluded from an area of key prey resource it will likely seek an alternative food resource and this could have an impact on the individual's fitness. For example, they may have to travel further or take less Than optimum prey species. The impacts on an individual's fitness are partly caused by the exclusion of animals from high-quality foraging areas and partly by the net energy losses associated with fleeing from disturbances (Nabe-Nielsen et al., 2014). Therefore, impacts in lower quality habitat are likely to have a lower potential impact on an animal's fitness.

218. Harbour porpoise are assessed as having medium sensitivity to disturbance from foraging at sea during construction.

219. Minke whales spend approximately 15% of their time foraging and have been shown to exhibit reduced foraging behaviour in the presence of increased vessel traffic. For example, in a study looking at the impacts of wildlife tour boats on minke whale behaviour, a decrease in energy intake of 42% was estimated during disturbance events lasting one hour, as a result of reduced time spent foraging and surface feeding (Christiansen et al., 2013). It is therefore possible that construction vessels will have a similar impact, with the additional disturbance sources of noise from construction activities such as piling (see Impacts 1 and 2).

220. Minke whale are expected to move away from sources of noise and have been shown to demonstrate increased horizontal movement and swimming speeds

from anthropogenic disturbance, likely leading to a short-term change in foraging behaviour (Christiansen et al., 2014). In addition, navy training operations have been shown to produce similar impacts, with increased horizontal avoidance movements during disturbances that included vessel traffic and the use of sonar, likely resulting in a decrease in time spent foraging. It was noted these behaviours were largely short-term and isolated to during disturbance events (Durbach *et al*., 2021).

221. Minke whale are therefore assessed as having a medium sensitivity to disturbance to foraging at sea during construction.

222. Grey seal and harbour seal exhibit alternate periods of foraging and resting at haul out sites (during which limited, or no feeding occurs). Prolonged fasting also occurs in these species during annual breeding and moult, when there are marked seasonal changes in body condition (Rosen and Renouf, 1997; Bäcklin *et al.,* 2011). Although adult seals may be relatively robust to short term (weeks rather than days compared to harbour porpoise) changes in prey resources, young and small individuals have a more sensitive energy balance. This is exhibited through impacts of mass dependent survival (Harding *et al.,* 2005). Although disturbance to harbour or grey seal may lead to a severe or sustained avoidance of an area, these species are considered less sensitive to such an impact than harbour porpoise, and are therefore assessed as having a low sensitivity.

Magnitude of impact

Behavioural response of harbour porpoise to piling

223. The Gescha 2 study (Rose *et al.,* 2019) analysed the impact from the construction of 11 OWFs in Germany on harbour porpoise in the German North Sea and adjacent Dutch waters, from 2014 to 2016. This study also included analysis of previously surveys within the Gescha 1 study, which studied the impact from the construction of eight German OWFs from 2009 to 2013. The study involved the deployment of Cetacean Porpoise Detectors (CPODs) and digital aerial surveys in order to monitor harbour porpoise presence and abundance during the construction of these projects, alongside the measurement of noise levels associated with piling at both 750m and 1,500m from source. The piling activities monitored in this study were mostly undertaken with noise abatement systems in order to reduce disturbance impacts on harbour porpoise.

224. The Gescha 2 study (Rose et al., 2019) found that noise levels recorded during piling were predominantly below the limit of 160dB at 750m (the German Federal Maritime and Hydrographic Agency mandatory noise limit for German waters). In addition, noise levels were 9dB lower than the noise levels recorded during the Gescha 1 study, due to advancement in noise abatement methods. Rose *et al.* (2019) also found that noise levels were 15dB less using noise abatement than for noise levels from unmitigated piling. It was expected that the improved efficiency of noise abatement for piling, and therefore the overall reduced noise levels, would lead to a reduction in disturbance impacts on harbour porpoise, however, this was not the case.

225. The range of disturbance impact of harbour porpoise to piling within the Gescha 2 study (Rose *et al.,* 2019) based on CPOD data was 17km (Standard Deviation

(SD) 15-19km), and the duration of disturbance (i.e. the time it took for harbour porpoise to return to baseline levels) was between 28 and 48 hours, and based on aerial data the impact range was found to be between 11.4 and 19.5km (at least 12 hours after piling) (Rose et al., 2019). These results are similar to those reported in the Gescha 1 study (with a disturbance range of 15km (SD 14-16km) and duration of disturbance of 25 to 30 hours), which showed higher piling noise levels (Rose et al., 2019). This suggests that the noise level of the piling is not the only determining factor when discussing the potential for disturbance.

226. Analysis of the CPOD data collected in the Gescha 2 study (Rose et al., 2019) indicated that there is no correlation between noise levels received and the range at which harbour porpoise become disturbed, for noise that is below 165dB at 750m from source. This could be due to individuals maintaining a certain distance from noisy activities, irrespective of the actual noise levels, provided that noise level is above a certain threshold for that individual (Rose et al., 2019). It should be noted however that this study recorded noise levels up to 20kHz only, and therefore there may be higher frequency noise associated with piling that these results do not take into account.

227. A reduction in harbour porpoise presence was seen for all wind farms, for both the Gescha 1 and 2 studies, up to 24 hours prior to any noisy activity occurring, which could be due to the increased vessel activity at the pile location prior to piling taking place (Rose et al., 2019). However, the displacement during pile driving was noted to be larger than for the period prior to piling. In Gescha 2, a decrease in detection rates was found in the three hours prior to piling activity at a distance up to 15km from the piling location, with no difference in detection rates observed at a distance of 25km (Rose *et al.,* 2019).

228. A study of harbour porpoise at Horns Rev (Brandt *et al.,* 2011), found that at closer distances (2.5 to 4.8km) there was 100% avoidance during piling. However, this proportion decreased significantly moving away from the pile driving activity, such that at distances of 10.1 to 17.8km, avoidance occurred in 32 to 49% of the population and at 21.2km, the abundance reduced by just 2%. This suggests that an assumption of behavioural displacement of all individuals is unrealistic and that in reality not all individuals would move out of the area.

229. During the piling campaign at Beatrice Offshore Wind Farm in 2017, an array of underwater noise recorders were deployed to determine noise levels associated with the piling campaign, alongside a separate array of acoustic recorders to monitor the presence of harbour porpoise during piling (Graham et al., 2019). Piling at Beatrice comprised of four pin piles at each turbine or sub-station structure, with a 2.2m diameter and a hammer energy of 2,400kJ. The sound levels recorded were then used to determine the sound level at each of the acoustic recorders.

230. This study assumed that a change in the number of harbour porpoise present at each location was based on the number of positive identifications of porpoise vocalisations (Graham et al., 2019). These two data sets (the harbour porpoise presence and the perceived sound level at each location) were then analysed in order to determine any disturbance impacts as a result of the piling activities and at what sound level impacts are observed. Harbour porpoise presence was measured over a period of 48 hours prior to piling, and continued following the cessation of piling to ensure that any change in porpoise detections could be

observed (a total period of 96 hours was recorded for each included piling event, with a total of 17 piling events included within this analysis) (Graham et al., 2019).

231. The results from Beatrice Offshore Wind Farm (Graham et al., 2019) showed that at the start of the piling campaign, there was a 50% chance of a harbour porpoise responding to piling activity, within a distance of 7.4km, during the 24 hours following piling. In the middle of the piling campaign, this 50% response distance had reduced to 4.0km, and by the end of the piling had reduced further to 1.3km.

232. The response to audiogram-weighted SEL noise levels reduced over time, with a 50% response being observed at sound levels of 54.1dB re 1 $\mu Pa^2 s$ at the first location, during the first 24 hours following piling, increasing to 60.0dB re 1 1$\mu Pa^2 s$ during the middle of the campaign, and to 70.9dB re 1 $\mu Pa^2 s$ by the end of the piling activities. Similarly, the response to unweighted SEL noise levels reduced over time, with a 50% response being observed at sound levels of 144.3dB re 1 $\mu Pa^2 s$ at the first location, during the first 24 hours following piling, increasing to 150.0dB re 1 1$\mu Pa^2 s$ during the middle of the campaign, and to 160.4dB re 1 $\mu Pa^2 s$ by the end of the piling activities (Graham *et al.,* 2019).

233. Additional comparisons were made through this study (Graham *et al.,* 2019) to assess the difference in harbour porpoise presence where ADDs were used and where they were not, as well as relating to the number of vessels present within 1km of the piling site. A significant difference was observed in the presence of harbour porpoise where ADDs were used compared to where they were not, but only in the short-term (< 12 hours following piling), and there was no significant difference when considering a longer time period from piling. With 50% response distances for pile locations with ADD use recorded as up to 5.3km (during 12 hours after piling), and up to 0.7km with no ADD in use, in the 12 hours following piling. It should be noted however that only two locations used in the analysis had ADD use, and therefore the sample number in this analysis is small (Graham et al., 2019).

234. Overall, this study has shown that the response of harbour porpoise to piling activities reduces over time, suggesting a habituation impact occurred. In addition, there is some indication that the use of ADDs does reduce the presence of harbour porpoise in the short term. In addition, higher levels of vessel activity increased the potential for a response by harbour porpoise. Harbour porpoise response to piling activity was best explained by the distance from the piling location, or from the received noise levels (taking into account weighting for their hearing) (Graham et al., 2019).

235. During the construction of two Scottish wind farms (Beatrice Offshore Wind Farm and Moray East Offshore Wind Farm), a set of CPODs were deployed to monitor harbour porpoise presence during construction (Benhemma-Le Gall et al., 2021). In addition, the broadband noise levels were recorded and monitored, and vessel Automatic Identification System (AIS) data. The purpose of this study was to assess the response of harbour porpoise to both the changes in the baseline noise level due to impact piling at the two wind farms, and due to an increase in vessel activity. Piling at Beatrice was for 2.2m jacket piles. The result of this study was that there was an 8-17% decline in porpoise

presence during impact piling and other construction activities, compared to baseline levels (Benhemma-Le Gall et al., 2021).

236. An increase in broadband noise levels due to piling led to a significant reduction in porpoise presence. When piling was not occurring, porpoise detections decreased by 17% as the noise levels increased (from 102dB re 1 µPa (sound pressure level; SPL) to 159dB re 1 µPa (SPL)) (Plate 12.1); Benhemma-Le Gall et al., 2021). During piling, porpoise detections decreased by 9% as noise levels increased (from 102dB to 159dB). A similar reduction in buzz vocalisations was also evident; the presence of buzz vocalisations can be attributed to foraging behaviours. When piling was not taking place, buzz vocalisations decreased by 41.5% as the noise levels increased (from 104dB re 1 µPa (SPL) to 155dB re 1 µPa (SPL)). During piling, porpoise detections decreased by 61.8% as noise levels increased (from 104dB to 155dB re 1 µPa (SPL)) (Benhemma-Le Gall et al., 2021).

237. Harbour porpoise buzz vocalisations increased by 4.2% during Moray East piling compared to the baseline levels. At this point, Beatrice foundations were constructed, and the introduction of hard substrates are likely to have improved the fine-scale habitat for key harbour porpoise prey species, with the potential of increasing prey resources (Benhemma-Le Gall *et al*., 2021).

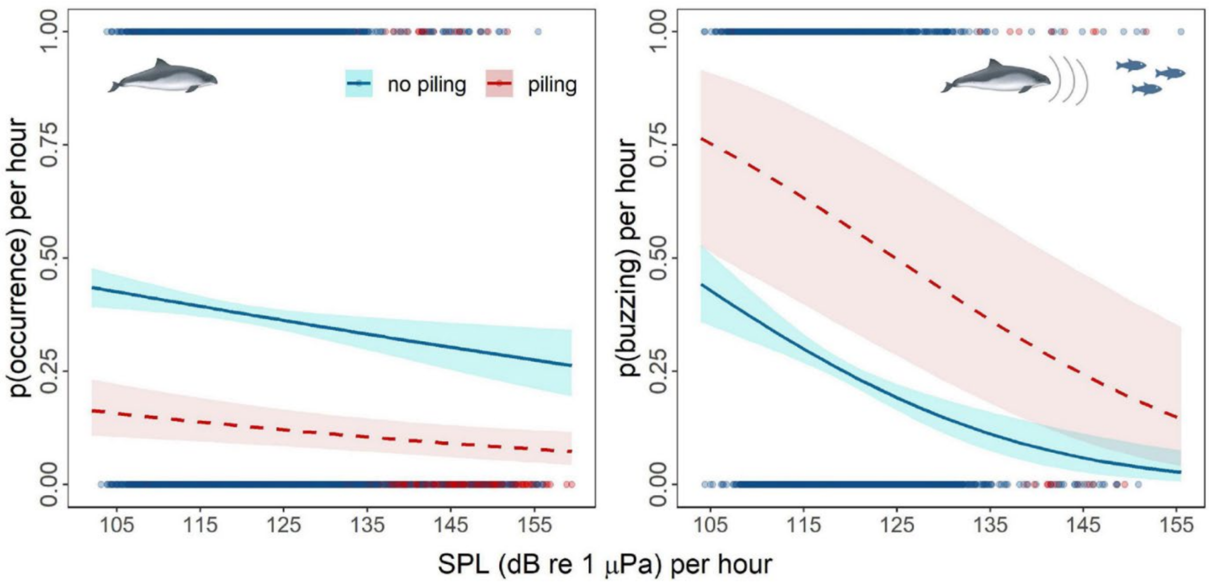

Plate 12.1 [Left] The probability of harbour porpoise presence in relation to the SPL (Red = during piling, Blue = outside of piling time, and [Right] the probability of buzzing activity per hour in relation to the SPL (Red = during piling, Blue = outside of piling time (Benhemma-Le Gall *et al.,* 2021)

Behavioural response of minke whale to piling

238. There is limited information on the behavioural response of minke whale to piling.

239. Southall *et al.* (2007) recommended that the most appropriate way to assess the disturbance impact of a noise source on marine mammals is the use empirical studies. The same paper presented a severity scale to apply to observed behavioural responses, and subsequent JNCC guidance indicates that a score of five or more on this behavioural response severity scale could be significant. A score of five relates to extensive changes in swim speed and

direction, or dive pattern, but no avoidance of the noise source, or a moderate shift in distributions, a change in group size, aggregations and separation distances, and a prolonged cessation in vocal behaviours. The higher the behavioural response score, the more likely the associated noise source is to cause a significant disturbance impact.

240. Southall et al. (2007) includes a summary of the observed behavioural responses from noise sources, however, the majority of the studies included were based on the responses to seismic surveys. These studies contain some relevant information for whale species behavioural responses.

241. Whale species were typically observed to respond significantly at a received level of 150dB to 160dB re 1 µPa (rms) (Malme et al., 1983, 1984; Richardson et al., 1986; Ljungblad et al., 1988; Todd et al., 1996; McCauley et al., 1998), with behavioural changes including visible startle responses, extended cessation or modification of vocal behaviour, brief cessation of reproductive behaviour or brief and minor separation of females and dependent offspring.

242. During migration periods, avoidance behaviours of bowhead whales Balaena mysticetus were observed at distances of more than 20km from seismic sources (Koski & Johnson, 1987; Richardson et al., 1999), however, during foraging periods, bowhead whales did not respond at greater than 6km from the source (Richardson *et al.,* 1986; Miller *et al.,* 2005). Richardson *et al*. (1986) concluded that due to a single airgun, avoidance and behavioural response was observed once noise levels reached more than 160dB re 1 µPa.

243. For a migrating bowhead whale study, most individuals avoided a seismic survey source at distances of up to 20km (the seismic surveys used airgun arrays of up to 16 guns, and total volume of 560 to 1,500 cu. In.), with significantly reduced bowhead whale presence between 20 and 30km from the source, with estimated received noise levels of 120 to 130dB re 1 µPa ($_{rms}$) at that distance (Richardson *et al.,* 1999).

244. Observations of behavioural changes in baleen whale species have shown avoidance reactions of up to 10km for a seismic survey, with a noise source level of 143dB 1 µPa (peak to peak) (Macdonald *et al.,* 1995).

245. Dose-response functions for avoidance responses of grey whales *Eschrichtius robustus* to both continuous and impulsive noises were developed for vessel noise and seismic air guns by Malme (1984). For continuous noise sources, avoidance of minke whale started at a received level of 110-119dB re 1 µPa (Lpeak, rms), with more than 80% of individuals responding at 130dB re 1 µPa (Lpeak, rms), and 50% at 120dBdB re 1 µPa (Lpeak, rms).

246. Higher noise levels were required for an avoidance response due to the impulsive noise source (seismic airguns), with 10% of migrating grey whales responding at 164dB re 1 µPa (Lpeak, rms), 50% at 170dB re 1 µPa (Lpeak, rms), and 90% at 180dB re 1 µPa (Lpeak, rms) (Malme, 1984 cited in Tyack & Thomas, 2019). A secondary study (Malme, 1987) using 100 cu. In. air guns (with a source level of 226dB re 1µPa) for foraging grey whales found a response level (where individuals would cease foraging activities) of 50% at 173dB re 1 µPa ($L_{peak,\ rms}$), and 10% at 163dB re 1 µPa ($L_{peak,\ rms}$).

Behavioural response of seals to piling

247. There is limited data on the behavioural response of seals to disturbance from underwater noise such as piling. A study undertaken on ringed seals Pusa hispida, bearded seals Erignathus barbatus, and spotted seals Phoca largha (Harris *et al*., 2001) found the onset of a significant behavioural response at a received noise level of 160 to 170dB re 1 µPa (rms), although a larger proportion of individuals showed no response at noise levels of up to 180dB re 1 µPa (root-mean-square; rms). Only at much higher sound pressure levels (190 to 200dB re 1 µPa (rms)) did significant numbers of seals exhibit a significant disturbance response.

248. Data from tagged harbour seals in the Wash indicated that seals were not excluded from the vicinity of the Lincs wind farm during the construction phase but there was clear evidence of avoidance during pile driving events (Russell *et al*., 2016). Seal activity was significantly reduced at ranges of up to 25km from piling sites, although within two hours of cessation of piling, seal distribution returned to pre-piling levels (Russell *et al*., 2016).

Disturbance / displacement of marine mammals based on known disturbance ranges for piling

249. The current advice from the Statutory Nature Conservation Bodies (SNCBs) is that a potential disturbance range (Effective Deterrence Range (EDR)) of 26km[6] around piling locations for monopiles (without noise abatement), and 15km[7] for pin piles (with and without noise abatement) is used to determine the area that harbour porpoise may be disturbed from in relevant SACs (JNCC *et al*., 2020). North Falls is located wholly within the Southern North Sea SAC, and therefore this approach has been followed for both this ES and the Habitats Regulations Assessment (HRA). Not all harbour porpoise within these potential disturbance areas based on EDRs will be disturbed, however as worst case scenario 100% disturbance of harbour porpoise in the areas has been assumed.

250. The estimated number of harbour porpoise and percentage of the North Sea MU reference population that could be disturbed as a result of underwater noise during piling at North Falls is presented in Table 12.32.

251. For one piling event at a time, the magnitude of the potential impact is assessed as low for the 26km EDR for monopiles, with 2.02% of the reference population anticipated to be affected, and negligible for the 15km EDR for jacket pin piles with 0.7% of the reference population anticipated to be temporarily disturbed (Table 12.32).

252. For two simultaneous piling events, the magnitude of the potential impact is assessed as low for the 26km EDR for monopiles, low for multiple jacket pin piles with the 15km EDR for jacket pin piles, and negligible for a single jacket pin pile (Table 12.32). Note that this does not assume any overlap between disturbance areas from the piling events and is therefore precautionary.

---

[6] A potential disturbance area of up to 2,123.7km^2
[7] A potential disturbance area of up to 706.9km^2

253. Further assessments in relation to the Southern North Sea SAC are provided in the RIAA.

Table 12.32 Assessment of the potential for disturbance to harbour porpoise based on the EDR approach for monopiles and jacket pin piles, and for both a single and two simultaneous piling events (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

EDR	Assessment of impact	Magnitude of impact
For a single piling event		
EDR of 26km for monopiles	6,832 harbour porpoise (2.02% of the NS MU reference population), based on the HiDef winter density estimate).	Low
EDR of 15km for jacket pin piles	2,274 harbour porpoise (0.67% of the NS MU reference population), based on the HiDef winter density estimate).	Negligible
For two simultaneous piling events[8]		
EDR of 26km for monopiles, at two simultaneous locations	13,664 harbour porpoise (4.03% of the NS MU reference population), based on the HiDef winter density estimate).	Low
EDR of 15km for jacket pin piles, at two simultaneous locations	4,549 harbour porpoise (1.34% of the NS MU reference population), based on the HiDef winter density estimate).	Low

254. There is very little information on the potential disturbance ranges of minke whale due to impact piling. As noted above, baleen whale species (bowhead whale) have been recorded to have a deterrence distance of up to 30km from a seismic source ((Richardson *et al.,* 1999). While this was for a seismic survey rather than impact piling, it is an impulsive noise source with a high source level. In addition, the 30km potential avoidance range is similar to the modelled TTS / fleeing response range for minke whale of 30km for cumulative monopile installation, or 31km for cumulative jacket pin pile installation (Table 12.27), and therefore, in the absence of any further information on the potential for disturbance of minke whale from piling, the assessment as undertaken for TTS / fleeing response is used to inform the potential for a disturbance impact (Table 12.28 for a single piling location, and Table 12.30 for a multiple pile location). There is therefore the potential for a negligible magnitude of impact for minke whale from the disturbance of piling.

255. Regarding both grey and harbour seal, as noted above, a study has shown that harbour seal are present in significantly reduced number, up to a distance of 25km during piling (or a disturbance area of 1,963.5km^2) (Russell *et al.,* 2016). This range has been used to determine the number of both grey and harbour seal that may be disturbed during piling at North Falls (Table 12.33).

256. The magnitude of the potential impact is assessed as negligible for both grey seal and harbour seal, with up to less than 1% of the reference population anticipated to be temporarily disturbed, for either a single or multiple piling

[8] Not taking into account any overlap between disturbance areas between the two locations

location/s. (Table 12.33). Note that this does not assume any overlap between disturbance areas from the piling events and is therefore precautionary.

Table 12.33 Assessment of the potential for disturbance to grey seal and harbour seal based on a disturbance range of 25km for monopiles (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Marine mammal species	Assessment of impact	Magnitude of impact
For a single piling event		
Grey seal	138 grey seal (0.45% of the SE England MU reference population, or 0.25% of the wider reference population).	Negligible
Harbour seal	1 harbour seal (0.02% of the SE England MU reference population).	Negligible
For two simultaneous piling events[9]		
Grey seal	275 grey seal (0.90% of the SE England MU reference population, or 0.49% of the wider reference population).	Negligible
Harbour seal	2 harbour seal (0.04% of the SE England MU reference population).	Negligible

Dose response curve assessment

257. As per current best practice guidance (Southall *et al*., 2021), a behavioural disturbance dose-response analysis has been carried out for those species for which appropriate dose-response evidence exists within the scientific literature.

258. Where sufficient scientific evidence exists, a species-specific dose-response assessment has been undertaken rather than the fixed behavioural threshold approach that is described above. The dose-response methodology has therefore been undertaken for harbour porpoise, harbour seal, and grey seal.

259. The application of a dose-response curve allows for an evidence-based estimate which accounts for the fact that the likelihood of an animal exhibiting a response to a stressor or stimulus will vary according to the dose of stressor or stimulus received (Dunlop *et al.,* 2017). Therefore, unlike the traditional threshold assessments commonly used, a dose-response analysis assumes that not all animals in an impacted area will respond (with behavioural disturbance response in this case). For the purposes of this assessment, the dose is the received single-strike SEL (SEL_{SS}). The use of SEL_{SS} in a dose-response analysis, where possible, is considered to be best practice in the latest guidance provided by Southall *et al.,* (2021).

260. To estimate the number of animals disturbed by piling, SEL_{SS} (sound exposure level single strike) contours at 5dB increments (generated by the noise modelling – see Appendix 12.3 (Document Reference: 3.3.8)) were overlain on the relevant species density surfaces (Figures 12.7 to 12.14, Document Reference: 3.2.8) to quantify the number of animals receiving each SEL_{SS}, and subsequently the number of animals likely to be disturbed based on the corresponding dose-response curve.

---

[9] Not taking into account any overlap between disturbance areas between the two locations

261. For harbour porpoise, the Waggitt *et al*., (2019) density estimates were used. As August was the month with the greatest harbour porpoise densities within the offshore project area, density estimates from this month were used for the analysis as worst case. For both seal species, the Carter et al., (2022) density estimates were used.

262. The dose-response relationship used for harbour porpoise was developed by Graham et al., (2017) using data collected during Phase 1 of piling at the Beatrice OWF. This dose response relationship is displayed in Plate 12.2. Following the development of this dose-response relationship, further study revealed that the responses of harbour porpoises to piling noise diminishes over the construction period (Graham *et al*., 2019). Therefore, the use of the dose-response relationship related to an initial piling event for all piling events in this assessment can be considered conservative.

263. In the absence of species-specific dose-response data for dolphins or whales, harbour porpoise is the only species of cetacean that this analysis is applied to. Due to differences in hearing of baleen whales, dolphins, and porpoise, as well as their behaviour, it would not be appropriate to extrapolate the findings of Graham *et al.,* (2017) to minke whale.

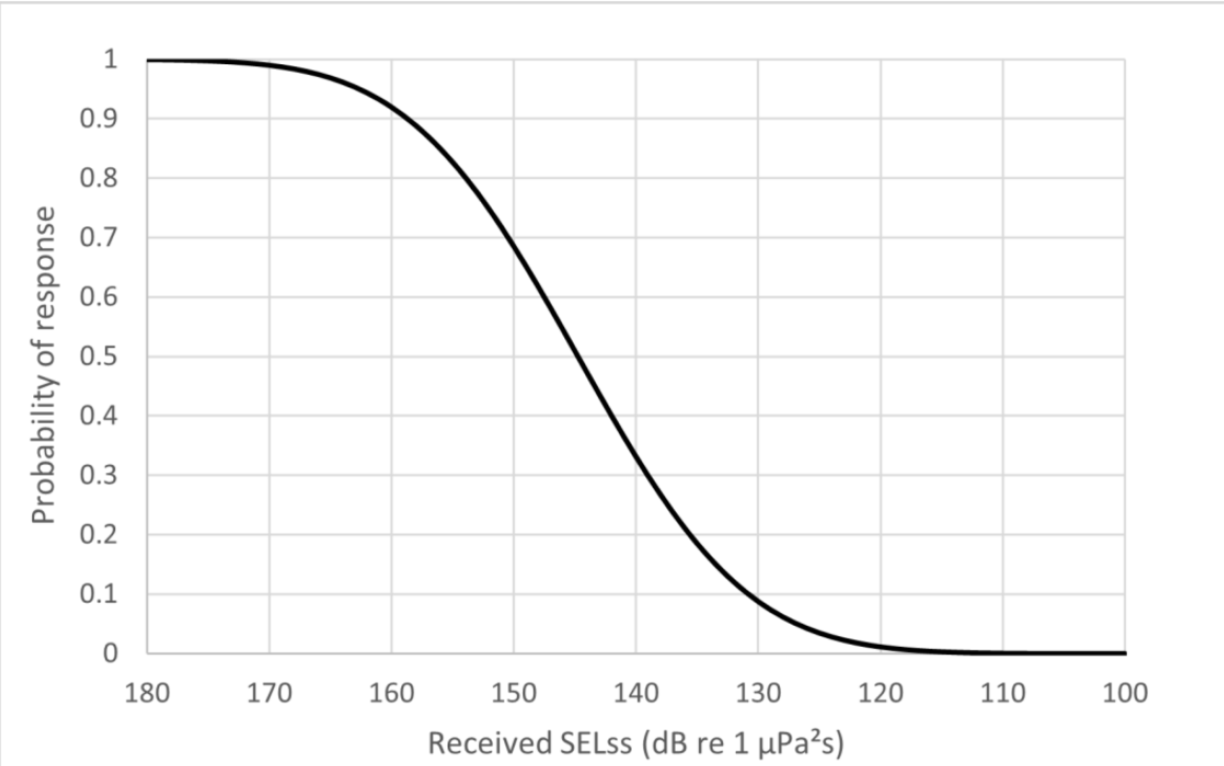

Plate 12.2 Dose-response relationship developed by Graham *et al.* (2017) used for harbour porpoise in this assessment

264. For seals, a dose-response relationship derived from harbour seal telemetry data collected during several months of piling at the Lincs OWF has been used (Whyte *et al.,* 2020). As seen in Plate 12.3, the greatest SEL_{SS} considered in the Whyte *et al.,* (2020) study was 180dB re 1 μPa^{2}s. This assessment has therefore conservatively assumed that at SEL_{SS} > 180dB re 1 μPa^{2}s all seals will be disturbed. The dose-response curve for harbour seal is appropriate for grey seal, as both species have similar hearing audiograms.

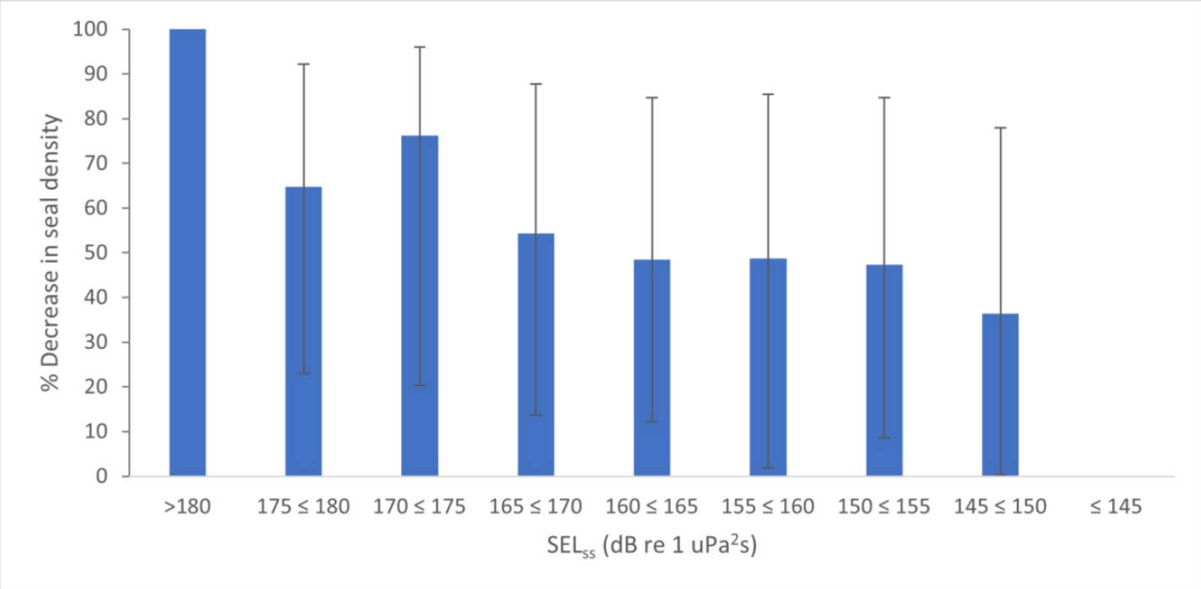

Plate 12.3 Dose-response behavioural disturbance data for harbour seal derived from the data collected and analysed by Whyte *et al.* (2020).

265. The estimated numbers (and percentage of the relevant reference populations) of harbour porpoise, grey seal, and harbour seal disturbed as a result of underwater noise during piling are presented in Table 12.34.

266. For all species assessed, the magnitude of the potential impact is assessed as negligible, with less than 1% of the relevant reference population predicted to be disturbed Table 12.34.

267. It should be noted that this dose-response analysis is carried out in relation to pile driving noise only, and therefore does not account for the use of ADDs which may reduce localised marine mammal densities prior to piling. This assessment can therefore be considered conservative.

Table 12.34 Number of individuals (and % of reference population) that could be disturbed during piling at North Falls based on the dose-response approach (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Marine mammal species	Assessment of impact	Magnitude of impact
Instantaneous behavioural disturbance due to a single, maximum energy monopile strike (SEL$_{SS}$)		
Harbour porpoise	1,072 harbour porpoise (0.32% of the NS MU reference population).	Negligible
Grey seal	112 grey seal (0.37% of the SE England MU reference population, or 0.20% of the wider reference population)[10].	Negligible
Harbour seal	7 harbour seal (0.14% of the SE England MU reference population)[10].	Negligible

[10] Based on the west piling location as the worst-case location

Marine mammal species	Assessment of impact	Magnitude of impact
Instantaneous behavioural disturbance due to a single, maximum energy pin pile strike (SEL_{SS})		
Harbour porpoise	1,023 harbour porpoise (0.30% of the NS MU reference population).	Negligible
Grey seal	105 grey seal (0.34% of the SE England MU reference population, or 0.19% of the wider reference population)[10].	Negligible
Harbour seal	6 harbour seal (0.12% of the SE England MU reference population)[10].	Negligible

Population modelling

268. Population modelling has been conducted for harbour porpoise, minke whale, harbour seal and grey seal. The interim Population Consequences of Disturbance (iPCoD) framework (Harwood *et al.,* 2014, King *et al*., 2015) has been used to estimate the potential medium- and long-term population consequences of the predicted amount of disturbance resulting from piling at North Falls. iPCoD uses a stage-structured model of population dynamics with nine age classes and one stage class (adults 10 years and older). The model is used to run a number of simulations of future population trajectory with and without the predicted level of impact. This allows an understanding of the potential future population-level consequences of predicted behavioural responses to auditory injury.

269. There is a lack of empirical data on the way in which changes in behaviour and hearing sensitivity may affect the ability of individual marine mammals to survive and reproduce. Therefore, in the absence of empirical data, the iPCoD framework uses the results of an expert elicitation process described in Donovan *et al.* (2016) to predict the impacts of disturbance and Permanent Threshold Shift (PTS) on survival and reproductive rates. The process generates a set of statistical distributions for these impacts and then simulations are conducted using values randomly selected from these distributions that represent the opinions of a “virtual” expert. This process is repeated many 100s of times to capture the uncertainty among experts. While the iPCoD model is subject to many assumptions and uncertainties relating to the link between impacts and vital rates, the model presents the best available scientific expert opinion at this time. See Appendix 12.6 (Document Reference: 3.3.11) for further information on the limitations of the iPCoD approach.

270. At this stage, uncertainty exists around the exact piling schedule that will be used for construction at North Falls, however the periods during which piling is likely to occur are known. Therefore, the required number of piling days for each construction scenario have been distributed randomly within the known piling periods.

271. The piling parameters for North Falls included 57 days of mono piling for foundations and two days of mono piling for OSP/OCP installation (model assumes one pile per day as a worst case scenario) within 2030 (following current best practice, days were distributed randomly as exact piling days are not known). The iPCoD model v5.2 was set up using the program R v4.2.3

(2023) with RStudio as the user interface. To enable the iPCoD model to be run, the following data were provided:

- Demographic parameters for each key species;
- User specified input parameters
  - Vulnerable subpopulations
  - Residual days of disturbance
- Number of animals predicted to experience PTS and/or disturbance during piling; and
- Estimated piling schedule during the proposed construction programme.

272. Demographic parameters for the key species assessed in the population model are presented in Table 12.35. In the case of harbour seal, evidence for demographic parameters for the English populations is lacking (Sinclair *et al*., 2020). Given that the SE MU appears to be decreasing in recent years (as detailed in Section 12.5.6), the worst-case demographic parameters for the similarly decreasing population on the Scottish East coast (Sinclair *et al*., 2019) have been utilised in the modelling. See Appendix 12.6 (Document Reference: 3.3.11) for the full parameters used within the modelling.

Table 12.35 Demographic Parameters Recommended for Each Species for the Relevant Management Unit (MU/SMAs (Sinclair *et al*., 2019)

Species	MU	Age	Age	Calf/pup survival	Juvenile survival	Adult survival	Fertility	Growth rate
		Age1	Age2	Surv[1]	Surv[7]	Surv[13]		
Harbour porpoise	North sea	1	5	0.6	0.85	0.85	0.958	1.0000
Minke whale	CGNS	1	9	0.72	0.77	0.96	0.9	1.0000
Grey seal	NE England and SE England, as well as SE England separately	1	5	0.222	0.94	0.94	0.84	1.0100
Harbour seal	SE England	1	4	0.5	0.5	0.7701	0.88	0.8200

Harbour porpoise

273. For harbour porpoise, taking into account the project alone scenario assessed using the reference population (338,918) of the NS MU, the iPCoD model predicts there to be a negligible effect on the harbour porpoise population over time due to piling (Plate 12.4 and Table 12.36).

274. The median population size was predicted to be 100% of the un-impacted population size at the end of 2028 (1 year after the piling from all cumulative projects has commenced in the wider area). By the end of 2032 (the year piling

ends for all cumulative projects) the median population size for the impacted population is predicted to be 100% of the un-impacted population size. Beyond 2032, the impacted population is expected to maintain the same stable trajectory as the un-impacted population (as far as 2052 which is the end point of the modelling, at which point the median impacted to un-impacted ratio is 99.99%; Table 12.36).

275. For harbour porpoise, the potential magnitude of impact for disturbance from underwater noise from North Falls piling is assessed as negligible, due to there being less than a 1% population level impact on average per year over both the first six years and 25 year modelled periods.

Table 12.36 Results of the iPCoD modelling for the project alone assessment, giving the mean population size of the harbour porpoise population (wider reference population) for years up to 2053 for both impacted and un-impacted populations in addition to the median ratio between their population sizes.

Year	Un-impacted population mean	Impacted population mean	Median impacted as % of un-impacted
Start	338,918	338,918	100.00
End of 2028	338,485	338,468	100.00
End of 2029	338,770	338,719	100.00
End of 2032	340,101	340,054	100.00
End of 2037	339,347	339,297	99.99
End of 2047	339,372	339,322	99.99
End of 2052	337,661	337,611	99.99

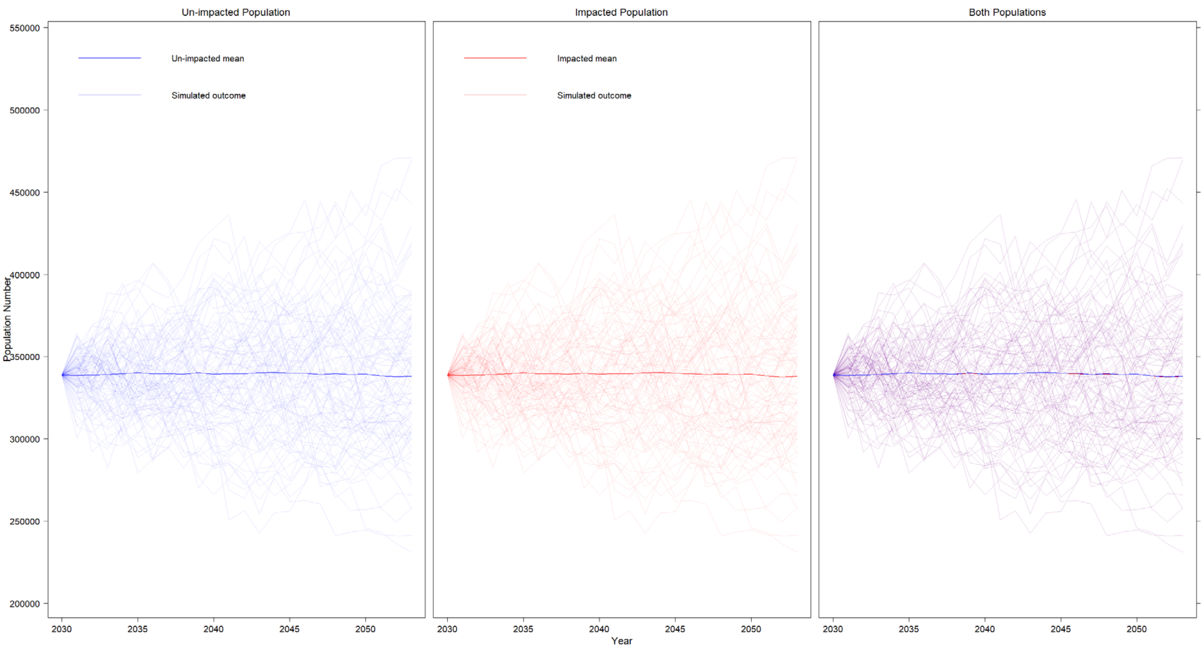

Plate 12.4 Simulated worst-case harbour porpoise population sizes for both the un-impacted and the impacted populations for the project alone assessment

Minke whale

276. For minke whale, taking into account the project alone scenario assessed using the reference population (20,118) of the CGNS MU, the iPCoD model predicts

there to be a negligible effect on the minke whale population over time due to piling (Plate 12.5 and Table 12.37).

277. The median population size was predicted to be 99.99% of the un-impacted population size at the end of 2028 (1 year after the piling from all cumulative projects has commenced in the wider area). By the end of 2032 (the year piling ends for all cumulative projects) the median population size for the impacted population is predicted to be 99.86% of the un-impacted population size. Beyond 2032, the impacted population is expected to maintain the same stable trajectory as the un-impacted population (as far as 2052 which is the end point of the modelling, at which point the median impacted to un-impacted ratio is 99.72%; Table 12.37).

278. For minke whale, the potential magnitude of impact for disturbance from underwater noise from North Falls piling is assessed as negligible, due to there being less than a 1% population level impact on average per year over both the first six years and 25 year modelled periods.

Table 12.37 Results of the iPCoD modelling for the project alone assessment, giving the mean population size of the minke whale population (wider reference population) for years up to 2053 for both impacted and un-impacted populations in addition to the median ratio between their population sizes.

Year	Un-impacted population mean	Impacted population mean	Median impacted as % of un-impacted
Start	20,120	20,120	100.00
End of 2028	20,138	20,133	99.99
End of 2029	20,130	20,113	99.94
End of 2032	20,158	20,119	99.86
End of 2037	20,162	20,103	99.77
End of 2047	20,098	20,030	99.72
End of 2052	20,077	20,009	99.72

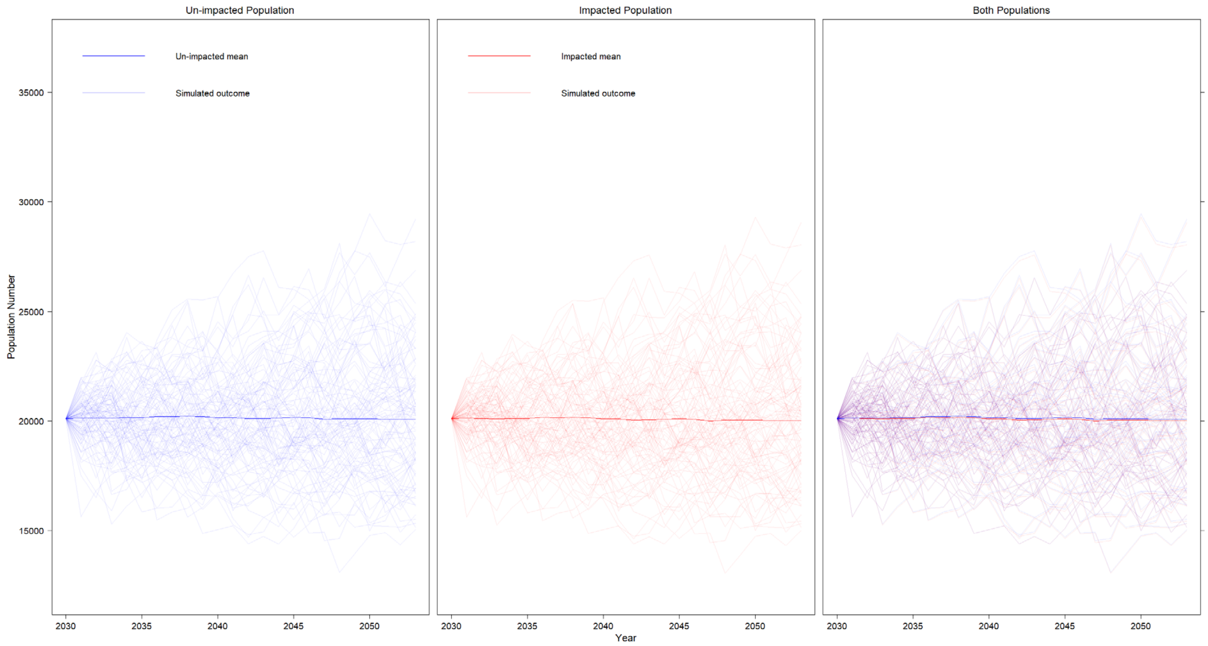

Plate 12.5 Simulated worst-case minke whale population sizes for both the un-impacted and the impacted populations for the project alone assessment.

Grey seal

279. For grey seal, with the project alone scenario assessed and using the wider reference population (of 56,505 for both the SE and NE MUs), the iPCoD model predicts there to be no effect on the grey seal population over time (Plate 12.6 and Table 12.38).

280. The median population size was predicted to be 100% of the un-impacted population size at the end of 2028, and by the end of 2032, the median population size for the impacted population is predicted to be 100% of the un-impacted population size. Beyond 2032, the impacted population is expected to maintain the same stable trajectory as the un-impacted population (as far as 2052 which is the end point of the modelling, at which point the median impacted to un-impacted ratio is 100%; Table 12.38).

Table 12.38 Results of the iPCoD modelling for the project alone assessment, giving the mean population size of the grey seal population (wider reference population) for years up to 2053 for both impacted and un-impacted populations in addition to the median ratio bet

Year	Un-impacted population mean	Impacted population mean	Median impacted as % of un-impacted
Start	56,502	56,502	100.00
End of 2028	57,094	57,094	100.00
End of 2029	57,666	57,666	100.00
End of 2032	59,445	59,445	100.00
End of 2037	62,692	62,692	100.00
End of 2047	69,134	69,134	100.00
End of 2052	72,487	72,487	100.00

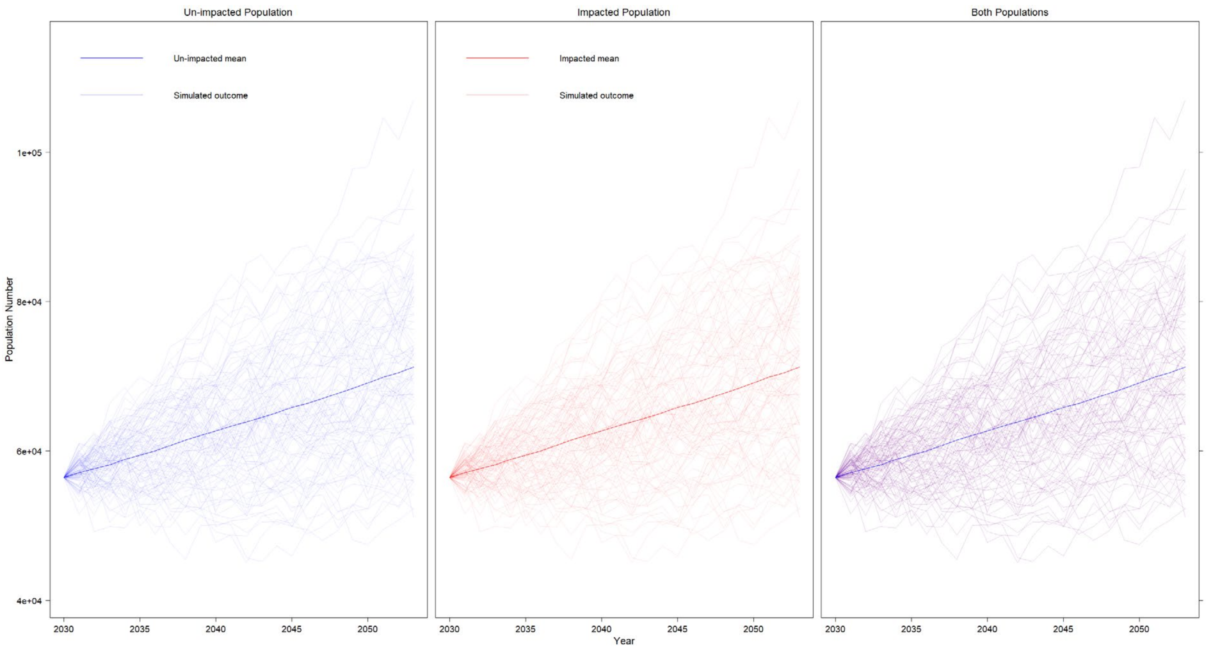

Plate 12.6 Simulated worst-case grey seal (based on wider reference population) population sizes for both the un-impacted and the impacted populations for the project alone assessment

281. Additional population modelling was undertaken for grey seal, for just the SE MU reference population (30,592). Again, the iPCoD model predicts no effect on the grey seal population over time (Plate 12.7 and Table 12.39).

282. The median population size was predicted to be 100% of the un-impacted population size at the end of 2028 and by the end of 2032, the median population size for the impacted population is predicted to be 100% of the un-impacted population size. Beyond 2032, the impacted population is expected to maintain the same stable trajectory as the un-impacted population (as far as 2052 which is the end point of the modelling, at which point the median impacted to un-impacted ratio is 100%; Table 12.39).

283. For grey seal, the potential magnitude for disturbance from underwater noise from North Falls piling on both the SE MU and wider reference population is assessed as negligible, due to there being less than a 1% population level effect on average per year over both the first six years and 25 year modelled periods.

Table 12.39 Results of the iPCoD modelling for the project alone assessment, giving the mean population size of the grey seal population (SE MU population) for years up to 2053 for both impacted and un-impacted populations in addition to the median ratio between their population sizes.

Year	Un-impacted population mean	Impacted population mean	Median impacted as % of un-impacted
Start	30,594	30,594	100.00
End of 2028	30,931	30,594	100.00
End of 2029	31,196	30,594	100.00
End of 2032	32,051	30,594	100.00
End of 2037	33,737	30,594	100.00
End of 2047	37,174	30,594	100.00
End of 2052	38,919	30,594	100.00

Plate 12.7 Simulated worst-case grey seal (based on SE MU) population sizes for both the un-impacted and the impacted populations for the project alone assessment.

Harbour seal

284. For harbour seal, the project alone scenario assessed using the reference population of 4,868, the iPCoD model predicts no effect on the harbour seal population over time (Plate 12.8 and Table 12.40).

285. The median population size was predicted to be 100% of the un-impacted population size at the end of 2028. By the end of 2032, the median population size for the impacted population is predicted to be 100% of the un-impacted population size. Beyond 2032, the impacted population is expected to maintain the same stable trajectory as the un-impacted population (as far as 2052 which is the end point of the modelling, at which point the median impacted to un-impacted ratio is 100%; Table 12.40).

286. For harbour seal, the potential magnitude for disturbance from underwater noise from North Falls piling is assessed as negligible due to there being less than a 1% population level effect on average per year over both the first six years and 25 year modelled periods.

Table 12.40 Results of the iPCoD modelling for the project alone assessment, giving the mean population size of the harbour seal population for years up to 2053 for both impacted and un-impacted populations in addition to the median ratio between their population size

Year	Un-impacted population mean	Impacted population mean	Median impacted as % of un-impacted
Start	4,866	4,866	100.00
End of 2028	3,995	3,995	100.00
End of 2029	3,277	3,277	100.00
End of 2032	1,811	1,811	100.00
End of 2037	674	674	100.00
End of 2047	92	92	100.00

Year	Un-impacted population mean	Impacted population mean	Median impacted as % of un-impacted
End of 2052	33	33	100.00

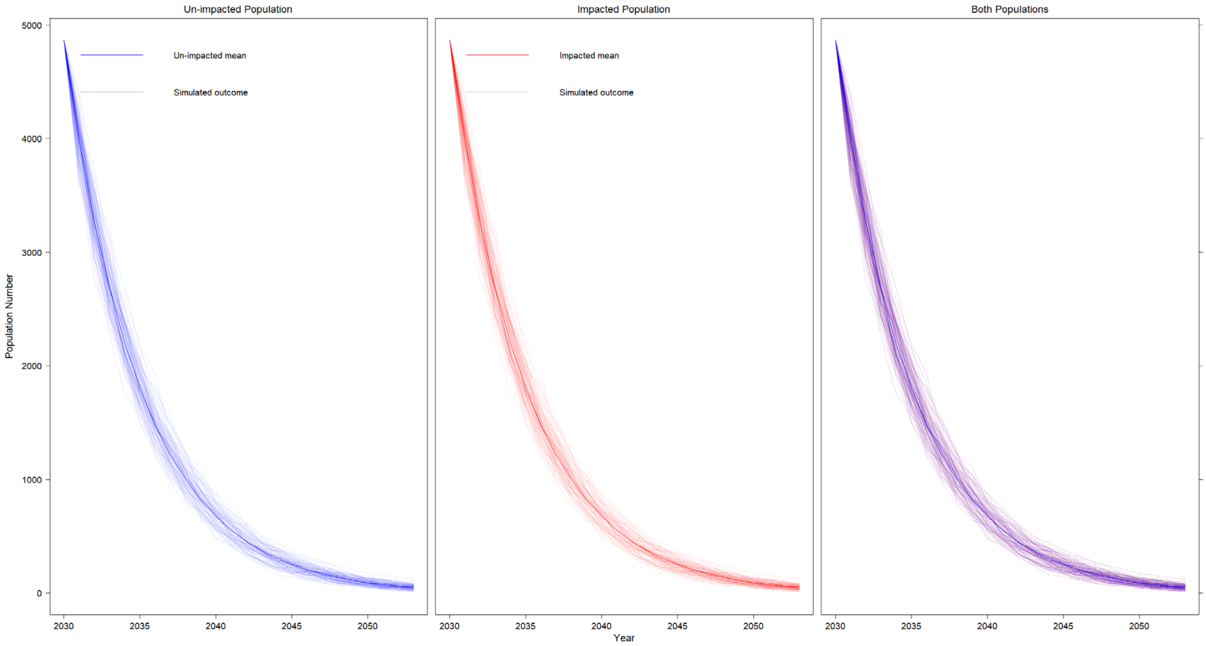

Plate 12.8 Simulated worst-case harbour seal population sizes for both the un-impacted and the impacted populations of the project alone assessment.

Reduction in foraging due to noise disturbance

287. Whilst underwater noise has been shown to disturb cetaceans foraging at sea, especially sensitive species such as the harbour porpoise and to a lesser extent minke whale, it is expected that the main sources of disturbance will be short-term in nature. Construction activities such as piling will include measures to reduce the direct impacts of noise on marine mammals, which will also help to mitigate disturbance to foraging behaviour and reduce the impact. In addition, the area is a high-traffic zone for vessels and the period of construction (approximately two years) is unlikely to increase this significantly. The magnitude of impact for harbour porpoise and minke whale is therefore low.

288. Hastie et al. (2021) studied the change in foraging behaviour of grey seal when exposed to underwater noise. A high density and low density area of prey was present within an experimental pool, and speakers were located at each prey patch. During the control periods, seals would forage mainly at the high-density patch, but also at the low-density patch for a smaller proportion of time. When the seals were exposed to noise at the low density patch, there was a reduction in foraging of 16-28%, however, when seals were exposed to noise at the high density prey patch, there was no change in foraging in comparison to control periods (Hastie et al., 2021). This indicates that seals would choose to remain at a noisy environment, if there were good prey resources at the same location (Hastie et al., 2021).

289. As described in Section 12.5.4, a tagging study of harbour seal within the outer Thames Estuary was used to determine key foraging areas. The five key

foraging areas identified are shown on Plate 12.11 and Plate 12.12 (Barker et al., 2014), and point that the closest identified foraging area for harbour seal is at north east Buxey Sand, at more than 10km from the closest point of the offshore cable corridor, and 47km from the array area. The largest disturbance range for seal species for activities within the offshore cable corridor would be 4km (Section 12.6.1.2.4), and for activities within the array area would be 25km (Section 12.6.1.1.4). Therefore, there is no potential for disturbance of seals from the currently identified key foraging areas of harbour seal. However, given the paucity of understanding on key seal foraging areas and the longer term effects of disturbance, as a precautionary approach the magnitude for grey seal and harbour seal is considered to be low.

Duration of piling

290. The foundation installation period (for both monopiles and jacket pin piles) is currently expected to take place over 12 months. This will include transit of the foundation components in batches to the array area and foundation installation, including any piling.

291. Piling would not be constant during the piling phases and construction periods. There will be gaps between the installations of individual piles, and if installed in groups there could be time periods when piling is not taking place as piles are brought out to the site. There will also be potential delays for weather or other technical issues.

292. Table 12.41 summarises the worst case scenarios for the duration of piling based on the maximum number of WTGs, number of piles and piling duration to install each pile, including soft-start, ramp-up and ADD activation. For monopiles, including ADD activation, there will be up to 20 days of active piling within the 12 month foundation installation period (or for 5.5% of the total period), and for jacket pin piles, including ADD activation, there will be up to 103 days of active piling within the foundation installation period (or for 28.2%). Note that the actual active piling period will be less than this, as piling will not be required for the full 7.5 hours per pile for monopiles, or 4.5 hours per pile for jacket pin piles at all locations.

Table 12.41 Maximum duration of piling at North Falls, based on worst case scenarios, including soft-start, ramp-up and ADD activation

Parameter	Number of piles	Maximum active piling time per pile	Total piling time	ADD activation	Total duration (including ramp-up, soft-start and ADD activation) for all piles
Up to 57 WTGs	Up to 57 monopiles	7.5 hours including soft-start and ramp-up	Up to 427 hours and 30 minutes (17.8 days) for 57 monopiles	35 hours and nine minutes for 37 minute ADD activation per monopile	462 hours and 39 minutes (19.3 days)
	Up to 456 jacket pin piles	4.5 hours including soft-start and ramp-up	Up to 2,052 hours (85.5 days) for 456 jacket pin piles	281 hours and 12 minutes 37 minute ADD activation per jacket pin pile	2,333 hours and 12 minutes (97.2 days)

Parameter	Number of piles	Maximum active piling time per pile	Total piling time	ADD activation	Total duration (including ramp-up, soft-start and ADD activation) for all piles
Two OSP / OCPs	Up to two monopiles	7.5 hours including soft-start and ramp-up	Up to 15 hours (0.6 days) for two monopiles	1 hour and 14 minutes for 37 minute ADD activation per monopile	16 hours and 14 minutes (0.7 days)
	Up to 24 jacket pin piles	4.5 hours including soft-start and ramp-up	Up to 108 hours (4.5 days) for 24 jacket pin piles	14 hours and 48 minutes for 37 minute ADD activation per jacket pin pile	122 hours and 48 minutes (5.1 days)
Piling of up to 59 monopiles (including soft-start, ramp-up and 37 minute ADD activation) = up to 478 hours (up to 20 days) (or for 5.5% of the total piling programme days); or **Piling of up to 480 jacket pin piles (including soft-start, ramp-up and 37 minute ADD activation) = up to 2,456 hours (up to 103 days) with 37 minute ADD activation (or for 28.2% of the total piling programme days).**					

293. The duration of piling is based on a worst case scenario and a very precautionary approach. As has been shown at other OWFs, the duration used in the impact assessment can be overestimated. For example, for the installation of monopile foundations at Dudgeon Offshore Wind Farm (DOWL), the impact assessment estimated a piling period of 93 days, time to install each monopile was estimated to be up to 4.5 hours and the estimated duration of active piling was 301.5 hours (approximately 13 days). However, the actual total duration of active piling was 65 hours (approximately 3 days) with the average time for installation per monopile of 71 minutes (DOWL, 2016). Therefore, the actual piling duration was approximately 21% of the predicated maximum piling duration.

294. The piling duration to install the individual monopiles at DOWL varied considerably for each location, and the worst case scenario of up to 4.5 hours to install a pile was an accurate assessment of the actual maximum duration (4.35 hours), however the majority of piles were installed in much shorter duration. At DOWL, the time intervals between the installations of individual monopiles (not including time to collect further piles for installation) was on average approximately 23 hours. Monopiles were installed in groups of up to three, due to the capacity of the piling vessel, which meant that it could only carry three monopiles and three transition pieces before returning to port to collect the next three monopiles. The intervals between groups of monopiles being installed ranged from approximately 2.5 days to 11 days, with an average of approximately four days between the 22 groups of three monopiles (DOWL, 2016).

295. Similar results were also observed for the Beatrice OWF, where within the ES it was estimated that each pin pile would require 5 hours of active piling time. However, during construction, the total duration of piling ranged from 19 minutes to 2 hours and 45 minutes, with an average duration of 1 hour and 15 minutes per pile (Beatrice OWF, 2018).

296. Once the piling is completed, the duration of the exclusion could last up to three days following a single piling event if the animal is close to the source. Data presented by Brandt *et al.* (2009, 2011) indicated that harbour porpoise would completely leave the area (indicated by the duration of waiting time between porpoise detections after first piling) for a median time of 16.6 hours and a maximum of 74.2 hours within 0.5 to 6.0km of the noise source. Waiting times did not return to 'normal' until 22.7 hours after piling. At distances of greater than approximately 9.0km from the noise source there was a much shorter duration of impact; with waiting times returning to 'normal' between one and 2.6 hours after piling ceased. However, at 18 to 25km there was still a marked impact. Porpoise activity was significantly lower within approximately 3km of the noise source for 40 hours after piling.

297. A study on the impacts of OWF construction on harbour porpoise within the German North Sea between 2009 and 2013 (Brandt *et al*., 2016), indicated that the duration of impact after piling was about 20-31 hours within close vicinity of the construction site (up to 2km) and decreased with increasing distance. The study also observed significant decreases in porpoise detections prior to piling at distances of up to 10km, which is thought to relate to increased vessel activity during preparation works. The study concluded that although there were adverse short-term impacts (1-2 days in duration) of construction on acoustic porpoise detections, there was no indication that harbour porpoises within the German Bight were negatively affected by wind farm construction at the population level (Brandt *et al.,* 2016). It is acknowledged that some of the projects included in this study used noise mitigation techniques.

298. The duration of any potential displacement impact will differ depending on the distance of the individual from the piling activity and the noise level the animal is exposed to. Furthermore, those individuals that are distant from the activity that do not respond, and therefore are not affected, will continue with their normal behaviour that may involve approaching the array area.

299. Nabe-Nielsen *et al.* (2018) developed the DEPONS (Disturbance Effects of Noise on the Harbour Porpoise Population in the North Sea) model to simulate individual animal's movements, energetics and survival for assessing population consequences of sub-lethal behavioural effects. The model was used to assess the impact of OWF construction noise on the North Sea harbour porpoise population, based on the acoustic monitoring of harbour porpoise during construction of the Gemini OWF. Local population densities around the Gemini OWF recovered 2–6 hours after piling, similar recovery rates were obtained in the model. The model indicated that, assuming noise influenced porpoise movements as observed at the Gemini OWF, the North Sea harbour porpoise population was not affected by construction of 65 OWFs, as required to meet the EU renewable energy target (Nabe-Nielsen *et al*., 2018).

300. The DEPONS model determined that at the North Sea scale, population dynamics were indistinguishable from those in the noise-free baseline scenario when porpoises reacted to noise up to 8.9km from the construction sites, as at the Gemini OWF. Underwater noise from OWF construction noise only influenced population dynamics in the North Sea when simulated animals were assumed to respond at distances exceeding 20–50km from the OWFs. Indicating that in these scenarios, the population impact of noise was more

strongly related to the distance at which animals reacted to noise (Nabe-Nielsen *et al.,* 2018). The duration of any potential displacement impact will differ depending on the distance of the individual from the piling activity and the noise level to which the animal is exposed.

Significance of effect

301. The assessment for the potential for disturbance to marine mammals due to both monopile and jacket pin pile installation is provided in Table 12.42, taking into account the medium marine mammal sensitivity and the potential magnitude of impact (i.e. number of individuals as a percentage of the reference population; Table 12.27, Table 12.32, Table 12.33 and Table 12.34)

302. The effect significance for disturbance, based on the known effect ranges for marine mammals, has been assessed as minor adverse for harbour porpoise and minke whale, and as negligible for grey seal and harbour seal, for either monopiles or jacket pin piles (Table 12.42).

303. The effect significance for disturbance from construction on disturbance to foraging at sea has been assessed as minor adverse for harbour porpoise and minke whale, and negligible for grey seal and harbour seal (Table 12.42).

304. For the potential of disturbance to marine mammals based on the dose-response-curves for each relevant species, the effect significance has been assessed as minor adverse for harbour porpoise, and negligible for grey and harbour seal (Table 12.42).

Table 12.42 Assessment of effect significance for the potential for disturbance from monopiles and jacket pin piles

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual effect
Potential for disturbance based on known effect ranges for monopiles or jacket pin piles					
Harbour porpoise	Medium	Low	Minor adverse	None required.	Minor adverse
Minke whale		Negligible			
Grey seal and harbour seal	Low	Negligible	Negligible		Negligible
Potential for disturbance based on a dose-response curve for monopiles or jacket pin piles					
Harbour porpoise	Medium	Negligible	Minor adverse	None required.	Minor adverse
Grey seal and harbour seal	Low	Negligible	Negligible		Negligible

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual effect
Reduction in foraging due to underwater noise disturbance					
Harbour porpoise and minke whale	Medium	Low	Minor adverse	None required.	Minor adverse
Grey seal and harbour seal	Low	Low	Negligible		Negligible

Mitigation

305. While no mitigation is required for marine mammal species (based on significance of effect in EIA terms), the measures that will be put in place through the Site Integrity Plan (SIP), to ensure there is no significant disturbance to harbour porpoise within the Southern North Sea SAC (outlined in Section 12.8 and discussed further in the RIAA) may reduce the potential for disturbance to all marine mammal populations. An Outline Southern North Sea SAC Site Integrity Plan has been submitted alongside this DCO Application that sets out the options for management of disturbance to be considered (Document Reference: 7.8).

12.6.1.1.5 Impact 1d: Disturbance effects due to ADD activation

Sensitivity of marine mammals

306. As detailed in Section 12.6.1.1.4, harbour porpoise and minke whale are assessed as having a medium sensitivity to disturbance, while grey seal and harbour seal have a sensitivity of low.

Magnitude of impact

307. The assessments of the potential disturbance during any ADD activation is indicative only, as the final requirements for mitigation in the MMMP will be determined prior to construction.

308. Mitigation to reduce the risk of PTS would include activation of ADDs prior to the soft-start commencing. The period of time that an ADD is required to be activated for is dependent on the potential PTS ranges for each species (Table 12.18 and Table 12.20), and their known swim speeds, as used within the underwater noise modelling.

309. Based on the swim speeds of each species[11], and the maximum ranges of cumulative PTS onset for the installation of one pile (Table 12.20), the ADD

[11] Of 1.5m/s for harbour porpoise, grey seal and harbour seal (Otani *et al.*, 2000) and 3.25m/s for minke whale (Blix and Folkow, 1995)

would be required to be activated for a period of 37 minutes prior to piling, for both monopiles and jacket pin piles. This would result in;

- Harbour porpoise fleeing to a range of 3.33km (further than the modelled cumulative PTS onset range of 3.3km for both monopiles and jacket pin piles);
- Minke whale fleeing to a range of 7.215km (further than the modelled cumulative PTS onset range of 7.0km and 6.9km for a monopile or jacket pin pile respectively); and
- Both grey and harbour seal fleeing to a range of 3.33km further than the modelled cumulative PTS onset range of 100m for both monopiles and jacket pin piles).

310. The magnitude of the potential impact is assessed as negligible for all species (Table 12.43).

Table 12.43 Assessment of the potential for disturbance due to ADD activation for both monopile and jacket pin piles (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Marine mammal species	Marine mammal fleeing range (and area) for ADD activation of 37 minutes	Assessment of impact	Magnitude of impact
Harbour porpoise	3.33km ($34.84km^2$)	113 harbour porpoise (0.03% of the NS MU reference population), based on the HiDef winter density estimate).	Negligible
Minke whale	7.215km ($163.54km^2$)	3 minke whale (0.01% of the CGNS MU reference population).	Negligible
Grey seal	3.33km ($34.84km^2$)	3 grey seal (0.008% of the SE England MU reference population, or 0.004% of the wider reference population).	Negligible
Harbour seal		0.02 harbour seal (0.0003% of the SE England MU reference population).	Negligible

311. The ADD activation would ensure marine mammals are beyond the maximum impact range for cumulative PTS for both monopiles and jacket pin piles (Table 12.18).

312. The maximum total ADD activation time to install all piles, based on worst case scenarios is provided in Table 12.41.

Significance of effect

313. The assessment for the potential for disturbance to marine mammals due to both monopile and jacket pin pile installation is provided in Table 12.44, taking into account the marine mammal sensitivity and the potential magnitude of impact (i.e. number of individuals as a percentage of the reference population; Table 12.43).

314. The effect significance for disturbance based on the known effect ranges for marine mammals has been assessed as minor adverse for harbour porpoise and minke whale, and as negligible for grey seal and harbour seal, for either monopiles or jacket pin piles (Table 12.44).

Table 12.44 Assessment of effect significance for the potential for disturbance from ADD activation prior to piling

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual effect
Harbour porpoise and minke whale	Medium	Negligible	Minor adverse	None required.	Minor adverse
Grey seal and harbour seal	Low	Negligible	Negligible		Negligible

Mitigation

315. No mitigation is required for marine mammal species (based on significance of effect in EIA terms). Therefore, the residual significance of effect due to ADD disturbance would be negligible to minor adverse (not significant in EIA terms) for all species.

12.6.1.2 Impact 2: Effects from underwater noise associated with other construction activities

316. Potential sources of underwater noise during construction activities, other than piling, include seabed preparation, dredging, rock placement, trenching and cable installation.

317. There are no clear indications that underwater noise caused by the installation of subsea cables poses a high risk of harming marine fauna (OSPAR, 2009). However, behavioural responses of marine mammals to dredging, an activity emitting comparatively high underwater noise levels, are predicted to be similar to those during cable installation (OSPAR, 2009).

318. Dredging produces continuous, broadband sound. SPLs can vary widely, for example, with dredger type, operational stage, or environmental conditions (e.g., sediment type, water depth, salinity and seasonal phenomena such as thermoclines; Jones and Marten, 2016). These factors will also affect the propagation of sound from dredging/cable installation activities and along with ambient sound already present, will influence the distance at which sounds can be detected.

319. Dredging/cable installation activities has the potential to generate underwater noise at sound levels and frequencies for sufficient durations to disturb marine mammals. Noise measurements indicate that the most intense sound emissions from trailing suction hopper dredgers (TSHD) are typically low frequencies, up to and including 1kHz (Robinson *et al.,* 2011) and are comparable to those for a cargo ship travelling at modest speed (between 8 and 16 knots) (Theobald *et al.,* 2011).

320. Reviews of published sources of underwater noise during dredging activity (e.g., Thomsen *et al.,* 2006; Theobald *et al.,* 2011; Todd *et al.,* 2014), indicate that the sound levels that marine mammals may be exposed to during dredging activities are typically below permanent auditory injury thresholds (PTS)

exposure criteria (as defined in Southall *et al.,* 2019). Therefore, the potential risk of any auditory injury in marine mammals as a result of dredging activity is highly unlikely. The thresholds for temporary loss in hearing sensitivity (TTS) could be exceeded during dredging, however, only if marine mammals remain in close proximity to the active dredger for extended periods, which is highly unlikely (Todd *et al.,* 2014).

321. Underwater noise as a result of dredging activity/cable installation, also has the potential to disturb marine mammals (Pirotta et al., 2013). Therefore, there is the potential for short, perhaps medium-term behavioural reactions and disturbance to marine mammals in the area during dredging / cable installation activity. Marine mammals may exhibit varying behavioural reactions intensities as a result of exposure to noise (Southall *et al.,* 2007).

322. The noise levels produced by dredging activity/cable installation, could overlap with the hearing sensitives and communication frequencies used by marine mammals (Todd *et al.,* 2014), and therefore have the potential to impact marine mammals present in the area. However, species such as harbour porpoise have a relatively poor sensitivity below 1kHz, and are less likely to be affected by masking, although for seals there could be the potential of masking communication, especially during the breeding season (Todd *et al.,* 2014).

12.6.1.2.1 Underwater noise modelling

323. Underwater noise modelling was undertaken by Subacoustech Environmental Ltd to estimate the noise levels likely to arise during noisy activities (Appendix 12.3 (Document Reference: 3.3.8)) and determine the potential impacts on marine mammals. Key information on the methodology of underwater noise modelling, and the full results of the assessments for marine mammals, is provided in Appendix 12.4 (Document Reference: 3.3.9).

12.6.1.2.2 Impact 2a: Permanent auditory injury (PTS) due to other construction activities

Sensitivity of marine mammals

324. Marine mammals are all assessed as having a high sensitivity to the potential for PTS, as outlined in Section 12.6.1.1.2.

Magnitude of impact

PTS due to other construction activities (for a single activity)

325. The full underwater noise modelling results and assessments are provided in Appendix 12.4 (Document Reference: 3.3.9) for the potential for PTS from the cumulative exposure of other construction activities.

326. Table 12.45 presents the underwater noise modelling results for the predicted impact ranges and areas for PTS from the cumulative exposure of other construction activities. For SEL_{cum} calculations, the duration of the noise is also considered, with all sources operating for a worst case of 24-hours in a day.

327. The results of the underwater noise modelling does not define impact ranges of <100m, and therefore, where the impact ranges are less than that, the results show effect ranges of <100m (it is possible that the actual impact ranges are therefore considerably lower).

328. The results of the underwater noise modelling (Table 12.45) indicate that any marine mammal would have to be <100m (precautionary maximum range) from the continuous noise source at the onset of the activity, to be exposed to noise levels that could induce PTS. It should be noted that the predicted impact ranges are the distances which represent the 'onset' stage, which is the minimum exposure that could potentially lead to the start of an impact and may only be marginal. In most hearing groups, the noise levels are low enough that there is negligible risk.

Table 12.45 The predicted impact ranges for cumulative PTS for other construction activities in all marine mammal species

Marine mammal species	Potential impact ranges (and areas) for PTS Cable laying, suction dredging, cable trenching, and rock placement*
Harbour porpoise	<100m (0.031km^2)
Minke whale	<100m (0.031km^2)
Grey seal	<100m (0.031km^2)
Harbour seal	

** impact areas are based on the area of a circle, with the impact range as the radius*

329. An assessment of the maximum number of individuals that could be at risk of PTS, due to other construction activities, is presented in Table 12.46, based on the impact areas as presented in Table 12.45. An assessment against all marine mammal densities is provided in Appendix 12.4 (Document Reference: 3.3.9), including the annual and summer seasonal density for harbour porpoise.

330. The magnitude of the potential impact is assessed as negligible for harbour porpoise, minke whale, grey seal, and harbour seal (Table 12.46).

331. The underwater noise modelling indicates that marine mammals would only be at risk if they were within 100m of a vessel at the onset of the activity, which is considered highly unlikely. For minke whale and both seal species, the potential for TTS in marine mammals is also modelled at being within 100m, and therefore it is likely that the impact range for PTS, which has a higher threshold than TTS, is lower than the 100m as used within the assessments.

Table 12.46 Assessment of the potential for PTS due to other construction activities, including cable laying, suction dredging, cable trenching, and rock placement, for one activity taking place at any one time (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Marine mammal species	Assessment of impact	Magnitude of impact
Harbour porpoise	0.1 harbour porpoise (0.00003% of the NS MU reference population.	Negligible
Minke whale	0.0005 minke whale (0.00000002% of the CGNS MU reference population).	Negligible
Grey seal	0.006 grey seal (0.00002% of the SE England MU reference population, or 0.00001% of the wider reference population), based on the worst case density for the offshore cable corridor.	Negligible

Marine mammal species	Assessment of impact	Magnitude of impact
Harbour seal	0.003 harbour seal (0.00007% of the SE England MU reference population), based on the worst case density of the offshore cable corridor.	Negligible

PTS due to other construction activities at multiple simultaneous locations

332. There is the potential that more than one of these other construction activities could be underway within the array area, or within the offshore cable corridor, at the same time. As a worst case and unlikely scenario, an assessment for all four activities (cable laying, suction dredging, cable trenching, and rock placement) being undertaken simultaneously has also been undertaken.

333. Table 12.47 presents the potential areas of PTS for all four other construction activities taking place at the same time.

Table 12.47 The predicted impact areas for cumulative PTS, for all other construction activities* taking place at the same time for all marine mammal species

Marine mammal species	Potential impact areas for PTS
Harbour porpoise	0.126km^2
Minke whale	0.126km^2
Grey seal	0.126km^2
Harbour seal	

* Cable laying, suction dredging, cable trenching, and rock placement at the same time

334. An assessment of the maximum number of individuals that could be at risk of PTS, due to all other construction activities undertaken at the same time is presented in Table 12.48, based on the impact areas as presented in Table 12.47. An assessment against all marine mammal densities is provided in Appendix 12.4 (Document Reference: 3.3.9), including the annual and summer seasonal density for harbour porpoise.

335. The magnitude of the potential impact is assessed as negligible for harbour porpoise, minke whale, grey seal, and harbour seal (Table 12.48).

Table 12.48 Assessment of the potential for PTS due to all other construction activities taking place at the same time (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Marine mammal species	Assessment of impact	Magnitude of impact
Harbour porpoise	0.4 harbour porpoise (0.0001% of the NS MU reference population).	Negligible
Minke whale	0.002 minke whale (0.00001% of the CGNS MU reference population).	Negligible
Grey seal	0.02 grey seal (0.00008% of the SE England MU reference population, or 0.00004% of the wider reference population), based on the density for the offshore cable corridor.	Negligible
Harbour seal	0.01 harbour seal (0.0003% of the SE England MU reference population), based on the density for the offshore cable corridor.	Negligible

336. The significance of effect assessment for permanent auditory injury due to other construction activities is provided in Section 12.6.1.2.5, within the summary Table 12.55.

12.6.1.2.3 Impact 2b: Temporary auditory injury (TTS) due to other construction activities

Sensitivity of marine mammals

337. As outlined in Section 12.6.1.1.2, the sensitivity of marine mammals to TTS as a result of underwater noise during construction activities, other than piling, is considered to be medium in this assessment.

Magnitude of impact

TTS due to other construction activities (for a single activity)

338. The full underwater noise modelling results and assessments are provided in Appendix 12.4 (Document Reference: 3.3.9) for the potential for TTS from the cumulative exposure of other construction activities.

339. Table 12.49 presents the underwater noise modelling results for the predicted impact ranges and areas for TTS from the cumulative exposure of other construction activities. For SEL_{cum} calculations, the duration of the noise is also considered, with all sources operating for a worst case of 24-hours in a day.

340. The results of the underwater noise modelling does not define impact ranges of <100m, and therefore, where the impact ranges are less than that, the results show impact ranges of <100m (it is possible that the actual impact ranges are therefore considerably lower).

341. There is unlikely to be any significant risk of any TTS, as the modelling indicates that the marine mammal would have to be within 100m at the onset of the activity to be at risk of TTS onset (with the exception of harbour porpoise which would have to be at 200m prior to dredging, or within 1km at the start of any rock placement activity) (Table 12.49). Therefore, TTS as a result of construction activity, other than piling, is highly unlikely.

342. It should be noted that the predicted impact ranges are the distances which represent the TTS 'onset' stage, which is the minimum exposure that could potentially lead to the start of an impact and may only be marginal. In most hearing groups, the noise levels are low enough that there is negligible risk.

Table 12.49 The predicted impact ranges for cumulative TTS for other construction activities in all marine mammal species

Marine mammal species	Potential impact ranges (and areas) for TTS		
	Cable laying and cable trenching	Suction dredging	Rock placement
Harbour porpoise	<100m (0.031km^2)	200m (0.126km^2)	1km (3.14km^2)
Minke whale	<100m (0.031km^2)	<100m (0.031km^2)	<100m (0.031km^2)
Grey seal	<100m (0.031km^2)	<100m (0.031km^2)	<100m (0.031km^2)
Harbour seal			

** impact areas are based on the area of a circle, with the impact range as the radius*

343. An assessment of the maximum number of individuals that could be at risk of TTS, due to other construction activities, is presented in Table 12.49. An assessment against all marine mammal densities is provided in Appendix 12.4 (Document Reference: 3.3.9), including the annual and summer seasonal density for harbour porpoise.

344. The magnitude of the potential impact is assessed as negligible for harbour porpoise, minke whale, grey seal and harbour seal (Table 12.50).

Table 12.50 Assessment of the potential for TTS due to other construction activities, including cable laying, suction dredging, cable trenching, and rock placement, for one activity taking place at any one time (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Marine mammal species	Other construction activity	Assessment of impact	Magnitude of impact
Harbour porpoise	Cable laying and cable trenching	0.1 harbour porpoise (0.00003% of the NS MU reference population).	Negligible
	Dredging	0.4 harbour porpoise (0.0001% of the NS MU reference population).	
	Rock placement	11 harbour porpoise (0.003% of the NS MU reference population).	
Minke whale	Cable laying, dredging, cable trenching, and rock placement	0.0005 minke whale (0.00000002% of the CGNS MU reference population).	Negligible
Grey seal	Cable laying, dredging, cable trenching, and rock placement	0.006 grey seal (0.00002% of the SE England MU reference population, or 0.00001% of the wider reference population reference population), based on the worst case density for the offshore cable corridor.	Negligible
Harbour seal	Cable laying, dredging, cable trenching, and rock placement	0.003 harbour seal (0.00007% of the SE England MU reference population), based on the worst case density for the offshore cable corridor.	Negligible

TTS due to other construction activities at multiple simultaneous locations

345. There is the potential that more than one of these other construction activities could be underway within the array area, or within the offshore cable corridor, at the same time. As a worst case and unlikely scenario, an assessment for all four activities (cable laying, suction dredging, cable trenching, and rock placement) being undertaken simultaneously has also been provided.

346. Table 12.51 presents the potential areas of TTS for all four other construction activities taking place at the same time.

Table 12.51 The predicted impact areas for cumulative TTS, for all other construction activities taking place at the same time for all marine mammal species.

Marine mammal species	Potential impact areas for TTS
	Cable laying, suction dredging, cable trenching, and rock placement at the same time
Harbour porpoise	3.33km^2
Minke whale	0.126km^2

Marine mammal species	Potential impact areas for TTS Cable laying, suction dredging, cable trenching, and rock placement at the same time
Grey seal	$0.126km^2$
Harbour seal	

347. An assessment of the maximum number of individuals that could be at risk of TTS, due to all other construction activities undertaken at the same time is presented in Table 12.52, based on the impact areas as presented in Table 12.51. An assessment against all marine mammal densities is provided in Appendix 12.4 (Document Reference: 3.3.9), including the annual and summer seasonal density for harbour porpoise.

348. The magnitude of the potential impact is assessed as negligible for harbour porpoise, minke whale, grey seal and harbour seal (Table 12.52).

Table 12.52 Assessment of the potential for TTS due to all other construction activities taking place at the same time (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Marine mammal species	Assessment of impact	Magnitude of impact
Harbour porpoise	11 harbour porpoise (0.003% of the NS MU reference population).	Negligible
Minke whale	0.002 minke whale (0.00001% of the CGNS MU reference population).	Negligible
Grey seal	0.02 grey seal (0.00008% of the SE England MU reference population, or 0.00004% of the wider reference population), based on the density for the offshore cable corridor as a worst case.	Negligible
Harbour seal	0.01 harbour seal (0.0003% of the SE England MU reference population), based on the density for the offshore cable corridor as a worst-case.	Negligible

349. The significance of effect assessment for temporary auditory injury due to other construction activities is provided in Section 12.6.1.2.5, within the summary Table 12.55.

12.6.1.2.4 Impact 2c: Disturbance effects due to other construction activities

Sensitivity of marine mammals

350. Marine mammals within the potential disturbance area are considered to have limited capacity to avoid such impacts, although any disturbance to marine mammals would be temporary and they would be expected to return to the area once the disturbance had ceased or they had become habituated to the sound.

351. For the same reasons as outlined in Section 12.6.1.1.4, harbour porpoise and minke whale are assessed as having a medium sensitivity to disturbance as a result of underwater noise during construction activities, other than piling, while grey seal and harbour seal have a sensitivity of low.

Magnitude of impact

352. If the response is displacement from the area, it is predicted that marine mammals will return once the activity has been completed and therefore any

impacts from underwater noise as a result of construction activities other than piling noise will be both localised and temporary. Therefore, there is unlikely to be the potential for any significant disturbance impact on marine mammals.

353. There is limited data on the potential for a behavioural response or disturbance from other construction activities (or other continuous noise sources).

354. Southall *et al.,* 2007 presents a review of behavioural response studies in marine mammals, according to the behavioural severity scores. For continuous noise sources, the lowest SPL at which a score of five or more was recorded for whale species was 90dB to 100dB re 1 µPa (rms). However, this relates to a study involving migrating grey whales.

355. One study recorded a significant behavioural response on a single harbour seal at a received level of 100 to 110dB re 1 µPa (rms), although other studies found no response much higher received levels of up to 140dB re 1 µPa (rms).

356. The noise levels generated by the majority of the other construction activities are not significantly higher than the noise levels associated with vessels (e.g., cable laying, cable trenching and rock placement have source levels of <172dB re 1 µPa @ 1m (rms), compared to a source level of 168dB re 1 µPa@ 1m (rms) for a large vessel (Appendix 12.4 (Document Reference: 3.3.9)).

357. In 2012, 25 harbour seal from The Wash were tagged, as well as a further 10 from the Thames (Russell, 2016). Of those, 24 of the tags were in place for sufficient time to determine key foraging areas of harbour seal in the southern North Sea. The results of this study show foraging activity of harbour seal off the coast off Norfolk (Plate 12.9: Russell, 2016). The results of this tagging study show foraging activity (in red) within Sheringham Shoal OWF[12] which was undergoing construction, with turbine installation undertaken from 2011 to 2012, and cabling works from 2010 to 2012. This indicates that harbour seal will still undertake foraging activity during wind farm construction activities.

[12] Note that although seals are shown foraging further offshore, all of the OWFs beside Sheringham Shoal were only in planning or pre-construction at the time.

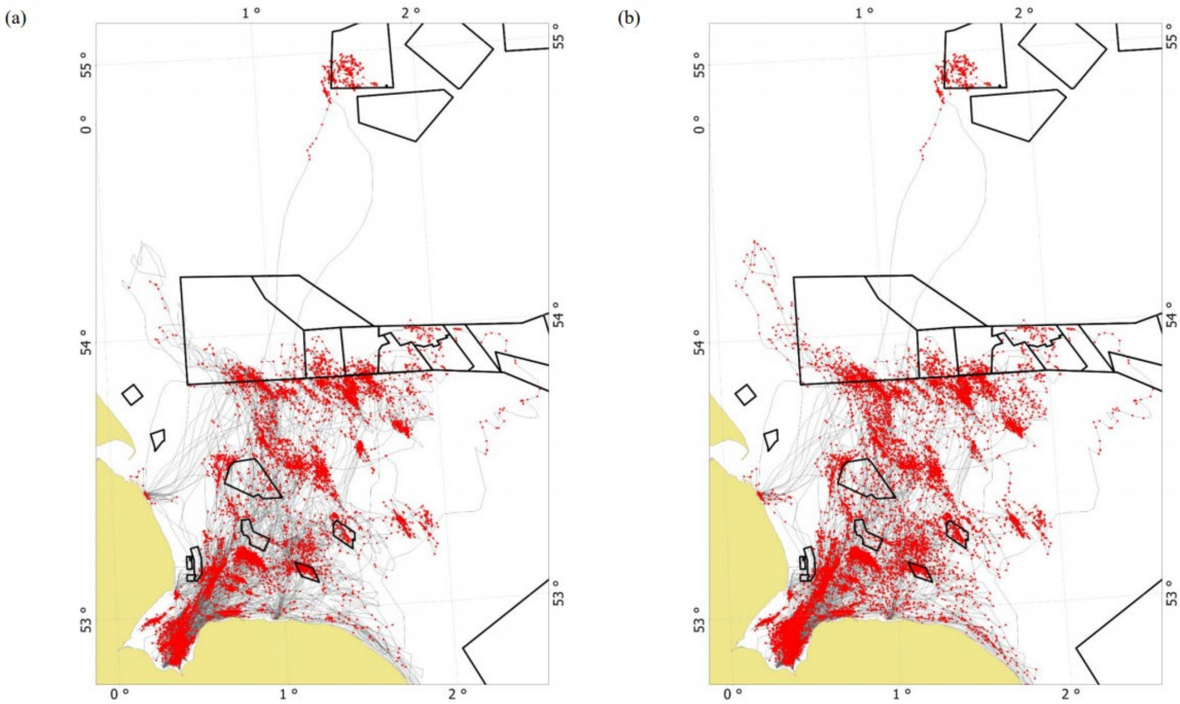

Plate 12.9 The tracks (grey) and estimated foraging locations (red) of tagged harbour seals in geo- (a) and hydro- (b) space (Russell, 2016).

358. Studies undertaken during the construction of two Scottish Wind Farms (Beatrice OWF and Moray East OWF) (Benhemma-Le Gall *et al*., 2021), found that the probability of harbour porpoise being present increased with distance from the vessels and construction activities, and decreased with increasing vessel presence and background noise. During the period of turbine installation at Beatrice OWF, a significant reduction in harbour porpoise presence was detected even while no piling was taking place. Various construction activities were undertaken during this turbine installation phase, including jacket installation, turbine and cable installations, with some activities occurring simultaneously, which led to high levels of vessel traffic within the OWF site.

359. A reduction in porpoise presence was detected at up to 12km from pile driving, and up to 4km from construction related vessels (Plate 12.10; Benhemma-Le Gall *et al*., 2021). With construction vessels at 2km from CPOD locations, harbour porpoise activity decreased by up to 35.2%, with construction vessels at 3km from the CPODs, there was a decrease of up to 24%, and at 4km from construction vessels, there was an increase of 7.2%. Outside of the piling period, the study found that the presence of harbour porpoise decreased by 17% with SPLs of 57dB (above ambient noise). It was not practicable to determine what activities were being undertaken by the construction vessels in order to determine what activity was causing this impact (Benhemma-Le Gall *et al*., 2021).

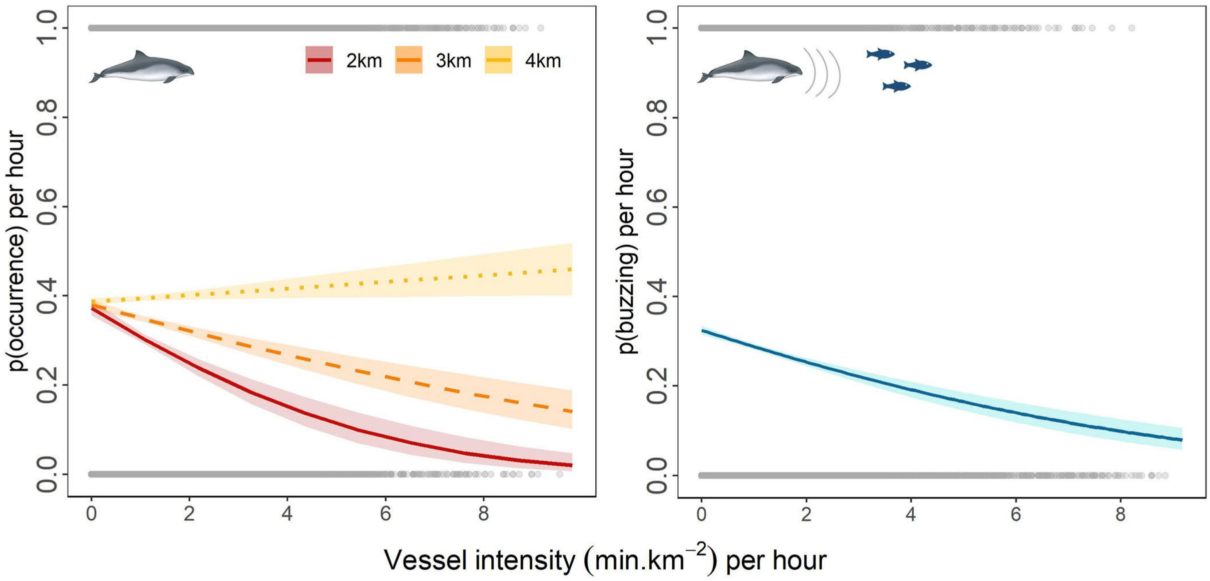

Plate 12.10 [Left] The probability of harbour porpoise presence in relation to vessel activity (Red = mean vessel distance of 2km, Orange = mean vessel distance of 3km, Yellow = mean vessel distance of 4km, and [Right] the probability of buzzing activity per hour in relation to vessel activity (Benhemma-Le *Gall et al.,* 2021)

360. While the study did not define which activities were taking place to cause the disturbance, it was while a number of construction vessels were on site (Benhemma-Le Gall *et al.*, 2021). Therefore, this reported 4km reduction in harbour porpoise presence has been used as a potential disturbance range for other construction activities in this assessment.

361. As harbour porpoise are the most sensitive marine mammal species, this 4km potential disturbance range (with a potential impact area of 50.27km^2) has been used for all species assessed, due to the absence of any other data to inform an assessment. This is therefore considered to be a precautionary approach for other species. All related construction activities are considered to be a moving source, and therefore once the activity / vessel moves past a certain area, the marine mammals would return to baseline numbers.

Disturbance due to other construction activities (for a single activity)

362. An assessment of the maximum number of individuals that could be at risk of disturbance due to other construction activities based on the 4km potential disturbance range (with an impact area of 50.3km^2) is presented in Table 12.53. This is a precautionary approach as it is unlikely that all marine mammal species would react in the same manner as harbour porpoise to the other construction activities that are expected to be taking place in the offshore project area.

363. The magnitude of the potential impact is assessed as negligible for all species (Table 12.53).

Table 12.53 Assessment of the potential for disturbance due to other construction activities, including cable laying, suction dredging, cable trenching, and rock placement, for one activity taking place at any one time (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Marine mammal species	Assessment of impact (for a single activity)	Magnitude of impact
Harbour porpoise	162 harbour porpoise (0.05% of the NS MU reference population), based on the HiDef winter density estimate.	Negligible
Minke whale	0.08 minke whale (0.004% of the CGNS MU reference population).	Negligible
Grey seal	10 grey seal (0.03% of the SE England MU reference population, or 0.02% of the wider reference population), based on the density for the offshore cable corridor as a worst-case.	Negligible
Harbour seal	6 harbour seal (0.11% of the SE England MU reference population), based on the density for the offshore cable corridor as a worst-case.	Negligible

Disturbance due to other construction activities at multiple simultaneous locations

364. As noted above, there is the potential that more than one of these other construction activities could be underway at either array area, or within the offshore cable corridor, at the same time. As a worst case and unlikely scenario, an assessment for all four activities being undertaken simultaneously has also been provided.

365. Based on a 4km potential disturbance range, and up to four other construction activities taking place at the same time, there is the potential for a simultaneous disturbance impact of 201.06km^2 for all marine mammal species. As noted above, this assumes that the disturbance would only affect the area around the vessel at the time of the activity taking place, and that marine mammals would return to the disturbed area once the activity had either completed or transited to a new location.

366. An assessment of the maximum number of individuals that could be at risk of disturbance, due to all other construction activities undertaken at the same time is presented in Table 12.54.

367. The magnitude of the potential impact is assessed as negligible for all species (Table 12.54).

Table 12.54 Assessment of the potential for disturbance due to all other construction activities taking place at the same time (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Marine mammal species	Assessment of impact for four activities at one time	Magnitude of impact
Harbour porpoise	647 harbour porpoise (0.19% of the NS MU reference population), based on the HiDef winter density estimate.	Negligible
Minke whale	4 minke whale (0.02% of the CGNS MU reference population).	Negligible
Grey seal	39 grey seal (0.12% of the SE England MU reference population, or 0.07% of the wider reference population), based on the density for the offshore cable corridor as a worst-case density estimate.	Negligible

Marine mammal species	Assessment of impact for four activities at one time	Magnitude of impact
Harbour seal	23 harbour seal (0.45% of the SE England MU reference population), based on the density for the offshore cable corridor as a worst-case density estimate.	Negligible

368. The significance of effect assessment for disturbance due to other construction activities is provided in Section 12.6.1.2.5, within the summary Table 12.55.

Duration of other construction activities

369. The potential for disturbance that could result from underwater noise during other construction activities, including cable laying and protection, would be temporary in nature, not consistent throughout the offshore construction period, and would be limited to only part of the overall construction period and area at any one time.

370. The duration for the offshore construction period, including piling and export cable installation, is approximately two years. However, construction activities would not be underway constantly throughout this period. Further details on the construction schedule is provided in Chapter 5 Project Description(Document Reference: 3.1.7).

12.6.1.2.5 Significance of effect

371. The assessment for the potential effects of underwater noise associated with other construction activities is provided in Table 12.55. This takes into account the high marine mammal sensitivity for the potential of PTS, medium for TTS, medium for disturbance for harbour porpoise and minke whale and low for seals; and the potential magnitude of impact (i.e. number of individuals as a percentage of the reference population) for other construction activities, as presented in Table 12.46 and Table 12.48 for PTS, Table 12.50 and Table 12.52 for TTS, and Table 12.53 and Table 12.54 for disturbance.

372. The effect significance for either permanent or temporary changes in hearing sensitivity (PTS or TTS) due to other construction activities has been assessed as minor adverse for all species (Table 12.55).

373. For the potential for disturbance due to other construction activities, the effect significance has been assessed as minor adverse for harbour porpoise and minke whale, and as negligible for grey seal and harbour seal (Table 12.55).

Table 12.55 Assessment of effect significance for the potential for underwater effects due to other construction activities

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual effect
PTS due to other construction activities					
Harbour porpoise, minke whale, grey seal and harbour seal	High	Negligible	Minor adverse	None required.	Minor adverse

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual effect
TTS due to other construction activities					
Harbour porpoise, minke whale, grey seal and harbour seal	Medium	Negligible	Minor adverse	None required.	Minor adverse
Disturbance due to other construction activities					
Harbour porpoise and minke whale	Medium	Negligible	Minor adverse	None required.	Minor adverse
Grey seal and harbour seal	Low	Negligible	Negligible	None required.	Negligible

Mitigation

374. No mitigation is proposed for underwater noise for construction activities other than piling. Therefore, the residual significance of effect for PTS, TTS or disturbance from underwater noise during construction activities other than piling at the Projects would be negligible to minor adverse (not significant in EIA terms) for all species.

12.6.1.3 Impact 3: Effects from underwater noise and disturbance associated with construction vessels

375. During the construction phase, there will be an increase in the number of vessels in the offshore project area; this is estimated to be up to a total of 35 vessels at any one time (Table 12.1). The number, type and size of vessels will vary depending on the activities taking place at any one time.

376. Vessel movements to and from any port will be incorporated within existing vessel routes and therefore any increase in disturbance as a result of underwater noise from vessels during construction will be within the array area and offshore cable corridor.

377. ES Chapter 15 Shipping and Navigation (Document Reference: 3.1.17) provides a description of the baseline conditions. The main vessel types were cargo, tankers, oil and gas and wind farm support. Aggregate dredgers, passenger and fishing and recreational vessels were also recorded.

378. The types of vessels that were recorded in the shipping and navigation study area (of the array area plus 10 nautical mile (nm) buffer, and the cable corridors plus 2 nm buffer) include fishing vessels, military vessels, dredgers, tugs, passenger vessels, cargo ships, tankers, vessels associated with either oil and gas or OWF projects, or recreational vessels. In total, an average of 134 vessels per day were recorded in the shipping and navigation study area in winter, and 147 per day in summer. The most common vessel type during both survey periods was cargo, which accounted for more than half of all vessel traffic recorded (58%). Tankers were the next most common, accounting for nearly quarter of all vessel traffic across both surveys. (23%).

379. There could be up to 1,266 vessel round-trips per year (approximately 3.5 two-way trips/ 7 one-way trips per day) during North Falls construction, representing

an increase of up to 4.7% compared to average daily vessels in summer, and up to 5.2% compared to the daily vessels in winter..

380. Noise measurements indicate that the most intense sound emissions from a cargo ship are typically low frequencies, up to and including 1kHz (Robinson *et al.,* 2011) travelling at modest speed (between 8 and 16 knots) (Theobald et al., 2011). Underwater noise from construction vessels of a similar size also has the potential to disturb marine mammals in the short-term, in areas of increased vessel traffic, but are unlikely to produce any permanent auditory injury (PTS) (Pirotta et al., 2013).

381. The vessels will be slow moving (or stationary), and most noise emitted is likely to be of a lower frequency. Noise levels reported by Malme et al. (1989) and Richardson et al. (1995) for transiting large surface vessels indicate that physiological damage to auditory sensitive marine mammals is unlikely. The potential risk of permanent auditory injury (PTS) in marine mammals as a result of vessel activity is highly unlikely, as the sound levels that are produced by vessels is well below the threshold for permanent injury (Southall et al., 2019). Trigg et al. (2020) found the predicted exposure of grey seals to shipping noise did not exceed thresholds for TTS.

382. A study of the noise source levels from several different vessels (Jones *et al*., 2017) shows that for a cargo vessel of 126m in length (on average), travelling at a speed of 11 knots (on average) would generate a mean sound level of 160dB re 1 µPa @ 1m (with a maximum sound level recorded of 187dB re 1 µPa @ 1m). The levels could be sufficient to cause local disturbance to marine mammals in the immediate vicinity of the vessel, depending on ambient noise levels. Thomsen *et al.* (2006) reviewed the impacts of ship noise on harbour porpoise and seal species, and concluded that ship noise around 0.25kHz could be detected at distances of 1km; and ship noise around 2kHz could be detected at around 3km.

12.6.1.3.1 Underwater noise modelling

383. Underwater noise modelling was undertaken by Subacoustech Environmental Ltd to estimate the noise levels likely to arise due to vessel presence (Appendix 12.3 (Document Reference: 3.3.8)) and determine the potential impacts on marine mammals. Information on the methodology of underwater noise modelling, and the full results of the assessments for marine mammals, is provided in Appendix 12.4 (Document Reference: 3.3.9).

384. Underwater noise modelling was undertaken for medium and large vessels. Medium vessels are less than 100m in length, while large vessels are over 100m.

12.6.1.3.2 Impact 3a: Permanent auditory injury (PTS) due to construction vessels

Sensitivity of marine mammals

385. As outlined in Section 12.6.1.1.2, marine mammals are assessed as having a high sensitivity to the potential for PTS.

Magnitude of impact

PTS due to construction related vessels (single vessel)

386. The full underwater noise modelling results and assessments are provided in Appendix 12.4 (Document Reference: 3.3.9) for the potential for PTS from the cumulative exposure of other construction activities.

387. Table 12.56 presents the underwater noise modelling results for the predicted impact ranges and areas for PTS from the cumulative exposure of vessels within the site. For SEL_{cum} calculations, the duration of the noise is also considered, with noise present for a worst case of 24-hours in a day.

388. The results of the underwater noise modelling does not define impact ranges of <100m, and therefore, where the impact ranges are less than that, the results show impact ranges of <100m (it is possible that the actual impact ranges are therefore considerably lower).

389. The results of the underwater noise modelling (Table 12.56) indicate that any marine mammal would have to be within 100m (precautionary maximum range) from the continuous noise source at the onset of vessel presence, to be exposed to noise levels that could induce PTS. It is therefore highly unlikely that any marine mammal would be at risk of PTS due to vessel noise. It should be noted that the predicted impact ranges are the distances which represent the 'onset' stage, which is the minimum exposure that could potentially lead to the start of an impact and may only be marginal. In most hearing groups, the noise levels are low enough that there is negligible risk.

Table 12.56 The predicted impact ranges for cumulative PTS for vessels in all marine mammal species

Marine mammal species	Potential impact ranges (and areas) for PTS Medium or large vessels*
Harbour porpoise	<100m (0.031km^2)
Minke whale	<100m (0.031km^2)
Grey seal	<100m (0.031km^2)
Harbour seal	

** impact areas are based on the area of a circle, with the impact range as the radius*

390. An assessment of the maximum number of individuals that could be at risk of PTS, due to other construction activities, is presented in Table 12.57, based on the impact areas as presented in Table 12.56. An assessment against all marine mammal densities is provided in Appendix 12.4 (Document Reference: 3.3.9), including the annual and summer seasonal density for harbour porpoise.

391. The magnitude of the potential impact is assessed as negligible for harbour porpoise, minke whale, grey seal, and harbour seal (Table 12.57).

392. The underwater noise modelling indicates that marine mammals would only be at risk if they were within 100m of a vessel at the onset of the activity, which is considered highly unlikely. For minke whale and both seal species, the potential for TTS in marine mammals is also modelled at being within 100m, and therefore it is likely that the impact range for PTS, which has a higher threshold than TTS, is lower than the 100m as used within the assessments.

Table 12.57 Assessment of the potential for PTS due to medium and large vessels (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Marine mammal species	Assessment of impact	Magnitude of impact
Harbour porpoise	0.1 harbour porpoise (0.00003% of the NS MU reference population).	Negligible
Minke whale	0.0005 minke whale (0.000002% of the CGNS MU reference population).	Negligible
Grey seal	0.006 grey seal (0.00002% of the SE England MU reference population, or 0.00001% of the wider reference population), based on the density for the offshore cable corridor as a worst-case density estimate.	Negligible
Harbour seal	0.003 harbour seal (0.00007% of the SE England MU reference population), based on the density for the offshore cable corridor as a worst-case density estimate.	Negligible

393. The significance of effect assessment for permanent auditory injury due to a single vessel is provided in Section 12.6.1.2.5, within the summary Table 12.64.

PTS due to construction related vessels (multiple vessels)

394. There is the potential that up to 35 vessels may be present in the North Falls site at any one time during construction. As a worst case and unlikely scenario, an assessment for all 35 vessels has also been undertaken.

395. Table 12.58 presents the potential areas of PTS for the maximum construction vessels at any one time, of 35 vessels.

Table 12.58 The predicted impact areas for cumulative PTS, for multiple construction vessels for all marine mammal species

Marine mammal species	Potential impact areas for PTS
Harbour porpoise	1.1km^2
Minke whale	1.1km^2
Grey seal	1.1km^2
Harbour seal	

396. An assessment of the maximum number of individuals that could be at risk of PTS, due to the maximum number of construction vessels at any one time is presented in Table 12.59, based on the impact areas as outlined in Table 12.59 Table 12.9. An assessment against all marine mammal densities is provided in Appendix 12.4 (Document Reference: 3.3.9), including the annual and summer seasonal density for harbour porpoise.

397. The magnitude of impact is assessed as low for harbour porpoise, and negligible for minke whale, grey seal, and harbour seal (Table 12.59 and Table 12.48).

Table 12.59 Assessment of the potential for PTS due to multiple construction vessels (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Marine mammal species	Assessment of impact	Magnitude of impact
Harbour porpoise	4 harbour porpoise (0.0012% of the NS MU reference population).	Low

Marine mammal species	Assessment of impact	Magnitude of impact
Minke whale	0.02 minke whale (0.0001% of the CGNS MU reference population).	Negligible
Grey seal	0.2 grey seal (0.0007% of the SE MU reference population, or 0.0004% of the wider reference population), based on the density for the offshore cable corridor as a worst-case density estimate.	Negligible
Harbour seal	0.1 harbour seal (0.003% of the SE E MU reference population), based on the density for the offshore cable corridor as a worst-case density estimate.	Negligible

398. The significance of effect assessment for permanent auditory injury due to multiple vessels is provided in Section 12.6.1.3.5, within the summary Table 12.64.

12.6.1.3.3 Impact 3b: Temporary auditory injury (TTS) due to construction vessels

Sensitivity of marine mammals

399. The sensitivity of marine mammals to TTS as a result of underwater noise due to vessels is considered to be medium in this assessment, for the same reasons as outlined in Section 12.6.1.1.2.

Magnitude of impact

TTS due to construction related vessels (single vessel)

400. The full underwater noise modelling results and assessments are provided in Appendix 12.4 (Document Reference: 3.3.9) for the potential for TTS from vessels.

401. Table 12.60 presents the underwater noise modelling results for the predicted impact ranges and areas for TTS from the cumulative exposure of noise from vessels. For SELcum calculations, the duration of the noise is also considered, and the model assumes that the vessels are present (and therefore emitting noise) for 24-hours a day.

402. The results of the underwater noise modelling does not define impact ranges of <100m, and therefore, where the impact ranges are less than that, the results show impact ranges of <100m (it is possible that the actual impact ranges are therefore considerably lower).

403. There is unlikely to be any significant risk of any TTS in any marine mammal, as again the modelling indicates that the marine mammal would have to be within 100m at the onset of vessel presence to be at risk of TTS onset (with the exception of harbour porpoise which would have to be within 200m) (Table 12.60). Therefore, TTS as a result of construction activity, other than piling, is highly unlikely.

404. It should be noted that the predicted impact ranges are the distances which represent the TTS 'onset' stage, which is the minimum exposure that could potentially lead to the start of an impact and may only be marginal. In most hearing groups, the noise levels are low enough that there is negligible risk.

Table 12.60 The predicted impact ranges for cumulative TTS for medium and large vessels in all marine mammal species

Marine mammal species	Potential impact ranges (and areas) for TTS	
	Medium vessels	Large vessels
Harbour porpoise	<100m (0.031km^2)	200m (0.126km^2)
Minke whale	<100m (0.031km^2)	<100m (0.031km^2)
Grey seal	<100m (0.031km^2)	<100m (0.031km^2)
Harbour seal		

** impact areas are based on the area of a circle, with the impact range as the radius*

405. An assessment of the maximum number of individuals that could be at risk of TTS, due to construction vessels, is presented in Table 12.61, based on the impact areas as presented in Table 12.60. An assessment against all marine mammal densities is provided in Appendix 12.4 (Document Reference: 3.3.9), including the annual and summer seasonal density for harbour porpoise.

406. The magnitude of the potential impact is assessed as negligible for all species, with less than one individual of any marine mammal species expected to be at risk of TTS (Table 12.61).

Table 12.61 Assessment of the potential for TTS due to construction vessels (magnitude levels are based on the percentage of the reference population affected, as set out in Table 12.9).

Marine mammal species	Other construction activity	Assessment of impact	Magnitude of impact
Harbour porpoise	Medium vessels	0.1 harbour porpoise (0.00003% of the NS MU reference population).	Negligible
	Large vessels	0.4 harbour porpoise (0.0001% of the NS MU reference population).	
Minke whale	Medium or large vessels	0.0005 minke whale (0.00000002% of the CGNS MU reference population).	Negligible
Grey seal	Medium or large vessels	0.006 grey seal (0.00002% of the SE E MU reference population, or 0.00001% of the wider reference population), based on the density of the offshore cable corridor as a worst-case density estimate.	Negligible
Harbour seal	Medium or large vessels	0.003 harbour seal (0.00007% of the SE E MU reference population), based on the density for the offshore cable corridor as a worst-case density estimate.	Negligible

407. The significance of effect assessment for temporary auditory injury due to a single vessel is provided in Section 12.6.1.2.5, within the summary Table 12.64.

TTS due to construction related vessels (multiple vessels)

408. There is the potential that up to 35 vessels may be present in the North Falls site at any one time during construction. As a worst case and unlikely scenario, an assessment for all 35 vessels has also been undertaken.

409. Table 12.62 presents the potential areas of TTS if all 35 vessels are operating at the same time.

Table 12.62 The predicted impact areas for cumulative TTS for multiple construction vessels for all marine mammal species

Marine mammal species	Potential impact areas for TTS
Harbour porpoise	4.4km^2
Minke whale	1.1km^2
Grey seal	1.1km^2
Harbour seal	

410. An assessment of the maximum number of individuals that could be at risk of TTS, due to the maximum of 35 construction vessels has been provided in Table 12.63, based on the impact areas as presented in Table 12.62. An assessment against all marine mammal densities is provided in Appendix 12.4 (Document Reference: 3.3.9), including the annual and summer seasonal density for harbour porpoise.

411. The magnitude of the potential impact is assessed as negligible for all species (Table 12.63).

Table 12.63 Assessment of the potential for TTS due to multiple construction vessels (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Marine mammal species	Assessment of impact	Magnitude of impact
Harbour porpoise	15 harbour porpoise (0.004% of the NS MU reference population).	Negligible
Minke whale	0.02 minke whale (0.0001% of the CGNS MU reference population).	Negligible
Grey seal	0.2 grey seal (0.0007% of the SE MU reference population), or 0.0004% of the wider reference population), based on the density for the offshore cable corridor as a worst-case density estimate.	Negligible
Harbour seal	0.1 harbour seal (0.003% of the SE E MU reference population), based on the density for the offshore cable corridor as a worst-case density estimate.	Negligible

412. The significance of effect assessment for temporary auditory injury due to multiple construction vessels is provided under Section 12.6.1.3.5 within the summary Table 12.64.

12.6.1.3.4 Impact 3c: Disturbance effects due to construction vessels

Sensitivity of marine mammals

413. Marine mammals within the potential disturbance area are considered to have limited capacity to avoid such effects, although any disturbance to marine mammals would be temporary and they would be expected to return to the area once the disturbance had ceased or they had become habituated to the sound.

414. There is the potential for sensitive species with high metabolic requirements, such as the harbour porpoise, to be more vulnerable to anthropogenic stressors such as vessel noise, forcing individuals to make trade-off decisions between using energy to leave the area or remaining in exposed areas (Benhemma-Le Gall *et al*., 2021). This additional energy use may have biological consequences in the short and long-term (Pirotta *et al*., 2014), and harbour porpoise have been shown to be displaced by vessel activity up to 7km away depending on vessel

type (Wisniewska *et al*., 2018). In a 2012 study, high-speed planning vessels (small boats, jet skis etc.) caused the most negative reactions in this species (Oakley *et al*., 2017). Whilst short to medium term behavioural responses have been recorded from vessel disturbance, there are no long-term or population level impacts recorded to date; therefore, harbour porpoise are deemed to have a medium sensitivity to disturbance from construction vessels.

415. Other cetacean species in the study area may also be disturbed by construction vessels, however, this is expected to a lesser degree than harbour porpoise. Minke whale have been shown to decrease foraging behaviour around wildlife tour boats, displaying horizontal avoidance behaviour and increased swimming speeds which may incur an energy cost (Machernis *et al.,* 2018). The sensitivity of minke whale to disturbance as a result of underwater noise due to construction vessels is considered to be medium in this assessment as a precautionary approach.

416. Pinnipeds vary in their reaction to vessels depending on vessel type and proximity to haul out sites; however, disturbance (flushing behaviour) has been demonstrated at haul-out sites in the UK up to 200m away if there are pups present (Cates *et al*., 2017). Land-based disturbance has been shown to cause higher levels of disturbance compared to marine sources, and smaller, quiet vessels like kayaks can cause the highest levels of flushing behaviour (Bonner, 2021). In areas of high vessel traffic, there are habituation impacts and disturbance behaviour is generally reduced (Strong *et al.,* 2010). A 2019 study on harbour seals in Scotland found that 30 minutes after a disturbance event, seals return to 52% pre-disturbance levels at haul-out sites and 94% four hours after disturbance (Paterson, 2019). Seals are therefore considered to have a low sensitivity to disturbance from construction vessel traffic.

Magnitude of impact

417. If the response is displacement from the area, it is predicted that marine mammals will return once the activity has been completed and therefore any impacts from underwater noise as a result of construction activities, other than piling, will be both localised and temporary. Therefore, there is unlikely to be the potential for any significant disturbance for marine mammals.

418. There is limited data on the potential for a behavioural response or disturbance from vessel noise.

Disturbance effect due to construction related vessels

419. Construction vessel activity may generate underwater noise at sound levels and frequencies for sufficient durations to disturb marine mammals. Whilst the main focus of concern remains on the loudest noise sources such as impact piling, dredging etc., intense vessel activity during construction may also alter the acoustic habitat and disturb marine mammal species (Merchant et al., 2014).

420. During surveys (see ES Chapter 15 Shipping and Navigation (Document Reference: 3.1.17)), the average recorded number of vessels per day in the summer was 147 (predominantly cargo). During the construction phase there may be an increase in the number of vessels in the area, however, this is likely to be offset by construction vessels/activity displacing existing vessel traffic as commercial vessels tend to deviate to avoid construction/decommissioning areas. The number, type and size of vessels will vary depending on the activities

taking place at any one time. Vessel movements to and from any port will be incorporated within existing vessel routes and therefore any increase in disturbance as a result of underwater noise from vessels during construction will be within the offshore project area only.

421. Disturbance from vessel noise could occur where increased noise from construction vessels associated is greater than the background ambient noise.

422. As outlined previously, Brandt *et al.* (2018) found that at seven German OWFs in the vicinity (up to 2km) of the construction site, harbour porpoise detections declined several hours before the start of piling as a result of increased construction related activities and vessels. Similarly, studies in the Moray Firth during piling of the Beatrice OWF, indicate higher vessel activity within 1km was associated with an increased probability of response in harbour porpoise (Graham et al., 2019).

423. Studies in the Moray Firth indicate that at a mean distance of 2km from construction vessels harbour porpoise occurrence decreased by up to 35.2% as vessel intensity increased. Harbour porpoise responses decreased with increasing distance to vessels, out to 4km where no response was observed (Benhemma-Le Gall *et al*., 2021).

424. During the periods when piling is underway, vessel noise is unlikely to add an additional impact to those assessed for piling, as the vessels and vessel noise would be within the maximum impact areas assessed.

425. The distance at which animals may react to vessels is difficult to predict and behavioural responses can vary a great deal depending on species, location, type and size of vessel, vessel speed, noise levels and frequency, ambient noise levels and environmental conditions.

426. Modelling by Heinänen and Skov (2015) indicates that the number of ships represents a relatively important factor determining the density of harbour porpoise in the NS MU during both seasons, with markedly lower densities with increasing levels of traffic. A threshold level in terms of impact seems to be approximately 20,000 ships per year (approximately 80 vessels per day within a $5km^2$ area).

427. Taking into account the maximum number of vessels that could be onsite during construction, the array area and the displacement of other vessels from the area, the number of vessels would not exceed the Heinänen and Skov (2015) threshold level of 80 vessels per day in a $5km^2$ area for harbour porpoise.

428. For example, 35 vessels within the offshore project area ($223.4km^2$) would equate to <0.16 vessels per km^2 (approximately 0.8 vessels per $5km^2$). In addition, due to safety and logistical considerations during piling, it is likely that the number of vessels in a small area, for example, around a pile location during pile installation would be limited to a very low number of essential vessels only.

429. Jones *et al*. (2017) produced usage maps characterising densities of grey and harbour seals and ships around the British Isles, which were used to produce risk maps of seal co-occurrence with shipping traffic. The analysis indicates that rates of co-occurrence were highest within 50km of the coast, close to seal haul-outs. When considering exposure to shipping traffic in isolation, the study found no evidence relating to declining seal population trajectories with high levels of

co-occurrence between seals and vessels. For example, in areas of east England where the harbour seal population is increasing there are high intensities of vessels (Duck and Morris, 2016; Jones *et al*., 2017).

430. If the behavioural response is displacement from the area, it is predicted that marine mammals will return once the activity has been completed, and therefore any impacts from underwater noise as a result of construction vessels will be both localised and temporary.

431. Based on the existing high vessel traffic in the study area, the temporary nature of increases in vessel numbers (for approximately two years), and relatively low noise disturbances from the types of vessels being used, the magnitude for the disturbance of all marine mammals as a result of underwater noise and presence of vessels has been assessed as negligible.

12.6.1.3.5 Significance of effect

432. The assessment for the likely significant effects of underwater noise associated with vessels is provided in Table 12.64, taking into account the high marine mammal sensitivity for the potential of PTS, medium for TTS and disturbance (except for seal species, with a sensitivity of low for disturbance from vessels), and the potential magnitude of impact (i.e. number of individuals as a percentage of the reference population) as presented in Table 12.57 for PTS, and Table 12.61 for TTS.

433. The effect significance for permanent changes in hearing sensitivity (PTS) due to construction vessels has been assessed as minor adverse for all species, expect for harbour porpoise, with a magnitude of minor to moderate adverse (without additional mitigation) (Table 12.64).

434. For the potential of TTS from construction vessels, the effect significance has been assessed as minor adverse for all species (Table 12.64).

435. For the potential for disturbance due to construction vessels, the effect significance has been assessed as minor adverse for harbour porpoise and minke whale, and negligible for grey seal and harbour seal (Table 12.64).

Table 12.64 Assessment of effect significance for the potential impacts due to construction vessels

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual effect
PTS due to construction vessels					
Harbour porpoise	High	Negligible to low	Minor to moderate adverse	Vessel good practice measures will be in place.	Minor adverse
Minke whale, grey seal and harbour seal	High	Negligible	Minor adverse		Minor adverse
TTS due to construction vessels					
Harbour porpoise, minke whale, grey seal and harbour seal	Medium	Negligible	Minor adverse	None required.	Minor adverse

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual effect
Disturbance due to construction vessels					
Harbour porpoise and minke whale	Medium	Negligible	Minor adverse	None required, but vessel good practice measures will reduce disturbance.	Minor adverse
Grey seal and harbour seal	Low	Negligible	Negligible		Negligible

12.6.1.3.6 Mitigation

436. Vessel good practice measures, as outlined in Table 12.93, would reduce the potential for effect. The measures include ensuring that vessel movements, where practicable, will be incorporated into recognised vessel routes and hence to areas where marine mammals are accustomed to vessels, in order to reduce any impacts, including increased disturbance.

12.6.1.3.7 Residual effect

437. As noted above and shown by Table 12.64, there is the potential for a significant effect due to PTS onset from multiple vessels for harbour porpoise. The vessel good practice measures (as described above) would reduce the number of all marine mammal species at risk of PTS onset due to vessels. This would therefore reduce the number of marine mammals at risk of PTS onset, and therefore the residual magnitude of effect would be negligible in all cases.

438. Therefore, the residual effect significance for the potential for PTS onset due to multiple construction vessels (taking into account the high sensitivity of all marine mammals) would be minor adverse.

12.6.1.4 Impact 4: Barrier effects from underwater noise during construction

439. Underwater noise during construction could have the potential to create a barrier effect, preventing movement or migration of marine mammals between important feeding and / or breeding areas, or potentially increasing swimming distances if marine mammals avoid the site and go around it. However, the offshore project area is not located on any known migration routes for marine mammals.

440. The array area is located 40km from the coast at closest point. The nearest seal haul-out site at Gunfleet Sands, approximately 2.8km from the offshore cable corridor at its closest point (Section 12.5.3.1 and 12.5.4.1). Note that this is a tidal haul-out site, and is only exposed at low tide, so is not a haul-out site that would be used for pupping.

12.6.1.4.1 Sensitivity of marine mammals

441. Harbour porpoise and minke whale have a medium sensitivity to barrier effects from underwater noise, in line with their sensitivity to disturbance from underwater noise, and grey seal and harbour seal have a sensitivity of low.

Magnitude of impact

442. Telemetry studies (see Appendix 12.2 (Document Reference: 3.3.7)) and the relatively low seal at sea usage (Carter *et al.,* 2022; see Appendix 12.2 (Document Reference: 3.3.7)) in and around the offshore project area do not

indicate any regular seal foraging routes through the sites. Plate 12.9 indicates that harbour seal will still undertake foraging activity during wind farm construction activities, based on a study by Russell (2016).

443. A tagging study was undertaken for harbour seals within the outer Thames estuary, through the Thames Harbour Seal Conservation Project (Barker *et al*., 2014). This study included the tagging of harbour seals in 2012. The results of this tagging study were used to define foraging areas of harbour seal within the outer Thames area. The activity of the seals while tagged was used to identify key foraging areas, with five such areas being found. These were all located within 4.5km of the nearest haul-out site (Plate 12.11; Barker *et al*., 2014). These foraging locations were plotted against the OWFs in the area (at the time of the study), which shows the Greater Gabbard is not located near to any of the five identified key foraging areas (Plate 12.12; Barker *et al*., 2014), with the closest being north east Buxey Sand, at more than 10km from the offshore cable corridor, and 47km from the array area.

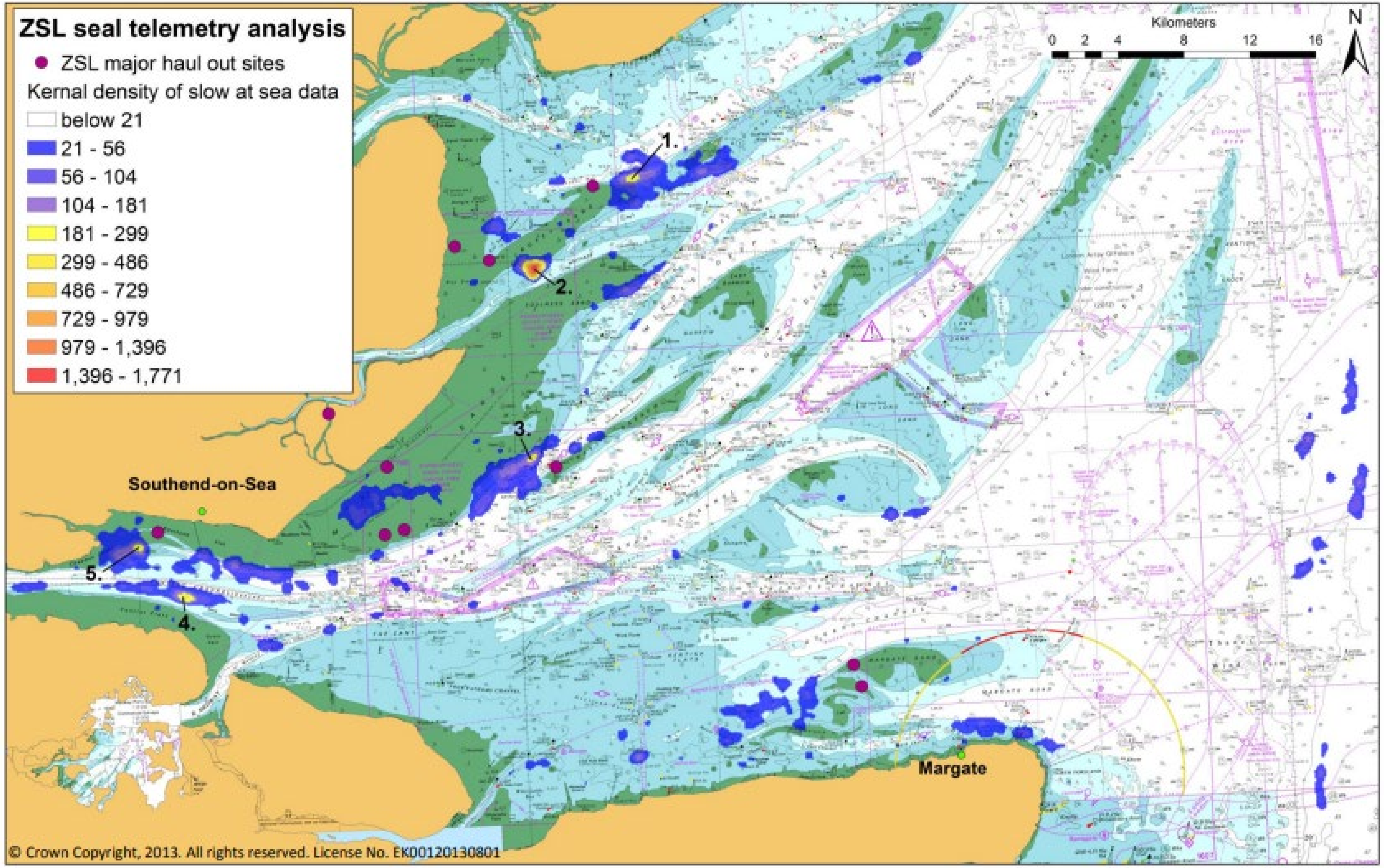

Plate 12.11 Major harbour seal foraging areas in the Thames Estuary; north east Buxey Sand (1), Whitaker Channel (2), West Swin Channel (3), north Yantlet Flats (4) and south Marsh End Sand (5) (Barker *et al*., 2014)

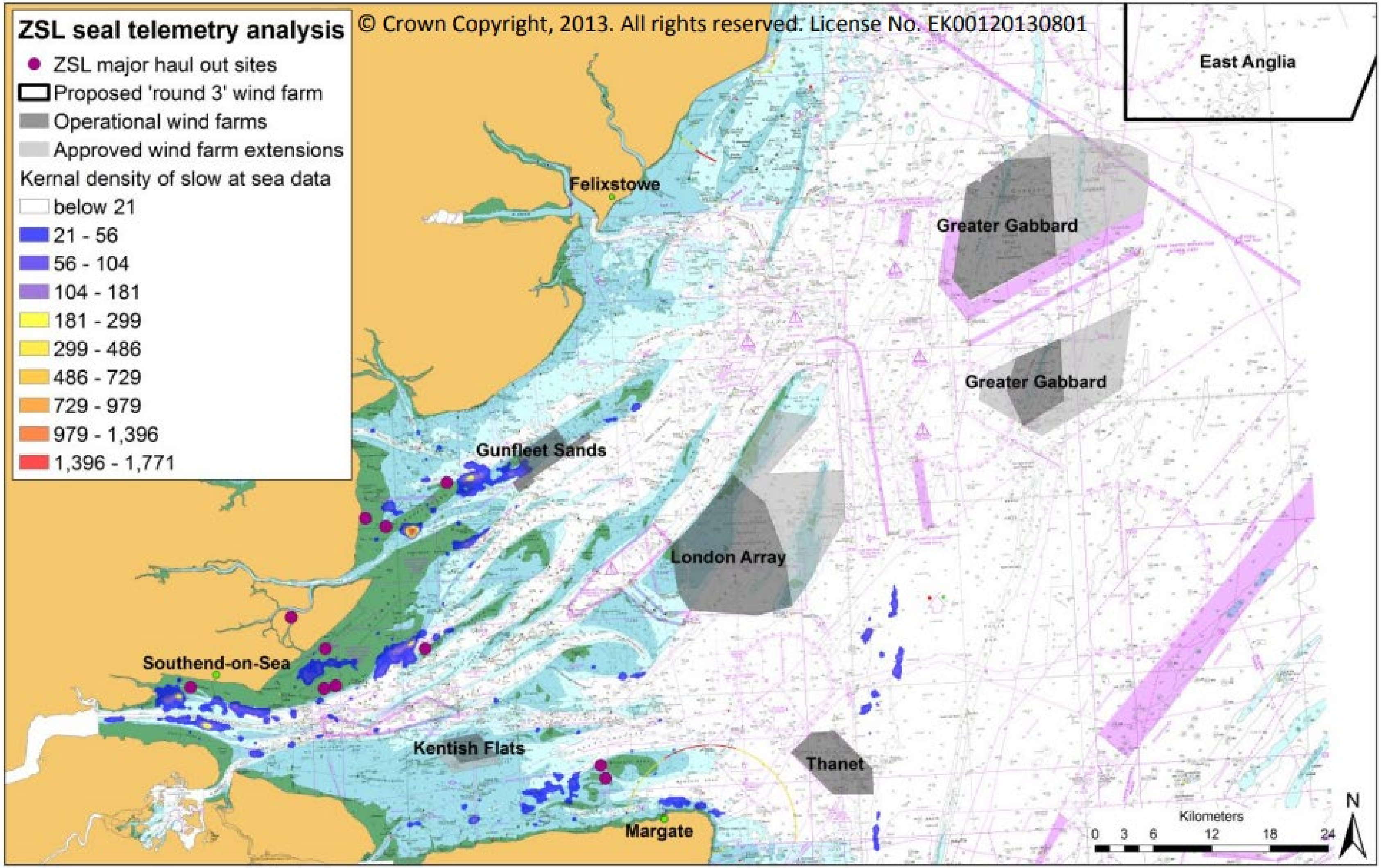

Plate 12.12 Location of major haul out sites and main foraging areas compared with the location of OWFs (Barker *et al*., 2014)

444. As shown in Table 12.41, the maximum duration of piling, based on worst case scenarios, including soft-start, ramp-up and ADD activation would be:

- Piling of up to 59 monopiles (including soft-start, ramp-up and 37 minute ADD activation) = up to 479 hours (up to 20 days); or
- Piling of up to 480 jacket pin piles (including soft-start, ramp-up and 37 ADD activation) = up to 2,456 hours (up to 102.4 days).

445. The greatest potential barrier effect for marine mammals could be from underwater noise during piling (Section 12.6.1.1). As outlined in Section 12.6.1.1.4, piling would not be constant during the piling phases and construction periods. There will be gaps between the installations of individual piles, and if installed in groups there could be time periods when piling is not taking place as piles are brought out to the site. There will also be potential delays for weather or other technical issues.

446. The maximum duration of any barrier effects would be for the maximum piling duration, based on worst case scenarios, including soft-start, ramp-up and ADD activation, as assessed in Table 12.41 and noted above.

447. There is unlikely to be the potential for any barrier effects from underwater noise for other construction activities (Section 12.6.1.2) and vessels (Section 12.6.1.3), as it is predicted that marine mammals will return once the activity has been completed, and therefore any impacts from underwater noise as a result of construction activities other than piling noise will be both localised and temporary. Therefore, there is unlikely to be the potential for any barrier effects that could significantly restrict the movements of marine mammals.

448. Marine mammals are wide ranging. For example, grey seals have foraging ranges of up to 448km (Carter *et al*., 2022), with foraging trips lasting up to 30 days (SCOS, 2021), and harbour seal have foraging ranges of up to 273km (Carter *et al*., 2022). Therefore, if there are any potential barrier effects from underwater noise, marine mammals would be able to compensate by travelling to other foraging areas within their range.

449. There is unlikely to be any significant long-term impacts from any barrier effects, as any areas affected would be relatively small in comparison to the range of marine mammals and would not be continuous throughout the offshore construction period. The magnitude of impact for any potential temporary barrier effects, based on worst case, is assessed as negligible for all species.

12.6.1.4.2 Significance of effect

450. Taking into account the medium sensitivity for harbour porpoise and minke whale, and low sensitivity for both seals, and the potential magnitude of impact, the significance for any potential barrier effects as a result of underwater noise during construction has been assessed as minor adverse for all species (Table 12.65).

Table 12.65 Assessment of effect significance for the potential of a barrier effect during construction due to underwater noise

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual effect
Harbour porpoise and minke whale	Medium	Negligible	Minor adverse	None required.	Minor adverse
Grey seal and harbour seal	Low	Negligible	Negligible		Negligible

12.6.1.4.3 Mitigation

451. No mitigation measures are required for a barrier effect due to underwater noise during construction, however, a SIP will be developed (as outlined in Section 12.8) to set out the approach to deliver any project mitigation or management measures in relation to the barrier effects of harbour porpoise within the Southern North Sea SAC.

452. Any measures to reduce the potential significant disturbance of harbour porpoise would also reduce the potential for any significant disturbance, including barrier effects, in other marine mammal species.

12.6.1.5 Impact 5: Increased risk of collision with vessels during construction

453. During offshore construction, there will be an increase in vessel traffic within the array area and offshore cable corridor. However, it is anticipated that vessels would follow an established shipping route to the relevant ports in order to minimise vessel traffic in the wider area.

12.6.1.5.1 Sensitivity of marine mammals

454. Marine mammals in and around the offshore project area and in the wider southern North Sea area would typically be habituated to the presence of vessels (given the existing levels of marine traffic, see ES Chapter 15 Shipping and Navigation (Document Reference: 3.1.17)) and would be able to detect and avoid vessels.

455. As marine mammals are able to avoid collision with vessels, they are assessed as having a low sensitivity, other than minke whale which, due to their larger size and decreased manoeuvrability in the presence of vessels, are given a sensitivity of medium.

Magnitude of impact

456. While marine mammals are able to detect and avoid vessel collision, any such collision could be fatal (therefore a permanent impact). Therefore, the magnitude of impact is assessed based on the permanent magnitude definitions (Table 12.9).

457. The approximate number of round trips (vessel movements) during construction is estimated to be 2,532 over two years. The number of vessels on site at any one time during construction is estimated to be up to 35 vessels.

458. As outlined in ES Chapter 15 Shipping and Navigation (Document Reference: 3.1.17), the baseline conditions indicate an already relatively high level of shipping activity in and around the array area, with an average of 134 vessels per day in winter, and 147 in summer.

459. Marine mammals are able to detect and avoid vessels. However, vessel strikes are known to occur, possibly due to distraction whilst foraging and socially interacting, or due to the marine mammals' inquisitive nature (Wilson *et al*., 2007). Therefore, increased vessel movements, especially those outside recognised vessel routes, can pose an increased risk of vessel collision to marine mammals.

460. Studies have shown that larger vessels are more likely to cause the most severe or lethal injuries, with vessels over 80m in length causing the most damage to marine mammals (Laist et al., 2001). Vessels travelling at high speeds are considered to be more likely to collide with marine mammals, and those travelling at speeds below 10 knots would rarely cause any serious injury (Laist *et al*., 2001).

461. Harbour porpoise are small and highly mobile, and given their responses to vessel noise (e.g. Thomsen et al., 2006; Polacheck and Thorpe, 1990), are expected to largely avoid vessel collisions. The Heinänen and Skov (2015) report indicates a negative relationship between the number of ships and the distribution of harbour porpoise in the North Sea, suggesting that the species could exhibit avoidance behaviour which reduces the risk of strikes.

462. In 2016, SMRU conducted a study to determine the likelihood of harbour seal injury occurring due to co-presence with large vessels within the Moray Firth (Onoufriou *et al.*, 2016). This study used telemetry data of harbour seal within the Moray Firth, alongside vessel AIS data. The data indicated vessel and seal co-occurrence was high (defined as over 2,500 co-occurrence minutes per year) in very localised areas. However, there appeared to be no relationship between areas in high co-occurrence and incidences of injury (Onoufriou *et al*., 2016).

463. Predictability of vessel movement by marine mammals is known to be a key aspect in minimising the potential risks imposed by vessel traffic (Nowacek *et al*., 2001, Lusseau, 2003, 2006).

464. Approximately 4% of all harbour porpoise post mortem examinations from the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS area) are thought to have evidence of interaction with vessels (Evans *et al*., 2011).

465. There is currently limited information on the collision risk of marine mammals in the southern North Sea area.

466. Both the Scottish Marine Animal Stranding Scheme (SMASS) and Cetacean Strandings Investigation Programme (CSIP) record strandings of marine mammals, and undertake investigations to determine causes of fatalities wherever possible. SMASS record and investigate all marine mammal strandings reported to them in Scotland, and the CSIP record and investigate all recorded strandings of cetacean species in the UK. Table 12.66 below summarises the data for the relevant species, for the most recent available data of both schemes, and details the number of deaths caused by either vessel strike, or physical trauma with an unknown cause (which could be attributed to vessel strike).

467. Between 2003 and 2020, SMASS and CSIP identified the cause of death for 1,165 of the 4,796 reported harbour porpoise strandings. Of these, 49 (4.2%) died from physical trauma of an unknown cause, and 19 (1.6%) died as a result

of physical trauma following probable impact from a ship or boat (Table 12.66). This results in a collision risk rate of 0.058 (or the proportion of the total harbour porpoise population at risk of collision due to vessels).

468. Between 2003 and 2020, 70 stranded minke whale were investigated with a cause of death established between SMASS and CSIP. Four of those were found to have been due to physical trauma following impact from a vessel. (Table 12.66). This results in a collision risk rate of 0.057.

469. For the 2003 to 2020 period, SMASS and CSIP identified the cause of death for a total of 470 of the 1,909 reported grey seal strandings. Of these, four died as a result of physical trauma following probable impact from a ship or boat (Table 12.66). This results in a collision risk rate of 0.009.

470. Between 2003 and 2020, 791 stranded harbour seal were investigated with a cause of death established between SMASS and CSIP. A total of 13 were attributed to a physical trauma of unknown cause, and four to physical trauma following impact from a vessel. (Table 12.66). This results in a collision risk rate of 0.028.

471. The SMASS and CSIP data (Table 12.66) shows that mortality of cetaceans from vessel collisions can occur, although it accounts for a relatively small number of the strandings where cause of death was established. It is also important to note that the strandings data are biased to those carcasses that wash ashore for collection, and therefore may not be representative.

Table 12.66 Summary of UK cetacean stranding's and causes of death from physical trauma of unknown cause and physical trauma following probable impact from a ship or boat

Species	Number of stranding's (SMASS 2009 – 2020[13] & CSIP 2003 – 2015[14])	Number of necropsies where cause of death established	Cause of death: physical trauma of unknown cause	Cause of death: physical trauma following probable impact from a ship or boat	Collision risk rate (number attributed to vessels strike / other physical trauma as proportion of total number necropsied)
Harbour porpoise	SMASS = 1,198 CSIP = 3,598 Total = 4,796	SMASS = 350 CSIP = 815 Total = 1,165	SMASS = 4 CSIP = 45 Total = 49	SMASS = 2 CSIP = 17 Total = 19	0.058 at risk of collision
Minke whale	SMASS = 137 CSIP = 162 Total = 299	SMASS = 45 CSIP = 25 Total = 70	SMASS = 0 CSIP = 0 Total = 0	SMASS = 2 CSIP = 2 Total = 4	0.057 at risk of collision
All large whale species	*SMASS = 225* *CSIP = 233* *Total = 458*	*SMASS = 69* *CSIP = 30* *Total = 99*	*SMASS = 0* *CSIP = 0* *Total = 0*	*SMASS = 1* *CSIP = 3* *Total = 4*	*0.040 at risk of collision*

[13]SMASS (2009); SMASS (2010); SMASS (2011); SMASS (2012); SMASS (2013); SMASS (2014); SMASS (2015); SMASS (2016); SMASS (2017); SMASS (2018); SMASS (2019); SMASS (2020) [available from: https://www.strandings.org/publications/]

[14]CSIP (2004); CSIP (2005); CSIP (2006); CSIP (2011); CSIP (2016) [available from: https://www.ukstrandings.org/csip-reports/]

Species	Number of stranding's (SMASS 2009 – 2020[13] & CSIP 2003 – 2015[14])	Number of necropsies where cause of death established	Cause of death: physical trauma of unknown cause	Cause of death: physical trauma following probable impact from a ship or boat	Collision risk rate (number attributed to vessels strike / other physical trauma as proportion of total number necropsied)
Grey seal	SMASS = 1,909	SMASS = 470	SMASS = 0	SMASS = 4	0.009 at risk of collision
Harbour seal	SMASS = 624	SMASS = 180	SMASS = 5	SMASS = 0	0.028 at risk of collision
All seal species	*SMASS = 3,869*	*SMASS = 791*	*SMASS = 13*	*SMASS = 4*	*0.021 at risk of collision*

472. To estimate the potential collision risk of vessels associated with North Falls during construction, the potential risk rate per vessel has been calculated for all relevant species (Table 12.66), which is then used to calculate the total risk to marine mammal species due to the presence of additional vessels during construction of North Falls (Table 12.67).

473. To inform this assessment, the total number of each marine mammal species in UK waters has been compared against the total vessels present in UK waters, as well as the potential collision risk rate of each species based on the SMASS and CSIP data. The total UK populations are taken from IAMMWG (2023) for all cetacean species, and the total UK populations for seal species are taken from SCOS (2022). The total presence of vessels in UK waters is taken from the total vessel transits within the 2015 AIS data, which is the latest publicly available.

474. The number of marine mammals at risk of collision, per vessel, in UK waters, has been calculated from the above described datasets. This has been used to calculate the number of each marine mammal species that would be at risk of collision (without the embedded mitigation shown in Table 12.67) from the estimated 5,064 vessel transits during the two year construction program (or 2,532 per year).

475. This is a highly precautionary assumption, as it is unlikely that marine mammals in the offshore project area would be at increased collision risk with vessels during construction, considering the minimal number of vessel movements compared to the existing number of vessel movements in the area, and that vessels within the offshore project area would be stationary for much of the time or very slow moving.

476. In addition, as discussed in Section 12.3.3, vessel movements, where practicable, will be incorporated into recognised vessel routes and hence to areas where marine mammals are accustomed to vessels, in order to reduce any increased collision risk. Vessel operators will use good practice to reduce any risk of collisions with marine mammals, such as reducing the speed of vessel transits wherever practicable.

477. The magnitude for potential increased collision risk with construction vessels, based on a precautionary worst case scenario, is low for harbour porpoise, minke whale and grey seal, and medium for harbour seal, based on the permanent magnitude thresholds as provided in Table 12.9.

Table 12.67 Predicted number of marine mammals at risk of collision with North Falls' construction vessels, based on current UK collision rates and vessel presence (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Marine mammal species	Collision risk rate (number attributed to vessels strike / other physical trauma as proportion of total number necropsied)[15]	Estimated total number of individuals in UK waters[16]	Estimated number of individuals at risk within UK waters	Annual number of vessel transits in UK and RoI for 2015[17]	Number of marine mammals at risk of collision per vessel in UK waters	Number annual vessel transits associated with construction	Additional marine mammals at risk due to increase in vessel number (collision rate * vessel increase)	% reference population
Harbour porpoise	0.058 at risk of collision	159,632	9,318	3,852,030	0.003	2,532	Up to seven at risk per year (n=6.1)	0.002%
Minke whale	0.057 at risk of collision	10,288	588	3,852,030	0.0002	2,532	Up to one at risk every two years (n=0.4)	0.002%
Grey seal	0.009 at risk of collision	162,000	1,379	3,852,030	0.0004	2,532	Up to one at risk every year (n=0.9)	0.003% SE MU population; or 0.002% wider reference population
Harbour seal	0.028 at risk of collision	42,900	1,192	3,852,030	0.0003	2,532	Up to one every year (n=0.8)	0.02% SE MU

[15] Where species specific data is not available, the species group data is used
[16] Based on the IAMMWG (2023) UK population estimates for cetacean species, SCOS (2022) UK population estimates for seal species
[17] Latest publicly available data, available from: https://www.data.gov.uk/dataset/963c1a7b-5b72-4cce-93f5-3f1e223fd575/anonymised-ais-derived-track-lines-2015

12.6.1.5.2 Significance of effect

478. Taking into account the low to medium marine mammal sensitivity, and the potential magnitude of impact, the significance for any increase in vessel collision risk during construction has been assessed as negligible to minor adverse for all species (Table 12.68).

Table 12.68 Assessment of effect significance for the potential of an increase in collision risk due to increased vessel presence during construction

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual effect
Harbour porpoise and grey seal	Low	Low	Negligible	Vessel good practice measures to manage collision risk.	Negligible
Minke whale	Medium	Low	Minor adverse		Minor adverse
Harbour seal	Low	Medium	Minor adverse		Minor adverse

12.6.1.5.3 Mitigation

479. Vessel good practice measures (as outlined in Table 12.93) will be in place in order to reduce any potential for vessel collision. Vessel movements, where possible, would follow set vessel routes where available and hence areas where marine mammals are accustomed to vessels, in order to reduce any increased collision risk. Additionally, vessel operators would use good practice to reduce any risk of collisions with marine mammals. These measures are detailed within the Outline PEMP (Document Reference: 7.6).

12.6.1.6 Impact 6: Disturbance at seal haul-out sites

480. Grey seal and harbour seal have been shown to be sensitive at haul-out sites to disturbance from anthropogenic sources such as vessel traffic, construction activities including piling, approaches from land etc. (Cates *et al.,* 2017, Paterson, 2019, Machernis *et al.,* 2018). The most common disturbance impacts at haul out sites include increased vigilance and 'flushing' behaviour, which can be energetically taxing especially if pups are present or during moulting season when seals tend to spend more time on land (Machernis *et al*., 2018).

481. During construction, piling represents the loudest and most likely source of disturbance to seal haul-outs, as well as increased vessel activity, and the number of seals spending time on land has been shown to decrease during the construction phase of wind farms (e.g., up to 60% reduction in number of seals hauling out at sites 4km away from construction activities during piling periods) (Edren *et al.,* 2010).

12.6.1.6.1 Sensitivity of marine mammals

482. Pinnipeds vary in their reaction to construction disturbance depending on disturbance type (vessel noise/presence, piling etc,) and proximity to haul-out sites. A 2016 study at Sheringham Shoal OWF demonstrated that there was no significant displacement of seals overall during construction. However, during pile driving activities there was a significant reduction in seals at haul-out sites up to 25km away, returning to typical levels two hours after piling had ceased (Russel *et al*., 2016).

483. Disturbance to seals from vessel noise and presence has been demonstrated at haul-out sites in the UK up to 500m away (Cates *et al.,* 2017). In a similar

study, harbour seals were 25 times more likely to flee into the water when cruise ships passed 100m from haul-out sites than when ships passed within 500m (Jansen *et al.,* 2010). Land-based disturbance has been shown to cause higher levels of disturbance compared to marine sources, and smaller, quiet vessels like kayaks can cause the highest levels of flushing behaviour (Bonner, 2021). In areas of high vessel traffic, there can be habituation impacts and disturbance behaviours are generally reduced over time (Strong *et al.,* 2010).

484. Based on the existing data and current information seals are considered to have a medium sensitivity to disturbance at haul-out sites from construction.

Magnitude of impact

485. Offshore construction activities are expected to take approximately two years to complete in total, with 12 months deemed as worst case scenario for installation of wind turbine foundations (including piling). Of these 12 months, up to 103 days are estimated for active piling for both WTGs and OSP/OCPs (based on the worst case of jacket pin piles). The majority of the identified haul-out sites are over 25km away from the array area where the highest levels of disturbance may occur and are unlikely to be disturbed by piling. Of the two sites within 25km, there were no counts of seals at Long Sand in 2021 (9km from array area) and 200 unidentified seals at Kentish Knock in 2021 (17km from array area) (Cox*,* 2021). The total number of seals in the study area vulnerable to piling disturbance at haul-out sites from construction is therefore relatively low.

486. The number of vessels relating to the wind farm are expected to increase during construction, however, as the area is an area of high-volume vessel traffic (up to 147 vessels a day during summer), this increase is not expected to cause any additional disturbance to seal haul-out sites, especially as seals in this area are likely to be habituated to this disturbance.

487. It is expected that disturbance to seals at haul-out sites from construction is a short-term impact. For example, a 2019 study on harbour seals in Scotland found that 30 minutes after a disturbance event, seals return to 52% pre-disturbance levels at haul-out sites and 94% pre-disturbance levels four hours after a disturbance event (Paterson, 2019). To date, in terms of long-term population impacts on seals from disturbance at haul-out sites, none have been shown from vessel noise/presence or construction activities (Edren *et al.,* 2010, Russel *et al.,* 2016, Cates *et al.,* 2017).

488. Based on high vessel traffic already in place in the study area, the temporary nature of increased construction vessels (approximately two years), and maximum disturbance events from piling deemed to be short-term and unlikely to cause population-level impacts, the potential for disturbance to seal haul-out sites is assessed as having a magnitude level of low.

12.6.1.6.2 Significance of effect

489. The assessment for the potential effect of disturbance from construction vessels on seal haul-outs is provided in Table 12.69, considering a medium sensitivity and the potential magnitude of impact (i.e., estimated number of days for piling, number of additional vessels in the area during construction and levels of noise emitted from vessels).

490. The effect significance for disturbance from construction on seal haul-outs has been assessed as minor adverse for grey seal and harbour seal.

Table 12.69 Assessment of effect significance for the potential for disturbance at seal haul-out sites during construction

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual effect
Grey seal and harbour seal	Medium	Low	Minor adverse	None required, but vessel good practice measures would reduce disturbance.	Negligible

12.6.1.6.3 Mitigation

491. Vessel good practice measures (as outlined in Table 12.93) will be in place to reduce any potential for seals to become disturbed while at haul-out sites. Vessel movements, where practicable, will be incorporated into recognised vessel routes (including those already used for the OWFs in the area) and hence to areas where marine mammals are accustomed to vessels.

492. In addition, vessel operators will use good practice to reduce any risk of collisions with marine mammals, such as reducing the speed of vessel transits wherever practicable, and by not transiting close to seal haul-out sites. Further information can be found in the Draft MMMP (Document Reference: 7.7) and the Outline PEMP (Document Reference: 7.6).

12.6.1.7 Impact 7: Changes to water quality

493. As outlined in ES Chapter 9 Marine Water and Sediment Quality (Document Reference: 3.1.11), potential changes in water quality during construction could occur through:

- Deterioration in water quality due to an increase in suspended sediment associated with seabed preparation for the installation of foundations;
- Deterioration in water quality due to an increase in sediment concentrations due to drill arisings for installation of piled foundations for wind turbines and OSP/OCP;
- Deterioration in water quality due to increases in suspended sediment associated with the installation of the export cable; and
- Deterioration in water quality associated with release of sediment bound contaminants.

494. The potential for accidental pollution has not been assessed within ES Chapter 9 Marine Water and Sediment Quality (Document Reference: 3.1.11) due to the commitments made by North Falls. North Falls are committed to the use of good practice techniques and due diligence regarding the potential for pollution throughout all construction activities. As a result, an outline PEMP has been submitted with the DCO application. The final PEMP would be agreed with the MMO prior to construction and would include, for example, measures to control accidental release of drilling fluids whilst ensuring that any chemicals used are listed on the OSPAR (Convention for the Protection of the Marine Environment of the North-East Atlantic; Oslo/Paris Convention) List of Substances Used and Discharged Offshore which Are Considered to Pose Little or No Risk to the Environment (PLONOR) (OSPAR, 2021).

12.6.1.7.1 Sensitivity of marine mammals

495. Marine mammals often inhabit turbid environments and cetaceans utilise sonar to sense the environment around them and there is little evidence that turbidity

affects cetaceans directly (Todd *et al.,* 2014). Pinnipeds are not known to produce sonar for prey detection purposes; however, it is likely that other senses are used instead of, or in combination with, vision. Studies have shown that vision is not essential to seal survival, or ability to forage (Todd *et al.,* 2014).

496. Increased turbidity is unlikely to have a substantial direct impact on marine mammals that often inhabit naturally turbid or dark environments. This is likely because other senses are utilised, and vision is not relied upon solely. Therefore, all species have negligible sensitivity to increases in suspended sediments during construction.

497. Any direct impacts to marine mammals as a result of any contaminated sediment during construction activities are unlikely as any exposure is more likely to be through potential indirect impacts via prey species, as assessed in Section 12.6.1.7.3. Therefore, marine mammals are considered to have negligible sensitivity to any direct impacts from contaminated sediment during construction activities.

Magnitude of impact

498. The magnitude for the potential changes in water quality has been based on the assessments in ES Chapter 9 Marine Water and Sediment Quality (Document Reference: 3.1.11) (Table 12.70), with a magnitude of low for all potential impacts.

Table 12.70 Magnitude of potential changes in water quality during construction, based on assessments in ES Chapter 9 Marine Water and Sediment Quality (Document Reference: 3.1.11)

Potential water quality impact	Magnitude as assessed in ES Chapter 9 (Document Reference: 3.1.11)	Embedded mitigation
Deterioration in water quality due to an increase in suspended sediment associated with seabed preparation for the installation of foundations, platform interconnector cable and array cables.	Low (effect significance of minor adverse).	Micro-siting will be used where practicable to minimise the requirements for seabed preparation prior to foundation and cable installation.
Deterioration in water quality due to an increase in sediment concentrations due to drill arisings for installation of piled foundations for wind turbines and OSP/OCP.	Low (effect significance of minor adverse).	For piled foundation types, such as monopiles and jackets with pin piles, pile-driving will be used in preference to drilling where it is practicable to do so (i.e. where ground conditions allow). This would minimise the quantity of sub-surface sediment released into the water column from the installation process.
Deterioration in water quality due to increases in suspended sediment associated with the installation of the export cable.	Low (effect significance of minor adverse).	Cables will be buried where practicable, minimising the requirement for cable protection measures and thus effects on sediment transport.
Deterioration in water quality associated with release of sediment bound contaminants.	Low (effect significance of negligible).	None.

12.6.1.7.2 Significance of effect

499. Taking into account the negligible marine mammal sensitivity, and the potential magnitude of impact of negligible to minor adverse (Table 12.70), the significance for any effect of the change in water quality for marine mammals has been assessed as negligible for all species (Table 12.71).

Table 12.71 Assessment of effect significance for the potential of indirect effects to marine mammals through changes to water quality during construction

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual impact
Harbour porpoise, minke whale, grey seal and harbour seal	Negligible	Low	Negligible	None required.	Negligible

12.6.1.7.3 Mitigation

500. No mitigation is required or proposed, other than the embedded mitigation for water quality as outlined in Table 12.2.

12.6.1.8 Impact 8: Changes to prey resources

501. Potential impacts to prey species that may cause changes to prey resources for marine mammals include:

- Physical disturbance
- Increased suspended sediment concentrations (SSC) and sediment re-deposition
- Re-mobilisation of contaminated sediments
- Underwater noise from construction activities e.g., piling (disturbance / displacement)
- Changes in fishing activity

502. Relevant marine mammal prey species in the study area include herring, cod, whiting, sprat, sandeel, lemon sole, plaice, sole, which are key prey species for;

- Harbour porpoise – 'schooling fish' e.g., herring, whiting, sprat
- Minke whale – sandeel, herring, sprat, krill
- Grey seal – flexible foragers – sandeel important, also cod, herring
- Harbour seal – flexible foragers – herring, cod, whiting, molluscs, squid etc.

503. ES Chapter 11 Fish and Shellfish Ecology (Document Reference: 3.1.13) provides an assessment of these impact pathways on the relevant fish and shellfish species. Any reductions in prey availability would be small scale, localised and temporary. It is considered highly unlikely that potential reductions in prey availability as a result of construction activities at North Falls would result in detectable changes to marine mammal populations.

12.6.1.8.1 Sensitivity of marine mammals

504. Harbour porpoise are highly influenced by the spatiotemporal distribution and availability of their prey (Santos & Pierce 2003, Santos *et al*., 2004, Sveegaard *et al*., 2012), as their small body size and lack of energy storage requires them to feed constantly and they must therefore be near abundant food sources (Read & Hohn 1995, Johnston et al., 2005, Wisniewska *et al*., 2016). However, it has been estimated that, depending on the conditions, harbour porpoise can rely on stored energy (primarily blubber) for three to five days, depending on body condition (Kastelein *et al*., 1997). Harbour porpoise are therefore considered to have low to medium sensitivity to changes in prey resources.

505. Minke whale diet is relatively varied at population level, but within the North Sea it consists mainly of mackerel and sand eels (Windsland *et al*., 2007). The latter

were found to comprise of 62% by weight, whereas Clupeids (herring and sprat) account for around 30% of the diet in minke whales in Scottish waters (Pierce *et al.,* 2004). They often forage in areas of upwelling or strong currents around headlands and small islands (Evans *et al.*, 2010). Therefore, minke whale are considered to have a low to medium sensitivity to changes in prey resources.

506. Grey seal are opportunistic feeders, preying on a variety of species, dominated by sandeel. Within the southern North Sea, their diet is more varied in composition where grey seals also prey on flat fish, sandy benthic, large gadid prey and scorpion fish (the latter mainly during autumn/winter) (Wilson & Hammond, 2019). They prefer habitat with rock, mixed and coarse sediment (Huon *et al.,* 2015), creating habitat heterogeneity that provides niches for a wide range of species and consequently prey availability (Jones *et al.,* 2014). Grey seals are therefore considered to have low sensitivity to changes in prey resources.

507. Harbour seals are considered generalist feeders, and feed on a variety of species, e.g. large gadid prey (Wilson & Hammond, 2019). They avoid muddy habitats and prefer sandy sediment, potentially driven by the distribution of their main prey, sand eels (Jones *et al.,* 2017a). Harbour seals are therefore considered to have low sensitivity to changes in prey resources.

12.6.1.8.2 Magnitude of impact

Physical disturbance and temporary habitat loss

508. The magnitude of impact of physical disturbance to seabed habitat during construction has been assessed as negligible for North Falls in ES Chapter 10 Benthic and Intertidal Ecology (Document Reference: 3.1.12) . In ES Chapter 11 Fish and Shellfish Ecology (Document Reference: 3.1.13) the magnitude of physical disturbance during construction activities for the Project is considered to be negligible for all species. This is based on the small area of disturbance, generally wide distribution ranges (and no or little direct overlap of habitats with construction activities) of fish and shellfish species, and the quick anticipated recovery the seabed. The Downs herring population (which are a key prey species for all marine mammal species) and sandeel (a key prey species for minke whale and grey seal) have a higher sensitivity to changes or loss of their habitats.

509. During construction activities, the worst-case footprint for disturbance would be 5.5km^2. The impact would be temporary, highly localised and was assessed as negligible for North Falls Benthic and Intertidal Ecology (see ES Chapter 10 (Document Reference: 3.1.12). The magnitude of impact for disturbance to fish and shellfish was considered negligible for all species (see ES Chapter 11 Fish and Shellfish Ecology (Document Reference: 3.1.13)).

Increased suspended sediments and sediment deposition

510. Increases in suspended sediment are expected to cause localised and short-term increases in SSC. Predominantly medium and coarse-grained sediment types were found at North Falls (see ES Chapter 8 Marine Geology, Oceanography and Physical Processes (Document Reference: 3.1.10), which typically remain close to the seabed and settle quickly once disturbed. There is a small proportion of fine sand and mud that, when disturbed, would result in a passive plume (tens of mg/l), which would likely be present for half a tidal cycle (or six hours). The worst-case level of sediment smothering, and deposition would be approximately <1mm, short-lived (minutes) and localised. Separately

assessed species were the Downs and Blackwater herring populations and sandeels resulting in an impact of minor significance based on an overlap with spawning habitat by means of changes in the characteristics of the substrate.

511. Generally, fish would be expected to distribute within their habitat range, whereas it would be of minor significance to more sensitive species such as the Downs and Blackwater herring populations and sandeels. Both species can tolerate SSCs to some extent, and additionally the Project area is of comparatively low importance to sandeels and low suitability for Downs herring spawning.

Re-mobilisation of contaminated sediment

512. The data and analysis in ES Chapter 9 Marine Water and Sediment Quality (Document Reference: 3.1.11) indicates that levels of contaminants within the North Falls offshore project area are low and do not contain significant elevated levels in relation to the relevant guidelines and typical regional levels, to cause concern.

513. Therefore, any potential changes to prey availability as a result of re-mobilisation of contaminated sediments is assessed as of negligible significance and would have no adverse effect to changes in prey availability during construction (due to re-mobilisation of contaminated sediment) for North Falls.

Underwater noise

514. ES Chapter 11 Fish and Shellfish Ecology (Document Reference: 3.1.13), provides an assessment of the potential underwater noise impacts on fish and shellfish species and predicts that impacts would be of negligible to low magnitude and of a temporary nature (see ES Chapter 11 Fish and Shellfish Ecology (Document Reference: 3.1.13) for a detailed assessment of underwater noise impacts on fish species).

515. Potential sources of underwater noise and vibration during construction include piling, increased vessel traffic, seabed preparation, dredging, rock placement and cable installation (trenching and cable laying). Of these, piling is considered to produce the highest levels of underwater noise and therefore has the greatest potential to result in adverse impacts on fish.

516. The underwater noise modelling (see Appendix 12.3 (Document Reference: 3.3.8) assessed the following fish groups (based on Popper *et al.*, 2014):

- No swim bladder (e.g., sole, plaice, lemon sole, mackerel and sandeels)
- Swim bladder not involved in hearing (e.g., sea bass, salmon and sea trout)
- Swim bladder which is involved in hearing (e.g., cod, whiting, sprat and herring).

517. The underwater noise modelling results indicate that fish species in which the swim bladder is involved in hearing are the most sensitive to the impact of underwater noise, therefore the worst-case scenario assessment uses these species as an indicator of overall impacts. The majority of the key marine mammal prey species are within the species grouping of fish with a swim bladder involved in hearing, and therefore are represented by this worst-case (sandeels are within the species grouping of no swim bladder).

Piling

518. For mortality and recoverable injury impacts associated with piling noise are considered to result in a negligible magnitude of impact for species with a swim bladder involved in hearing, and an overall minor significance of effect (with most species having a medium sensitivity other than herring with high sensitivity) (see ES Chapter 11 Fish and Shellfish Ecology (Document Reference: 3.1.13) for detailed assessment).

519. It is highly unlikely that there would be significant changes to prey over the entire area. It is more likely that impacts would be restricted to an area around the working sites. It is also important to note that there is unlikely to be any additional displacement of marine mammals as a result of any changes in prey availability during piling, as marine mammals would also be disturbed from the area.

520. In relation to the potential for mortality and potential mortal injury, there is the potential for impact up to 10km, and recoverable injury at ranges of up to 15km, under the worst case scenario. This worst case scenario is based on sequential monopiling using a stationary receptor model for fish species with a swim bladder involved in hearing.

521. The outputs of the underwater noise modelling for the spatial worst-case scenario indicate that TTS may occur at distances up to 16km and 17km assuming a fleeing animal scenario (single pin pile and sequential pin pile installation), increasing to up to 33km and 40km when considering a stationary receptor (single monopile and sequential monopile installation). Behavioural responses would be expected within these ranges and potentially in wider areas depending on the hearing ability of the species under consideration (see ES Chapter 11 Fish and Shellfish Ecology (Document Reference: 3.1.13)).

522. For TTS, the magnitude of the impact is considered to be negligible, taking account of the spatial extent of the impact, the overall short duration of piling and its intermittent nature. As the receptor sensitivities vary for each species, the overall effect significance for TTS and behavioural impacts associated with piling are considered as followed:

- Bass (low sensitivity): negligible significance
- Cod, sprat and sandeels (medium sensitivity): minor significance
- The Downs herring population and the Blackwater herring population (high sensitivity): minor significance.

523. The wide foraging ranges of marine mammals and the availability of prey in nearby areas has been taken into account and therefore the magnitude of any impact from the potential response of fish during piling is assessed as negligible for harbour and grey seal, and negligible to low for minke whale and harbour porpoise.

Other construction activities and vessels

524. The potential impact ranges modelled for fish species as a result of underwater noise during cable laying, trenching, rock placement, drilling, dredging and vessel activities are less than 50m (ES Chapter 11 Fish and Shellfish Ecology, (Document Reference: 3.1.13)), which is less than the predicted impact ranges for marine mammals (12.6.1.1).

525. The assessment of underwater noise due to other construction activities on fish species has been assessed as minor to negligible. Therefore, any potential changes to prey availability as a result of other construction activities and vessels is assessed as negligible for marine mammals.

UXO clearance

526. For the potential for UXO clearance, the magnitude of the impact is considered to be negligible due to the short term and intermittent nature of this activity. Physical trauma and injury would be expected in close proximity to the detonation, hence the species considered in ES Chapter 11 Fish and Shellfish Ecology (Document Reference: 3.1.13) are range from low to high sensitivity and therefore have an effect of negligible to minor significance.

527. Therefore, any potential changes to prey availability as a result of UXO clearance is assessed as negligible to low for marine mammals.

Changes in fishing activity

528. Fishing activity within the offshore project area may be reduced due to the presence of safety zones during construction. This may also alter the level of fishing in other areas through displacement of fishing activities. However, it is not expected that this change in fishing levels would affect the overall population level of fish species in the wider area. It would also be a short-term and temporary impact, during the construction only. The magnitude is therefore assessed as negligible within ES Chapter 11 Fish and Shellfish Ecology (Document Reference: 3.1.13), with an overall effect significance of negligible.

Summary of magnitudes of impact

529. The following sections summarise the potential impacts to fish species, based on the assessments provided in ES Chapter 11 Fish and Shellfish Ecology (Document Reference: 3.1.13). The magnitude of impact to marine mammal species is based on the magnitude of impact to prey species, although it should be noted that this is a precautionary approach as marine mammals are generally opportunistic foragers, and would be able to prey upon a range of other species.

Table 12.72 Magnitude of potential changes to prey resources during construction, based on assessments in ES Chapter 11 Fish and Shellfish Ecology

Potential impact to prey changes	Magnitude as assessed in ES Chapter 11 (Document Reference: 3.1.13)	Embedded mitigation
Physical disturbance and temporary habitat loss	Negligible (overall effect significance of minor to negligible). Note: the Downs and Blackwater herring populations and sandeels have a medium sensitivity, and therefore an effect significance of minor.	Micro-siting will be used where practicable to minimise the requirements for seabed preparation prior to foundation and cable installation.
Increased suspended sediments and sediment deposition	Negligible (overall effect significance of negligible to minor). Note: the Downs and Blackwater herring populations and sandeels have a medium sensitivity, and therefore an effect significance of minor to negligible.	For piled foundation types, such as monopiles and jackets with pin piles, pile-driving will be used in preference to drilling where it is practicable to do so (i.e. where ground conditions allow). This would minimise the quantity of sub-surface sediment released into the water column from the installation process.

Potential impact to prey changes		Magnitude as assessed in ES Chapter 11 (Document Reference: 3.1.13)	Embedded mitigation
			Cables will be buried where practicable, minimising the requirement for cable protection measures and thus effects on sediment transport.
Re-mobilisation of contaminated sediment		Negligible (overall effect significance of negligible).	Pollution prevention outlined in PEMP and in Chapter 9 Marine Sediment and Water Quality (Document Reference: 3.3.11).
Underwater noise	Piling noise	Mortality and potential mortal injury: Negligible to low (overall effect significance of negligible), or for gobies, an overall effect significance of minor (with an increased sensitivity). Recoverable injury: Negligible to low (overall effect significance of negligible), or for gobies, an overall effect significance of minor (with an increased sensitivity). TTS and behavioural effect: Low sensitivity (overall effect significance of negligible) for whiting, diadromous species and bass, high sensitivity for sandeels, Downs herring and the Blackwater herring population (overall effect significance of minor).	A soft start and ramp-up protocol will be used for pile driving. This would allow mobile species to move away from the area of highest noise impact during installation of foundations.
	Other construction activities	Negligible (overall effect significance of minor to negligible).	
	UXO clearance	Negligible (overall effect significance of minor to negligible).	Low-order clearance techniques to be used where practicable.
Changes in fishing activity		Negligible (overall effect significance of negligible).	None required.

**Magnitudes and effect significance based on worst-case scenario of fish with a swim bladder that is involved in hearing under a stationary receptor scenario.*

12.6.1.8.3 Significance of effect

530. Taking into account the low to medium marine mammal sensitivity, and the potential impact magnitude of negligible to low (Table 12.70) for all fish species, the significance for any effect of the changes of prey resource for marine mammals has been assessed as negligible to minor adverse for harbour porpoise, minke whale, grey seal and harbour seal (Table 12.73).

Table 12.73 Assessment of effect significance for the potential of an indirect effect to marine mammals through changes to prey resources during construction

Potential effect	Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual effect
Physical disturbance and temporary habitat loss	Harbour porpoise and minke whale	Low to medium	Low	Negligible to Minor adverse	None required.	Negligible to Minor adverse
	Grey seal and harbour seal	Low		Negligible adverse		Negligible adverse

Potential effect	Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual effect
Increased suspended sediments and sediment deposition, and re-mobilisation of contaminated sediment	Harbour porpoise and minke whale	Low to medium	Negligible	Negligible to Minor adverse		Negligible to Minor adverse
	Grey seal and harbour seal	Low		Negligible adverse		Negligible adverse
Underwater noise from piling	Harbour porpoise and minke whale	Low to medium	Negligible to low	Negligible to Minor adverse		Negligible to Minor adverse
	Grey seal and harbour seal	Low		Negligible to Minor adverse		Negligible to Minor adverse
Underwater noise from other construction activities	Harbour porpoise and minke whale	Low to medium	Low	Negligible to Minor adverse		Negligible to Minor adverse
	Grey seal and harbour seal	Low		Negligible adverse		Negligible adverse
Underwater noise from UXO clearance	Harbour porpoise and minke whale	Low to medium	Low	Negligible to Minor adverse		Negligible to Minor adverse
	Grey seal and harbour seal	Low		Negligible adverse		Negligible adverse
Change in fishing activity	Harbour porpoise and minke whale	Low to medium	Low	Negligible to Minor adverse		Negligible to Minor adverse
	Grey seal and harbour seal	Low		Negligible adverse		Negligible adverse

12.6.1.8.4 Mitigation

531. No mitigation is required or proposed in relation to any changes in prey availability, however, the mitigation which will be outlined in both the Draft MMMP (Document Reference: 7.7) and Outline SIP (Document Reference: 7.8) to reduce the potential impacts of underwater noise for marine mammals, may also reduce the potential impacts of underwater noise on prey species.

532. No mitigation is required or proposed, other than the embedded mitigation for water quality as outlined in Table 12.2.

12.6.2 Likely effects during operation and maintenance

533. The potential impacts during O&M that have been assessed for marine mammals are:

- Impact 1: Impacts from underwater noise resulting from operational WTGs;
    - Impact 1a: Permanent auditory injury (PTS).
    - Impact 1b: Temporary auditory injury (TTS).
    - Impact 1c: Disturbance.
- Impact 2: Auditory injury and disturbance or behavioural impacts resulting from underwater noise during maintenance activities, including cable protection and cable reburial;
    - Impact 2a: Permanent auditory injury (PTS).
    - Impact 2b: Temporary auditory injury (TTS).
    - Impact 2c: Disturbance.
- Impacts resulting from the deployment of O&M vessels:
    - Impact 3: Underwater noise and disturbance from O&M vessels;
        - Impact 3a: Permanent auditory injury (PTS).
        - Impact 3b: Temporary auditory injury (TTS).
        - Impact 3c: Disturbance.
    - Impact 5: Vessel interaction (collision risk).
- Impact 4: Barrier effects as a result of underwater noise during O&M;
- Impact 6: Disturbance at seal haul-out sites;
- Impact 7: Changes to water quality; and
- Impact 8: Changes to prey resource.

534. The realistic worst case scenario on which the assessments are based is outlined in Table 12.1.

12.6.2.1 Impact 1: Impacts from underwater noise associated with operational WTGs

535. The operational WTGs will work nearly continuously, except for occasional shutdowns for maintenance or severe weather. The North Falls indicative design life is 30 years. Therefore, there is concern that underwater noise from operational WTGs could contribute a consistent, long duration of sound to the marine environment. However, the underwater noise levels emitted during the operation of the turbines are low and not expected to cause physiological injury to marine mammals, but could cause behavioural reactions if the animals are in the immediate vicinity of the WTG (Tougaard et al., 2009a; Sigray and Andersson, 2011).

536. The main sources of sound generated during the operation of WTGs are aerodynamic and mechanical. The mechanical noise is from the nacelle at the top of the tower. As the WTG blades rotate, generated vibrations travel down the tower into the foundation and radiate into the surrounding water column and seabed (Tougaard et al., 2009a; 2020; Nedwell *et al.,* 2003). The resulting sound is described as continuous and non-impulsive and is characterized by one or more tonal components that are typically at frequencies below 1kHz. The frequency content of the tonal signals is determined by the mechanical properties of the wind turbine and does not change with wind speed (Madsen *et al.,* 2006). Noise levels generated above the water surface are low enough

that no significant airborne sound will pass from the air to the water (e.g., Godin, 2008).

537. Measurements made at three different WTGs in Denmark and Sweden at ranges between 14m and 40m from the foundations found that the sound generated due to WTG operation was only detectable over underwater ambient noise at frequencies below 500Hz (Tougaard *et al.,* 2009a).

538. Tougaard *et al.* (2020) reviewed the available measurements of underwater noise from different WTGs during operation and found that source levels were at least 10–20dB lower than ship noise in the same frequency range. A simple multi-turbine model indicated that cumulative noise levels could be elevated up to a few kilometres from a wind farm under very low ambient noise conditions. However, the noise levels were well below ambient levels unless very close to the individual WTGs in locations with high ambient noise from shipping or high wind speeds (Tougaard et al., 2020).

539. There is the potential for proposed larger WTGs to have greater noise levels compared to smaller WTGs currently in operation (Stöber and Thomsen, 2021). This increase in size of operational WTGs at North Falls has been taken into account in the underwater noise modelling (see Appendix 12.3 (Document Reference: 3.3.8)). However, the shift from using gear boxes to direct drive technology is expected to reduce the sound level by 10dB (Stöber and Thomsen, 2021).

540. As outlined in Appendix 12.3 (Document Reference: 3.3.8), noise measurements made at operational wind farms have demonstrated that the operational noise produced was at such a low level that it was difficult to measure relative to background noise at distances of a few hundred metres.

12.6.2.1.1 Underwater noise modelling

541. Underwater noise modelling was undertaken by Subacoustech Environmental Ltd to estimate the noise levels likely to arise during the operational phase (Appendix 12.3 (Document Reference: 3.3.8)),and determine the potential impacts on marine mammals. Key information on the methodology of underwater noise modelling, and the full results of the assessments for marine mammals, is provided in Appendix 12.4 (Document Reference: 3.3.9)).

12.6.2.1.2 Impact 1a: Permanent auditory injury (PTS) due to operational wind turbine noise

Sensitivity of marine mammals

542. Marine mammals are all assessed as having a high sensitivity to the potential for PTS as outlined in Section 12.6.1.1.2.

Magnitude of impact

PTS due to operational wind turbine noise (single WTG)

543. The full underwater noise modelling results are provided in Appendix 12.4 (Document Reference: 3.3.9) for the potential for PTS from the cumulative exposure of operational WTGs.

544. The reported PTS onset range of less than 100m is likely an overestimation, as the modelling does not provide exact ranges at less than 100m. The TTS modelling results also show an effect range of 100m, indicating that the actual potential PTS ranges would be much lower than the reported 100m. Therefore, the potential for any PTS effect is expected to be present in localised areas

only, and is assigned a magnitude level of negligible for all marine mammal species.

545. Table 12.74 presents the underwater noise modelling results for the predicted impact ranges and areas for PTS from the cumulative exposure of operational WTGs. For SEL$_{cum}$ calculations, the duration of the noise is also considered, with operating WTGs for a worst case of 24-hours in a day.

546. The results of the underwater noise modelling do not define impact ranges of less than 100m, and therefore, where the impact ranges are less than that, the results show impact ranges of <100m. The reported PTS onset range of less than 100m is likely an overestimation, as the modelling does not provide exact ranges at less than 100m. The TTS modelling results also show an effect range of 100m, indicating that the actual potential PTS ranges would be much lower than the reported 100m. Therefore, the potential for any PTS effect is expected to be present in localised areas only, and is assigned a magnitude level of negligible for all marine mammal species.

Table 12.74 The predicted impact ranges for cumulative PTS due to operational WTGs in all marine mammal species

Marine mammal species	Potential impact ranges (and areas) for PTS
Harbour porpoise	<100m (0.031km^2)
Minke whale	<100m (0.031km^2)
Grey seal	<100m (0.031km^2)
Harbour seal	

** impact areas are based on the area of a circle, with the impact range as the radius*

547. The significance of effect assessment for permanent auditory injury due to multiple operational WTGs is provided in Section 12.6.2.1.5, within the summary Table 12.79.

12.6.2.1.3 Impact 1b: Temporary auditory injury (TTS) due to operational wind turbine noise

Sensitivity of marine mammals

548. As outlined in Section 12.6.1.1.2, the sensitivity of marine mammals to TTS as a result of underwater noise due to operational WTGs is considered to be medium.

Magnitude of impact

TTS due to operational wind turbine noise (single WTG)

549. The full underwater noise modelling results and assessments are provided in Appendix 12.4 (Document Reference: 3.3.9) for the potential for TTS from the cumulative exposure of operational WTGs.

550. Table 12.75 presents the underwater noise modelling results for the predicted impact ranges and areas for TTS from the cumulative exposure of operational WTGs. For SEL$_{cum}$ calculations, the duration of the noise is also considered, with operational noise for a worst case of 24-hours in a day.

551. The results of the underwater noise modelling do not define impact ranges of <100m, and therefore, where the impact ranges are less than that, the results show impact ranges of <100m (it is possible that the actual impact ranges are therefore considerably lower).

552. It should be noted that the predicted impact ranges are the distances which represent the TTS 'onset' stage, which is the minimum exposure that could potentially lead to the start of an impact and may only be marginal. In most hearing groups, the noise levels are low enough that there is negligible risk.

Table 12.75 The predicted impact ranges for cumulative TTS for operational WTGs in all marine mammal species

Marine mammal species	Potential impact ranges (and areas) for TTS
Harbour porpoise	<100m (0.031km^2)
Minke whale	<100m (0.031km^2)
Grey seal	<100m (0.031km^2)
Harbour seal	

** impact areas are based on the area of a circle, with the impact range as the radius*

553. An assessment of the maximum number of individuals that could be at risk of TTS, due to a single operational WTG, is presented in Table 12.76, based on the impact areas as presented in Table 12.75. An assessment against all marine mammal densities is provided in Appendix 12.4 (Document Reference: 3.3.9), including the annual and summer seasonal density for harbour porpoise.

554. The magnitude of impact is assessed as negligible for all species for the potential long-term impact (Table 12.76).

Table 12.76 Assessment of the potential for TTS due to one operational WTG (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Marine mammal species	Assessment of impact	Magnitude of impact
Harbour porpoise	0.1 harbour porpoise (0.00003% of the NS MU reference population), based on the HiDef winter density estimate.	Negligible
Minke whale	0.0005 minke whale (0.00000002% of the CGNS MU reference population).	Negligible
Grey seal	0.002 grey seal (0.000007% of the SE England MU reference population, or 0.000004% of the wider reference population reference population).	Negligible
Harbour seal	0.00002 harbour seal (0.0000003% of the SE England MU reference population).	Negligible

555. The significance of effect assessment for temporary auditory injury due to a single operational WTG is provided in Section 12.6.2.1.5, within the summary Table 12.79.

TTS due to operational wind turbine noise (multiple WTGs)

556. More than one WTG will be operating at the same time, and therefore an assessment of the potential for auditory injury, due to all operational WTGs, is required. As for the potential for PTS from multiple WTGs, the potential auditory impact ranges are the same for the range of WTGs included in the North Falls design envelope, and therefore the worst case would be for a total of 57 operational WTGs.

557. Table 12.77 presents the potential areas of TTS for all operational WTGs (57 WTGs (57 x 0.031km^2 = 1.79km^2)).

Table 12.77 The predicted impact areas for cumulative TTS, due to all operational WTGs for all marine mammal species

<table>
<tr><th>Marine mammal species</th><th>Potential impact areas for TTS</th></tr>
<tr><td>Harbour porpoise</td><td>1.79km^2</td></tr>
<tr><td>Minke whale</td><td>1.79km^2</td></tr>
<tr><td>Grey seal</td><td rowspan="2">1.79km^2</td></tr>
<tr><td>Harbour seal</td></tr>
</table>

558. An assessment of the maximum number of individuals that could be at risk of TTS, due to the underwater noise associated with all operational WTGs is presented in Table 12.78, based on the impact areas as presented in Table 12.78. An assessment against all marine mammal densities is provided in Appendix 12.4 (Document Reference: 3.3.9), including the annual and summer seasonal density for harbour porpoise.

559. The magnitude of impact is assessed as negligible for harbour porpoise, minke whale, grey seal and harbour seal, for the potential long-term impact. As noted above, the potential TTS impact ranges are significantly lower than the turbine spacing, and therefore there is no potential for an overlap in impact areas.

Table 12.78 Assessment of the potential for TTS from all operational WTGs (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Marine mammal species	Assessment of impact	Magnitude of impact
Harbour porpoise	6 harbour porpoise (0.002% of the NS MU reference population), based on the HiDef winter density estimate.	Negligible
Minke whale	0.03 minke whale (0.0001% of the CGNS MU reference population).	Negligible
Grey seal	0.1 grey seal (0.0004% of the SE England MU reference population, or 0.0002% of the wider reference population).	Negligible
Harbour seal	0.0009 harbour seal (0.00002% of the SE England MU reference population).	Negligible

560. The significance of effect assessment for temporary auditory injury due to multiple operational WTGs is provided in Section 12.6.2.1.5, within the summary Table 12.79.

12.6.2.1.4 Impact 1c: Disturbance effects due to operational wind turbine noise

Sensitivity of marine mammals

561. Currently available data indicates that there is no lasting disturbance or exclusion of harbour porpoise or seals around OWF sites during operation (Diederichs et al., 2008; Lindeboom et al., 2011; Marine Scotland, 2012; McConnell et al., 2012; Russell et al., 2014; Scheidat et al., 2011; Teilmann et al., 2006; Tougaard et al., 2005, 2009a, 2009b). Data collected suggests that any behavioural responses for harbour porpoise and seal may only occur up to a few hundred metres away (Tougaard et al., 2009b; McConnell et al., 2012).

562. Monitoring was carried out at the Horns Rev and Nysted OWFs in Denmark during the operation between 1999 and 2006 (Diederichs et al., 2008). Numbers of harbour porpoise within Horns Rev were slightly reduced compared to the wider area during the first two years of operation, however, it was not possible to conclude that the OWF was solely responsible for this change in abundance

without analysing other dynamic environmental variables (Tougaard et al., 2009a). Later studies by Diederichs et al. (2008) recorded no noticeable impact on the abundances of harbour porpoise at varying wind velocities at both of the OWFs studied, following two years of operation.

563. Monitoring studies at Nysted and Rødsand have also indicated that operational activities have had no impact on regional seal populations (Teilmann et al., 2006; McConnell et al., 2012). Tagged harbour seals have been recorded within two operational OWF sites (Alpha Ventus in Germany and Sheringham Shoal in UK) with the movement of several of the seals suggesting foraging behaviour around WTGs (Russell et al., 2014).

564. Both harbour porpoise and seals have been shown to forage within operational OWFs (e.g., Lindeboom *et al.,* 2011; Russell et *al.,* 2014), indicating no restriction to movements in operational OWF sites.

565. Within the site-specific aerial surveys, a buffer of 4km was applied to the array area, which resulted in a proportion of the aerial survey area including the operational OWFs of both Galloper and Greater Gabbard (Figure 12.1.1 in Appendix 12.2 (Document Reference: 3.3.7)). The resultant density maps for harbour porpoise show a difference in distributions in some survey months, between the North Falls site and the existing wind farms sites within the survey buffer (e.g., February 2020), while other months show no difference (e.g., November 2020) (see Appendix 12.2, (Document Reference: 3.3.7)). It is noted, however that the aerial survey was not designed to provide information and data for this purpose, and therefore the ability to use it to inform such as assessment may be limited.

566. Modelling of noise impacts of operational OWFs suggest that harbour seals and grey seals are not considered to be at risk of displacement (Marmo *et al.,* 2013).

567. As a precautionary approach, harbour porpoise, grey seal and harbour seal are likely to have low sensitivity (rather than negligible) to disturbance from underwater noise as a result of operational WTGs.

568. Taking into account that minke whales are more sensitive to low frequency noise, it is probable that they could be more sensitive to operational wind turbine noise (Marmo et al., 2013). Therefore, as a precautionary approach minke whale are classed as having medium sensitivity.

569. Marine mammals within the potential disturbance area are considered to have limited capacity to avoid such impacts, although any disturbance to marine mammals would be temporary and they would be expected to return to the area once the disturbance had ceased or they had become habituated to the sound.

Magnitude of impact

570. If the response is displacement from the area any impacts from underwater noise as a result of operational WTG noise will be localised. Therefore, there is unlikely to be the potential for any significant disturbance impact on marine mammals, with a magnitude of negligible.

571. There is limited data on the potential for a behavioural response or disturbance from operational WTG noise.

12.6.2.1.5 Significance of effect

572. The assessment for the potential effects of underwater noise associated with operational noise from WTGs is provided in Table 12.79, taking into account

the high marine mammal sensitivity for the potential of PTS, and medium for TTS and disturbance in minke whale, and low for disturbance from harbour porpoise, grey seal and harbour seal, and the potential magnitude of impact for operational WTGs, as presented in Table 12.76 and Table 12.78 for TTS.

573. The effect significance for permanent or temporary changes in hearing sensitivity (PTS / TTS) due to operational WTG noise has been assessed as minor adverse for all species (Table 12.79).

574. For the potential for disturbance due to operational WTGs, the effect significance has been assessed as negligible for harbour porpoise, grey seal and harbour seal, and as minor adverse minke whale (Table 12.79).

Table 12.79 Assessment of effect significance for the potential for disturbance due to operational WTGs

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual Effect
PTS due to operational WTGs, from either a single WTG or all WTGs					
Harbour porpoise, minke whale, grey seal and harbour seal	High	Negligible	Minor adverse	None required.	Minor adverse
TTS due to operational WTGs, from either a single WTG or all WTGs					
Harbour porpoise, minke whale, grey seal and harbour seal	Medium	Negligible	Minor adverse	None required.	Minor adverse
Disturbance due to operational WTGs, from either a single WTG or all WTGs					
Harbour porpoise, grey seal and harbour seal	Low	Negligible	Negligible	None required.	Negligible
Minke whale	Medium	Negligible	Minor adverse		Minor adverse

12.6.2.1.6 Mitigation

575. No mitigation is proposed for underwater noise from operational WTGs, as the risk of any effect is minor adverse or negligible.

12.6.2.2 Impact 2: Impacts from underwater noise associated with operation and maintenance activities

12.6.2.2.1 Sensitivity of marine mammals

576. As outlined in Section 12.6.1.2, the sensitivity of marine mammals to PTS as a result of underwater noise due to activities such as dredging, rock placement, trenching and cable installation, is high, and the sensitivity of marine mammals from the potential for TTS is medium.

577. Disturbance to marine mammals may occur as a result of displacement from vessel traffic and sources of noise, including those associated with operation and maintenance activities. As outlined in Section 12.6.1.1.4, the sensitivity of harbour porpoise and minke whale to disturbance is assessed as a precautionary medium. Grey seal and harbour seal are assessed as having a low sensitivity.

Magnitude of impact

578. The requirements for any potential operation and maintenance work, such as additional rock placement or cable re-burial, are currently unknown, however the work required, and associated impacts to marine mammals would be less than those during construction. Table 12.1 provides estimates (as outlined in ES Chapter 5 Project Description (Document Reference: 3.1.7)) for potential cable repairs and reburial during the operational period.

579. As outlined in Sections 12.6.1.2.2 and 337, the potential for PTS or TTS is only likely in very close proximity to cable laying or rock placement activities at the onset of any activity. Therefore, it is highly unlikely for there to be any PTS or TTS due to these activities.

580. The impacts from additional cable laying and protection are temporary in nature and will be limited to relatively short periods during the operation and maintenance phase. Disturbance responses are likely to occur at significantly shorter ranges than construction noise. Any disturbance is likely to be limited to the area in and around where the actual activity is taking place. The requirements for any potential maintenance work are currently unknown, however, the work required, and impacts associated with underwater noise and disturbance from activities during operation and maintenance would be less than those during construction. As there is expected to be less noisy activities during the operation phase than is required during construction, it is therefore likely to cause less disturbance to foraging behaviours in all species present in the study area.

581. Therefore, the magnitude of impact of underwater noise from operation and maintenance activities is considered to be the same or less than that as assessed for underwater noise from other construction activities (including rock placement, trenching and cable laying) (Section 12.6.1.2).

582. The magnitude for all marine mammal species is assessed as negligible for the potential for PTS, TTS, or disturbance from maintenance activities including rock placement, trenching and cable laying (Table 12.55).

12.6.2.2.2 Significance of effect

583. The assessment for the likely significant effects of underwater noise associated with operation and maintenance activities, including rock placement, trenching and cable laying, is provided in Table 12.80, taking into account the high marine mammal sensitivity for the potential of PTS, and medium for TTS and disturbance, and the potential magnitude of impact, as presented in Table 12.46 and Table 12.48 for PTS, Table 12.50 and Table 12.52 for TTS, and Table 12.53 and Table 12.54 for disturbance.

584. The effect significance for permanent or temporary changes in hearing sensitivity (PTS/TTS) due to these operational activities has been assessed as minor adverse for all species (Table 12.80).

585. For the potential of TTS, the effect significance has been assessed as minor adverse for all species (Table 12.80).

586. For the potential for disturbance due to operational activities, the effect significance has been assessed as minor adverse for all species (Table 12.80

587. The effect significance for the likely effects of disturbance to marine mammals foraging at sea associated with operational activities has been assessed as

minor adverse for harbour porpoise and minke whale, and negligible for grey seal and harbour seal (Table 12.80).

Table 12.80 Assessment of effect significance for the potential for underwater noise effects due to operational activities (rock placement, trenching and cable laying)

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual Effect
PTS due to maintenance activities					
Harbour porpoise, minke whale, grey seal and harbour seal	High	Negligible	Minor adverse	None required.	Minor adverse
TTS due to maintenance activities					
Harbour porpoise, minke whale, grey seal and harbour seal	Medium	Negligible	Minor adverse	None required.	Minor adverse
Disturbance due to maintenance activities					
Harbour porpoise and minke whale	Medium	Negligible	Minor adverse	None required.	Minor adverse
Grey seal and harbour seal	Low	Negligible	Negligible	None required.	Negligible
Reduction in foraging due to underwater noise disturbance					
Harbour porpoise and minke whale	Medium	Negligible	Minor adverse	None required.	Minor adverse
Grey seal and harbour seal	Low	Negligible	Negligible	None required.	Negligible

12.6.2.2.3 Mitigation

588. No mitigation is proposed for underwater noise from operation and maintenance activities, as the risk of any effect is minor adverse or negligible.

12.6.2.3 Impact 3: Impacts from underwater noise and disturbance associated with operation and maintenance vessels

12.6.2.3.1 Impact 3a: Auditory injury due to operation and maintenance vessels

Sensitivity of Marine Mammals

589. As outlined in Section 12.6.1.3, the sensitivity of harbour porpoise, minke whale, grey seal and harbour seal is high for the potential of PTS, and medium for the potential of TTS.

Magnitude of impact

590. As outlined in Section 12.6.1.2.2 and Section 337, the potential for PTS or TTS is only likely in very close proximity to vessels (<100m).

591. The specific requirements for any potential maintenance work are currently unknown, however the work required is likely to be similar to those activities assessed in Section 12.6.1.2 for construction. During operation, there may be up to 22 vessels in the North Falls project area at any one time, compared to the 35 vessels that would be on site during construction.

592. During the operation and maintenance of North Falls, there could be up to 1,222 vessel round-trips per year (approximately 3.35 two-way trips/ 6.7 one-way trips

per day), representing an increase of up to 4.6% compared to average daily vessels in summer, and up to 5% compared to the daily vessels in winter.

PTS due to operational related vessels (multiple vessels)

593. There is the potential that up to 22 vessels may be present in the North Falls site at any one time during operation. As a worst case scenario, an assessment for all 22 vessels has also been undertaken.

594. Table 12.81 presents the potential areas of PTS for the maximum construction vessels at any one time, of 22 vessels.

Table 12.81 The predicted impact areas for cumulative PTS, for multiple operation vessels for all marine mammal species

Marine mammal species	Potential impact areas for PTS
Harbour porpoise	0.7km^2
Minke whale	0.7km^2
Grey seal	0.7km^2
Harbour seal	

595. An assessment of the maximum number of individuals that could be at risk of PTS, due to the maximum number of operation vessels at any one time is presented in Table 12.82, based on the impact areas as outlined in Table 12.85. An assessment against all marine mammal densities is provided in Appendix 12.4 (Document Reference: 3.3.9), including the annual and summer seasonal density for harbour porpoise.

596. The magnitude of impact is assessed as negligible for all marine mammal species (Table 12.82).

Table 12.82 Assessment of the potential for PTS due to multiple operation vessels (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Marine mammal species	Assessment of impact	Magnitude of impact
Harbour porpoise	3 harbour porpoise (0.0007% of the NS MU reference population).	Negligible
Minke whale	0.01 minke whale (0.0001% of the CGNS MU reference population).	Negligible
Grey seal	0.1 grey seal (0.0004% of the SE MU reference population, or 0.0002% of the wider reference population), based on the density for the offshore cable corridor as a worst-case density estimate.	Negligible
Harbour seal	0.08 harbour seal (0.002% of the SE E MU reference population), based on the density for the offshore cable corridor as a worst-case density estimate.	Negligible

597. The significance of effect assessment for permanent auditory injury due to multiple vessels is provided in Section 12.6.2.3.3, within the summary Table 12.85.

TTS due to construction related vessels (multiple vessels)

598. There is the potential that up to 22 vessels may be present in the North Falls site at any one time during operation. As a worst case and unlikely scenario, an assessment for all 22 vessels has also been undertaken.

599. Table 12.83 presents the potential areas of TTS if all 22 vessels are operating at the same time.

Table 12.83 The predicted impact areas for cumulative TTS for multiple operation vessels for all marine mammal species

Marine mammal species	Potential impact areas for TTS
Harbour porpoise	2.8km^2
Minke whale	0.69km^2
Grey seal	0.69km^2
Harbour seal	

600. An assessment of the maximum number of individuals that could be at risk of TTS, due to the maximum of 22 operation vessels has been provided in Table 12.84 based on the impact areas as presented in Table 12.83. An assessment against all marine mammal densities is provided in Appendix 12.4 (Document Reference: 3.3.9), including the annual and summer seasonal density for harbour porpoise.

601. The magnitude of the potential impact is assessed as negligible for all species (Table 12.84).

Table 12.84 Assessment of the potential for TTS due to multiple operation vessels (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Marine mammal species	Assessment of impact	Magnitude of impact
Harbour porpoise	9 harbour porpoise (0.003% of the NS MU reference population).	Negligible
Minke whale	0.01 minke whale (0.0001% of the CGNS MU reference population).	Negligible
Grey seal	0.1 grey seal (0.0004% of the SE MU reference population), or 0.0002% of the wider reference population), based on the density for the offshore cable corridor as a worst-case density estimate.	Negligible
Harbour seal	0.08 harbour seal (0.002% of the SE E MU reference population), based on the density for the offshore cable corridor as a worst-case density estimate.	Negligible

602. The significance of effect assessment for temporary auditory injury due to multiple operation vessels is provided within the summary Table 12.85.

12.6.2.3.2 Impact 3b: Disturbance due to operation and maintenance vessels

Sensitivity of marine mammals

603. As outlined in Section 12.6.1.3.4, the sensitivity of harbour porpoise and minke whale to disturbance from vessel noise and presence is assessed as a medium. Grey seal and harbour seal have been assessed as having low sensitivity to disturbance from vessel noise.

Magnitude of impact

604. As outlined in Section 12.6.1.3.4, the potential for impacts from vessels associated with the wind farm is related to the type of vessel and proximity to marine mammal species.

605. The requirements for any potential maintenance work are currently unknown, however the work required, and impacts associated with underwater noise and

disturbance from vessels during operation and maintenance would be less than those during construction.

606. It is estimated that the maximum number of vessels that could be required on site at any one-time during operation and maintenance could be 22, which is less than the 35 vessels that could be on site during construction. However, as a precautionary approach the assessment for construction has been used for the operation and maintenance assessment, as a worst case scenario.

607. The magnitude for all marine mammal species due to disturbance is assessed as negligible (Section 12.6.1.3.4).

608. If the response is displacement from the area, it is predicted that marine mammals will return once the activity has been completed and therefore any impacts from underwater noise as a result of operation and maintenance activities will be both localised and temporary. Therefore, there is unlikely to be the potential for any significant disturbance effect on marine mammals.

12.6.2.3.3 Significance of effect

609. The assessment for the likely significant effects of underwater noise associated with vessels is provided in Table 12.85, taking into account the high marine mammal sensitivity for the potential of PTS, medium for TTS and disturbance (except for seal species, with a sensitivity of low for disturbance from vessels), and the potential magnitude of impact (i.e. number of individuals as a percentage of the reference population), as presented in Table 12.59 for PTS, and Table 12.63 for TTS.

610. The effect significance for a permanent or temporary change in hearing sensitivity (PTS/TTS) has been assessed as minor adverse for all species (Table 12.85).

611. For the potential for disturbance, the effect significance has been assessed as minor adverse for harbour porpoise and minke whale, and negligible for grey seal and harbour seal (Table 12.85).

Table 12.85 Assessment of effect significance for the potential for operation and maintenance vessels to impact marine mammals

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual Effect
PTS due to operation and maintenance vessels					
Harbour porpoise, minke whale, grey seal and harbour seal	High	Negligible	Minor adverse	Vessel good practice measures will be in place.	Minor adverse
TTS due to operation and maintenance vessels					
Harbour porpoise, minke whale, grey seal and harbour seal	Medium	Negligible	Minor adverse	None required, but vessel good practice measures be in place.	Minor adverse
Disturbance due to operation and maintenance vessels					
Harbour porpoise and minke whale	Medium	Negligible	Minor adverse	None required, but vessel good practice measures	Minor adverse
Grey seal and harbour seal	Low	Negligible	Negligible		Negligible

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual Effect
				would reduce disturbance.	

12.6.2.3.4 Mitigation

612. Vessel good practice measures (as outlined in Table 12.93) will be in place; vessel movements, where practicable, will be incorporated into recognised vessel routes and hence to areas where marine mammals are accustomed to vessels, in order to reduce any impacts, including increased disturbance. Further information can be found in Section 12.3.3 and in the Outline PEMP (Document Reference: 7.6), Appendix C Vessel Good Practice and Code of Conduct to Avoid Marine Mammal Collisions.

12.6.2.4 *Impact 4: Barrier effects from underwater noise during operation and maintenance*

613. As assessed in Section 561, the sensitivities were assessed as low for harbour porpoise and both seals and medium for minke whale. The magnitude for displacement as a result of underwater noise from operational turbines has been assessed as negligible for harbour porpoise, minke whale, grey seal and harbour seal. The effect significance is therefore negligible to minor adverse (not significant) for all species.

614. The indicative separation distance between turbines would be a minimum of 944m, depending on WTG size, therefore there would be no overlap in the potential impact range of <100m around each turbine and there would be adequate room for marine mammals to move through the wind farm array.

615. While seal species are known to transit along the coastline (as can be seen in Appendix 12.2 (Document Reference: 3.3.7), there would be sufficient room for them to swim through the array through the operational period. In addition, as noted in Section 561, harbour porpoise and seal species are known to be present and forage within operational wind farm areas, and therefore it is concluded that the presence of North Falls infrastructure would not form a barrier to any movement of marine mammal species.

616. Therefore, no barrier effects as a result of underwater noise during operation and maintenance are anticipated, and no further assessment is required.

12.6.2.5 *Impact 5: Increased risk of collision with vessels during operation*

12.6.2.5.1 Sensitivity of marine mammals

617. As outlined in Section 12.6.2.5, harbour porpoise, grey seal and harbour seal are considered to have a low sensitivity to the risk of a vessel collision, while minke have a sensitivity of medium, due to their lower ability to avoid collision with a vessel.

Magnitude of impact

618. While marine mammals are able to detect and avoid vessel collision, any such collision could be fatal (therefore a permanent impact). Therefore, the magnitude of impact is assessed based on the permanent magnitude definitions (Table 12.9).

619. It is estimated that the maximum number of vessels that could be required on site at any one-time during operation and maintenance could be up to 22, with the potential for up to 1,222 vessel round trips (or 2,444 transits) per year.

620. The number of marine mammals at risk of collision, per vessel, in UK waters, has been calculated as described for the construction phase (Section 12.6.1.5), and has been used to calculate the number of each marine mammal species at risk of collision from the total number of vessel movements per year that are currently expected during the operation and maintenance phase (Table 12.86). As discussed in Section 12.3.3, vessel movements, where practicable, will be incorporated into recognised vessel routes and hence to areas where marine mammals are accustomed to vessels, in order to reduce any increased collision risk.

621. In addition, vessel operators will use good practice to reduce any risk of collisions with marine mammals, such as reducing the speed of vessel transits wherever practicable.

622. As a result there is a low magnitude of impact due to the potential for increased collision risk during the operational period of North Falls, for harbour porpoise, minke whale and grey seal (due to less than 0.01% of the population affected), medium magnitude for harbour seal, prior to additional mitigation (based on more than 0.01% of the population affected).

Table 12.86 Predicted number of marine mammals at risk of collision with North Falls' operation and maintenance vessels, based on current UK collision rates and vessel presence (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Marine mammal species	Collision risk rate (number attributed to vessels strike / other physical trauma as proportion of total number necropsied)[18]	Estimated total number of individuals in UK waters[19]	Estimated number of individuals at risk within UK waters	Annual number of vessel transits in UK and RoI for 2015[20]	Number of marine mammals at risk of collision per vessel in UK waters	Number annual vessel trips associated through operation and maintenance phase	Additional marine mammals at risk due to increase in vessel number (collision rate * proportion vessel increase)	% reference population
Harbour porpoise	0.058 at risk of collision	159,632	9,318	3,852,030	0.003	2,444	Up to six at risk per year (n=5.9)	0.002%
Minke whale	0.057 at risk of collision	10,288	588	3,852,030	0.0002	2,444	Up to one at risk every two years (n=0.4)	0.002%
Grey seal	0.009 at risk of collision	162,000	1,379	3,852,030	0.0004	2,444	Up to one at risk every year (n=0.9)	0.003% SE MU population; or 0.002% wider reference population
Harbour seal	0.028 at risk of collision	42,900	1,192	3,852,030	0.0003	2,444	Up to one every year (n=0.8)	0.02% SE MU

[18] Where species specific data is not available, the species group data is used
[19] Based on the IAMMWG (2023) UK population estimates for cetacean species, SCOS (2022) UK population estimates for seal species
[20] Latest publicly available data, available from: https://www.data.gov.uk/dataset/963c1a7b-5b72-4cce-93f5-3f1e223fd575/anonymised-ais-derived-track-lines-2015

12.6.2.5.2 Significance of effect

623. Taking into account the low sensitivity for harbour porpoise, grey seal and harbour seal, and medium for minke whale, and the potential magnitude of impact, the significance for any increase in vessel collision risk during operation and maintenance has been assessed as minor adverse for harbour porpoise, minke whale, grey seal and harbour seal (Table 12.87). With management measures in place, the residual effect significance would be minor adverse.

Table 12.87 Assessment of effect significance for the potential of an increase in collision risk due to increased vessel presence during operation and maintenance

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual Effect
Harbour porpoise and grey seal	Low	Low	Negligible	Vessel good practice measures to manage collision risk.	Negligible
Minke whale	Medium	Low	Minor adverse		Minor adverse
Harbour seal	Low	Medium	Minor adverse		Minor adverse

12.6.2.5.3 Mitigation

624. Vessel good practice measures (as outlined in Table 12.93) will be in place to reduce any potential for vessel collision. Vessel movements, where practicable, would follow set vessel routes where available and hence areas where marine mammals are accustomed to vessels, in order to reduce any increased collision risk. Additionally, vessel operators would use good practice to reduce any risk of collisions with marine mammals. These measures are detailed within the Outline PEMP (Document Reference: 7.6).

12.6.2.6 Impact 6: Disturbance at seal haul-out sites during operation and maintenance

12.6.2.6.1 Sensitivity of marine mammals

625. As outlined in Section 12.6.1.6.1, the sensitivity of grey seal and harbour seal to disturbance at haul-out sites is assessed as a precautionary medium.

Magnitude of impact

626. As outlined in Section 12.6.2.2.3, the potential for disturbance from activities associated with the wind farm is related to noise, increases in vessel activity, type of vessel and proximity to haul-out sites.

627. The requirements for any potential maintenance work are currently unknown, however, the work required, and impacts associated with underwater noise and disturbance from vessels during operation and maintenance would be less than those during construction.

628. It is estimated that the maximum number of vessels that could be required on site at any one-time during operation and maintenance could be 22, which is less than the 35 vessels that could be on site during construction. As discussed in Section 12.6.1.3, surveys found that up to 147 vessels are in the study area during summer as a baseline, and seals can become habituated to vessels in areas of high vessel traffic, therefore the additional presence of operation and maintenance vessels is unlikely to cause disturbance events.

629. In addition, the closest haul-out site to either the cable corridor or array area is located 11km away (Hamford Water), and noise-related disturbance from operation/maintenance activities are unlikely to have an impact at this range.

630. The magnitude for grey seal and harbour seal is assessed as negligible based on maximum impact areas for all vessels and potential noise disturbances from operation and maintenance.

12.6.2.6.2 Significance of effect

631. The assessment for the potential effects of disturbance at seal haul-out sites associated with operational activities is provided in Table 12.88, taking into account the medium sensitivity for grey seal and harbour seal, and a negligible magnitude.

632. The effect significance has been assessed as minor adverse for grey seal and harbour seal.

Table 12.88 Assessment of effect significance for the potential for disturbance at seal haul-out sites during operation

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual effect
Grey seal and harbour seal	Medium	Negligible	Minor adverse	None required, but vessel good practice measures will be in place.	Minor adverse

12.6.2.6.3 Mitigation

633. Vessel good practice measures (as outlined in Table 12.93) will be in place to reduce any potential for disturbance to seals at haul-out sites. Vessel movements, where practicable, will be incorporated into recognised vessel routes (including those already used for the OWFs in the area) and hence to areas where marine mammals are accustomed to vessels.

634. In addition, vessel operators will use good practice to reduce any risk of collisions with marine mammals, such as reducing the speed of vessel transits wherever practicable, and not transiting close to seal haul-out sites. Further information can be found in the Draft MMMP (Document Reference: 7.7) and Outline PEMP (Document Reference: 7.6).

12.6.2.7 Impact 7: Changes to water quality

635. As outlined in ES Chapter 9 Marine Water and Sediment Quality (Document Reference: 3.1.11), potential changes in water quality during operation could occur through:

- Deterioration in water quality due to increases in suspended sediment associated with cable repairs / reburial; and
- Deterioration in water quality associated with release of sediment bound contaminants during maintenance activities.

636. The potential for accidental pollution has not been assessed within ES Chapter 9 Marine Water and Sediment Quality (Document Reference: 3.1.11) due to the commitments made by North Falls.

12.6.2.7.1 Sensitivity of marine mammals

637. As stated in Section 12.6.1.7.1, harbour porpoise, minke whale, grey seal and harbour seal have negligible sensitivity to increases in suspended sediments, and to any direct impacts from contaminated sediment.

Magnitude of impact

638. The magnitude for the potential changes in water quality has been based on the assessments in ES Chapter 9 Marine Water and Sediment Quality (Document Reference: 3.1.11) (Table 12.89).

Table 12.89 Magnitude of potential changes in water quality during operation, based on assessments in ES Chapter 9 Marine Water and Sediment Quality

Potential water quality impact	Magnitude as assessed in Chapter 9 (Document Reference: 3.1.11)	Embedded mitigation
Deterioration in water quality due to increases in suspended sediment associated with cable repairs / reburial	Negligible (effect significance of negligible).	Micro-siting will be used where practicable to reduce the requirements for seabed preparation prior to foundation and cable installation.
Deterioration in water quality associated with release of sediment bound contaminants during maintenance activities.	Negligible (effect significance of negligible).	None.

12.6.2.7.2 Significance of effect

639. Taking into account the negligible marine mammal sensitivity, and the potential magnitude of impact of negligible (Table 12.89), the significance for any effect of the change in water quality for marine mammals has been assessed as negligible adverse for all species (Table 12.90).

Table 12.90 Assessment of effect significance for the potential of indirect effects to marine mammals through changes to water quality during operation

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual effect
Harbour porpoise, minke whale, grey seal and harbour seal	Negligible	Negligible	Negligible	None required.	Negligible

12.6.2.7.3 Mitigation

640. No mitigation is required or proposed, other than the embedded mitigation for water quality as outlined in Table 12.89.

12.6.2.8 Impact 8: Changes to prey resources

641. Potential impacts to prey species (as assessed in ES Chapter 11 Fish and Shellfish Ecology (Document Reference: 3.1.13), include;

- Physical disturbance and temporary habitat loss
- Long-term habitat loss
- Increased suspended sediments and sediment deposition
- Re-mobilisation of contaminated sediment
- Underwater noise and vibration
- Introduction of hard substrate
- Electromagnetic fields (EMF)
- Changes in fishing activity

642. ES Chapter 11 Fish and Shellfish Ecology (Document Reference: 3.1.13) provides an assessment of these impact pathways on the relevant fish and shellfish species. As noted in Section 12.6.1.7.3, any reductions in prey availability would be small scale, localised and temporary, and it is considered highly unlikely that potential reductions in prey availability as a result of construction activities at North Falls would result in detectable changes to marine mammal populations.

12.6.2.8.1 Sensitivity of marine mammals

643. As outlined in Section 12.6.1.8.1 harbour porpoise and minke whale are considered to have low to medium sensitivity, whereas grey and harbour seal have a low sensitivity to changes in prey resources.

12.6.2.8.2 Magnitude of impact

Physical disturbance and temporary habitat loss

644. The impacts from planned maintenance and repair works during the operational phase would be temporary, localised and small scale and overall there would be less impact on fish and shellfish receptors than during construction (see Section 12.6.1.7.3).

645. Given the small area of disturbance, the generally wide distribution ranges (or no direct overlap of habitats with North Falls) of fish and shellfish species, and that the seabed is anticipated to quickly recover to its original condition the magnitude of impact of physical disturbance/temporary habitat loss to fish and shellfish receptors during the operational phase is considered to be negligible.

Long-term habitat loss

646. Habitat loss will occur during the lifetime of North Falls as a result of structures, scour protection and external cable protection installed on the sea bed. The introduction of hard substrate, such as WTG and OSP/OCP foundations and associated scour protection and cable protection would increase habitat heterogeneity through the introduction of hard structures in an area predominantly characterised by sediment habitats. At North Falls, the estimated total permanent habitat loss would be up to 6.69km2 for the array area and 0.15km2 for the offshore cable corridor.

647. Overall, due to the presence of comparable habitats identified throughout the North Falls offshore project area and the wider region, as demonstrated by survey data from Hornsea Project Four OWF, Greater Gabbard OWF and EUSeaMap (2021) habitat types European nature information system (EUNIS) 2019 classification maps (European Marine Observation and Data Network; EMODnet, 2023) and the localised spatial extent of impacts, the magnitude of impact of permanent habitat loss is considered to be negligible.

Increased suspended sediments and sediment deposition

648. Increases in SSC within the water column and subsequent deposition onto the seabed may occur as a result of operation and maintenance activities. Disturbance caused by jack up vessel legs or anchors, as well as cable reburial and/or repair may result in small volumes of sediment being re-suspended. However, the volumes of sediment disturbed from such activities, as well as the overall duration of the disturbance, would be significantly less compared to construction.

649. Cable repairs or replacements will only be carried out infrequently, four offshore export repairs (69,120m3) and five array/platform interconnector cable repairs

(86,400m3) are estimated over the project life removing up to 600m sections of cable each time (24m disturbance width and average 1.2m depth).

650. For reburial, there may be up to 2,75% of the array cable length and platform interconnector cable length and 4% of the offshore export cable length requiring reburial over the project life. Considering 24m disturbance width and average 1.2m depth, this would result in a volume of suspended sediments during reburial of 134,640m3 for array cable, 15,840m3 for platform interconnector cables and 144,460.8m3 for offshore export cables throughout the life of the Project.

651. Prevailing hydrodynamic conditions allow the magnitude to remain negligible during O&M. Any increases in SSC would be temporary, localised and small scale. This would have negligible significance for most fish species (and minor significance for Downs herring and sandeels) and therefore the effect significance would be negligible for marine mammals.

Re-mobilisation of contaminated sediment

652. During the operational phase of North Falls, activities such as export cable repairs and reburial and WTG repairs have the potential to disturb contaminated sediment and re-mobilise it back into the water column. Any impacts from the remobilisation of contaminated sediments and sediment redeposition are likely to be less than during the construction phase. The contamination levels align with typical regional levels and are of negligible magnitude.

653. The impact arising from remobilisation of contaminated sediments is considered to be negligible for prey species and marine mammals.

Underwater noise and vibration

654. Sources of underwater noise during operation and maintenance include, operational wind turbines, maintenance activities, such as cable repairs, replacement and protection, and vessels. A full assessment of underwater noise from these sources can be found in Appendix 12.3 (Document: Reference 3.3.8).

655. The underwater noise modelling results indicate that impact ranges associated with operational noise from wind turbines would be very small (i.e., <50m in respect of fish for recoverable injury/TTS) as well as the anticipated noise of associated O&M vessels servicing the project (see ES Chapter 13 Offshore Ornithology (Document Reference: 3.1.15)). Based on this, the O&M activities would be of localised disturbance and be of a low magnitude of impact to prey species.

Introduction of hard substrate

656. The introduction of various man-made structures such as foundations and scour protection in soft sediment areas increases and changes habitat availability and type, resulting in locally altered biodiversity as species are able to establish and thrive in previously hostile environments (Wilhelmsson et al., 2006; Birchenough and Degraer, 2020). Physical structures provide a foundation for settling invertebrates, which increase the organic matter surrounding the structure, and underpin artificial reef ecosystems through ‘bottom-up’ control of productivity. Increasing nutrient availability and biomass presents opportunities for all fish and shellfish species, from top predators to detritivores (Raoux et al., 2017). The overall magnitude is considered low for prey species.

657. The increase in fish presence around the physical structures through the operation and maintenance phase could result in an indirect beneficial impact to marine mammal species, through the improvement of the quality of prey species in the area.

658. The benefit of this potential increase in prey availability to marine mammals has not yet been studied widely. However, the presence of an artificial reef does increase the abundance and biomass of species, and the increase in prey species availability increases the attractiveness of the area to predators (Devault et al., 2017; Paxton et al., 2022).

659. Seal species in particular have been shown to forage actively around submerged pipelines and wind turbine structures within a year of their construction (Russel et al., 2014; Arnould et al., 2015). A study of the use of marine structures in the North Sea by marine mammal species indicates that the structures are visited commonly by a range of species, including minke whale, harbour porpoise, grey seal, and harbour seal (Delefosse et al., 2018). Note that this study uses incidental sightings only, and therefore no firm conclusions can be drawn from the use of the structures by marine mammals in comparison to the wider area.

660. While there is potential for a benefit to marine mammals through the improvement in the quality of prey, the impact of this on marine mammal species is not well understood. The magnitude is therefore assessed as negligible (beneficial), although this is considered uncertain due to the current lack of scientific knowledge on the subject.

Electromagnetic fields

661. EMF occurs as a result of electricity transmission through conductive objects, such as transmission cables, and comprises an electric field (E field) and a magnetic field (B field). The electromagnetic attributes of EMFs have the potential to disrupt organs used for navigation and foraging within a number of fish species. EMFs can have attractive and repulsive impacts, that can cause barrier effects dependent on the species and the spatial scale of EMF, for further information, see ES Chapter 11 Fish and Shellfish Ecology (Document Reference: 3.3.13).

662. The greatest magnitude of impact will be in direct contact with cables within the water column. The cables interacting with the seabed will be buried, either within the seabed or under rock protection, resulting in a negligible impact for fish and shellfish. Therefore, the magnitude of EMF is considered low.

Changes in fishing activity

663. The Project infrastructure could result in changes to fishing activity within North Falls but also in the wider area (i.e., due to displacement of fishing activity into other areas). The maximum design scenario for reduced fishing activity in North Falls assumes no restrictions to fishing within the array area (except for advisory safety zones around the WTGs) or the offshore cable corridor during the design life, however, trawling activity may potentially be reduced within the array area.

664. Commercial species of importance include sole, whelk, bass, thornback ray, horse mackerel, herring, cod, plaice, lobster and crab which are targeted across the southern North Sea area and therefore the offshore project would only account for a small area. The magnitude of impact to prey species is assessed as low. The prey species preferred by the marine mammals assessed in this

chapter are typically highly mobile, so any reduction in fishing activity would be most beneficial to demersal fish species and shellfish.

Summary of magnitudes of impact

665. The magnitude for the potential changes in prey resource has been based on the assessments in ES Chapter 11 Fish and Shellfish Ecology (Volume I). The magnitude of impact to marine mammal species is based on the magnitude of impact to prey species, although it should be noted that this is a precautionary approach as marine mammals are generally opportunistic foragers, and would be able to prey upon a range of other species.

Table 12.91 Magnitude of potential changes to prey resources during operation, based on assessments in ES Chapter 11 Fish and Shellfish Ecology (Volume I)

Potential impact to prey changes	Magnitude as assessed in ES Chapter 11 (Volume I)	Embedded mitigation
Physical disturbance and temporary habitat loss	Negligible (effect significance of minor to negligible)*	Cables will be buried where practicable, minimising the requirement for cable protection measures and thus the amount of hard substrate which may be required and associated potential changes to seabed habitat.
Long-term habitat loss	Negligible (effect significance of minor to negligible)*	
Increased suspended sediments and sediment deposition	Negligible (effect significance of minor to negligible)*	
Re-mobilisation of contaminated sediment	Negligible (effect significance of negligible)	None required
Underwater noise and vibration	Low (effect significance of minor to negligible)	None required
Introduction of hard substrate	Negligible (effect significance of negligible)	None required
EMF	Low (effect significance of negligible)	None required
Changes in fishing activity	Low (effect significance of negligible)	None required

**Note: Downs and Blackwater herring and sandeels were assessed separately to determine the sensitivity of each receptor (with an effect significance of minor). However, marine mammals forage on various other fish species, not specifically herring and sandeels, therefore the magnitude for this assessment is considered negligible.*

12.6.2.8.3 Significance of effect

666. Table 12.92 summarises the significance of effect for changes to prey availability during the O&M stage of the offshore project. The conclusion is an effect significance of negligible adverse for grey and harbour seal and negligible to minor adverse for harbour porpoise and minke whale. The effect on prey resource due to the introduction of hard substrate is a negligible beneficial effect.

Table 12.92 Assessment of effect significance for the potential of indirect effects to marine mammals through changes to prey resources during operation

Potential impact	Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual effect
Physical disturbance and temporary habitat loss Increased suspended sediments and sediment deposition Re-mobilisation of contaminated sediment	Harbour porpoise and minke whale	Low to medium	Negligible	Negligible to Minor adverse	None required	Negligible to Minor adverse
	Grey and harbour seal	Low		Negligible adverse		Negligible adverse
Long-term habitat loss	Harbour porpoise and minke whale	Low to medium	Negligible to low	Negligible to Minor adverse		Negligible to Minor adverse
	Grey and harbour seal	Low		Negligible adverse		Negligible adverse
Underwater noise and vibration EMF Changes in fishing activity	Harbour porpoise and minke whale	Low to medium	Low	Negligible to Minor adverse		Negligible to Minor adverse
	Grey and harbour seal	Low		Negligible adverse		Negligible adverse
Introduction of hard substrate	Harbour porpoise and minke whale	Low to medium	Negligible (beneficial)	Negligible to Minor beneficial		Negligible to Minor beneficial
	Grey and harbour seal	Low		Negligible beneficial		Negligible beneficial

12.6.2.8.4 Mitigation

667. Given the assessment of minor adverse (Table 12.92), no further mitigation is proposed or required.

12.6.3 Likely effect during decommissioning

668. The scope of the decommissioning works would most likely involve the removal of the accessible installed components. This is outlined in ES Chapter 5 Project Description (Volume I) and the detail would be agreed with the relevant authorities at the time of decommissioning. Offshore, this is likely to include removal of all the wind turbine elements and part of the foundations (those above seabed level). Cables, cable protection and scour protection would likely be left in situ. The potential impacts during decommissioning that will be assessed for marine mammals include:

- Impact 1: Underwater noise and disturbance from decommissioning activities;
- Impact 2: Underwater noise and disturbance from vessels;
- Impact 3: Barrier effects as a result of underwater noise;
- Impact 4: Increased collision risk with vessels;
- Impact 5: Disturbance at seal haul-out sites;
- Impact 6: Changes to water quality; and
- Impact 7: Changes to prey resource.

669. A detailed decommissioning programme will be provided to and approved by the Secretary of State for the Department for Energy Security and Net Zero (DESNZ) that will give details of the techniques to be employed and any relevant mitigation required.

670. It expected that the activity levels will be comparable to construction (with the exception of pile driving noise which would not occur).

671. An indication of the likely significant effects on marine mammals during decommissioning is provided below.

12.6.3.1 Impact 1: Underwater noise and disturbance from decommissioning activities

672. Underwater noise and disturbance from decommissioning works are expected to be less than that for construction activities due to there being no pile driving, and therefore would be of a reduced magnitude.

673. Underwater noise and disturbance would primarily arise from pile cutting and infrastructure removal; similar in underwater noise levels to that of other construction activities.

12.6.3.1.1 Indicative significance of effect

674. Based on the assessment undertaken for other construction activities (Section 12.6.1.2), the worst case sensitivity of marine mammal receptors for similar activities would be high, medium, or low to medium (for PTS, TTS, and disturbance respectively), and the magnitude of the impact is assessed as

negligible in all cases. This would result in a negligible to minor adverse effect, which is not significant in EIA terms.

12.6.3.2 Impact 2: Underwater noise and disturbance from vessels

675. The amount of vessels required are expected to be similar or less than that required during the construction phase. Underwater noise and disturbance from decommissioning vessels are expected to be the same or less than as for construction activities, and therefore would be of a reduced magnitude. Indicative significance of effect

12.6.3.2.1 Indicative significance of effect

676. Based on the assessment undertaken for construction vessels (Section 12.6.1.3), the worst case sensitivity of marine mammal receptors would be high, medium, or low to medium (for PTS, TTS, and disturbance respectively), and the magnitude of the impact would be negligible to low. This would result in a minor adverse effect in all cases, with the exception of the potential for PTS onset in harbour porpoise as a result of multiple vessels present at the same time, with an effect significance of moderate adverse.

677. Therefore, it is expected that vessel good practice measures, as described in Table 12.93, would be in place throughout the decommissioning phases, in line with construction and O&M. Taking into account this additional mitigation, the overall effect significance would be minor adverse in all cases, which is not significant in EIA terms.

12.6.3.3 Impact 3: Barrier effects as a result of underwater noise

678. Underwater noise from decommissioning works are expected to be less than that for construction activities (Section 12.6.1.4) due to there being no pile driving, and therefore would be of a reduced magnitude.

679. Underwater noise would primarily arise from pile cutting and infrastructure removal, as well as vessel activity. Therefore, the potential for barrier effects to occur due to decommissioning underwater noise are expected to be of a similar or reduced level than that during other construction activities and vessels.

12.6.3.3.1 Indicative significance of effect

680. Based on the assessment undertaken for construction, the worst case sensitivity for harbour porpoise and minke whale is medium and is low for both seals, and the magnitude for all species is negligible. This would result in a negligible to minor adverse effect, which is not significant in EIA terms.

12.6.3.4 Impact 4: Increased collision risk with vessels

681. The amount of vessels required are expected to be similar or less than that required during the construction phase. Therefore, collision risks from decommissioning vessels are expected to be similar or less than that for construction activities.

12.6.3.4.1 Indicative significance of effect

682. Based on the assessment undertaken for construction (Section 12.6.1.5), the worst case sensitivity for harbour porpoise, grey and harbour seal is low and is medium for minke whale. The magnitude for harbour porpoise, minke whale and grey seal is low, and is medium for harbour seal. This would result in a negligible to minor adverse effect for all species, which is not significant in EIA terms.

12.6.3.5 Impact 5: Disturbance at seal haul-out sites

683. Disturbance at seal haul out sites from decommissioning works due to noise is expected to be less than that for construction activities due to there being no piling, and would therefore be of a reduced magnitude. There may be potential disturbance due to vessel transits but the magnitude of this effect is expected to either be similar or less than the magnitude of effect during construction.

12.6.3.5.1 Indicative significance of effect

684. Based on the assessment undertaken for construction (Section 12.6.1.6), the worst case sensitivity for both grey and harbour seal is low, and the magnitude of effect is low. This would result in a minor adverse effect for both seal species, which is not significant in EIA terms.

12.6.3.6 Impact 6: Changes to water quality

685. Changes due to water quality (due to an increased SSC and subsequent deposition from decommissioning works) are expected to be less than that for construction activities as seabed preparation, such as sandwave levelling required during the construction phase would not be required during decommissioning, and any effects would therefore be of a reduced magnitude. Sediment analysis has been conducted and sediment contamination levels are not to be of significant concern and are low risk, as discussed in Section 12.6.1.7.1.

12.6.3.6.1 Indicative significance of effect

686. Based on the assessment undertaken for construction (Section 12.6.1.7), the worst case sensitivity of marine mammal receptors is negligible and the magnitude of the impact is low. This would result in a negligible effect, which is not significant in EIA terms.

12.6.3.7 Impact 7: Changes to prey resource

687. Changes to prey resource due to physical disturbance is assumed (for the purposes of this assessment) to be similar to that described for the equivalent activities during the construction phase. As discussed in Section 12.6.3.6, decommissioning works have a negligible effect on changes to water quality, therefore water quality is unlikely to have an effect on prey resources. As discussed in Section 12.6.3.1 and 12.6.3.2 the magnitude of underwater noise is expected to reduce during decommissioning works compared to the construction phase. Therefore, underwater noise impacts on prey resources for marine mammals are expected to be less than those during construction.

12.6.3.7.1 Indicative significance of effect

688. Based on the assessment undertaken for construction (Section 12.6.1.8), the worst case sensitivity of marine mammal receptors is low to medium, and the magnitude is negligible to low. This would result in a negligible to minor adverse effect, which is not significant in EIA terms.

12.7 EPS Licence Application

689. An EPS licence application (marine wildlife licence) will be made for all activities that have the potential for injury or disturbance on EPS (cetaceans). The activities that may require an EPS licence are:

- UXO clearance; and

- Piling

690. Prior to these activities taking place, an EPS risk assessment will be undertaken, following the staged approach as outlined in *The protection of Marine EPS from injury and disturbance*[21]. If it is deemed that an EPS licence is required for any activity, an EPS Risk Assessment document will be produced, and EPS licence applied for.

691. Mitigation will be put in place for UXO clearance, and piling, as per the JNCC guidelines. Where ADDs are required, these will also be considered within the EPS risk assessments.

12.8 Additional mitigation and monitoring requirements

692. Mitigation will be required for the following activities, and will use the relevant JNCC guidelines as standard (the relevant guidelines are noted below);

- UXO clearance

693. Following the JNCC guidelines for minimising the risk of injury to marine mammals from using explosives (JNCC, 2010a)[22]

    - Natural England Offshore Wind Marine Environmental Assessments: Best Practice Advice for Evidence and Data Standards (Phase III and IV) (Parker *et al*. 2022a and Parker *et al*. 2022b)

- Piling

    - Following the Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise (JNCC, 2010b)

694. While the JNCC guidelines will be used as a standard, they may be adapted to ensure that the predicted instantaneous and cumulative PTS ranges are mitigated against, for all marine mammal species. It is expected that ADDs will be used as part of the mitigation for both UXO clearance and piling. Mitigation and monitoring protocols will be developed for each of the above listed activities.

695. Mitigation and monitoring will be secured through the following management plans (Table 12.93). A Draft MMMP (Document Reference: 7.7) and Outline Southern North Sea SAC SIP (Document Reference: 7.8) have been submitted with the DCO application.

Table 12.93 Additional mitigation

Parameter	Additional mitigation measures
MMMP for piling activities in accordance with the Draft MMMP (Document Reference: 7.7)	
MMMP for Piling Activities	The MMMP for piling will be developed in the pre-construction period and based upon relevant available information, methodologies, industry good practice, latest scientific understanding, current guidance and detailed project design. The MMMP for piling will be

[21] The Protection of Marine EPS from Injury and Disturbance: Draft Guidance for the Marine Area in England and Wales and the UK Offshore Marine Area (Joint Nature Conservation Committee (JNCC *et al.*, 2010)

[22] The *DRAFT JNCC guidelines for minimising the risk of injury to marine mammals from explosive use in the marine environment* (JNCC, 2023) will also be taken into account

Parameter	Additional mitigation measures
	developed in consultation with the relevant SNCBs and the MMO, detailing the proposed mitigation to reduce the risk of any physical or permanent auditory injury (PTS) to marine mammals during all piling operations.
MMMP for UXO Clearance in accordance with the Draft MMMP (Document Reference: 7.7) [if UXO clearance is required, will be consented through a separate Marine Licencing process, which would include a full MMMP based on the principles set out in the submitted draft MMMP]	
MMMP for UXO	The MMMP for UXO clearance will ensure there are adequate mitigation to minimise the risk of any physical or permanent auditory injury to marine mammals as a result of UXO clearance. The MMMP for UXO clearance will be developed in the pre-construction period, when there is more detailed information on the UXO clearance which could be required and the most suitable mitigation, based upon best available information and methodologies at that time, in consultation with the MMO and relevant SNCBs. The MMMP for UXO clearance will include details of all the required mitigation to minimise the potential risk of physical and auditory injury (PTS) as a result of underwater noise during UXO clearance, for example, this would consider the options, suitability and effectiveness of mitigation such as, but not limited to: Low-order disposal technique, such as deflagration; The use of bubble curtains (taking into consideration the environmental limitations); All detonations to take place in daylight and, when practicable, in favourable conditions with good visibility (sea state 3 or less); Establishment of a monitoring area with minimum of 1km radius. The observation of the monitoring area will be by dedicated and trained marine mammal observers during daylight hours and suitable visibility; The potential use of Passive Acoustic Monitoring; The activation of ADDs; The controlled explosions of the UXO will be undertaken by specialist contractors, using the minimum amount of explosive required in order to achieve safe disposal of the UXO; and Other UXO clearance techniques, such as the use of multiple detonations, if UXO are located in close proximity; avoidance of UXO; or relocation of UXO.
SIP in accordance with the Outline SIP (Document Reference: 7.8)	
Southern North Sea SAC SIP	In addition to the MMMPs for piling and UXO clearance, a Southern North Sea SAC SIP will be developed. The SIP will set out the approach to deliver any project mitigation or management measures to reduce the potential for any significant disturbance of harbour porpoise in relation to the Southern North Sea SAC conservation objectives. The SIP will be an adaptive management tool, which can be used to ensure that the most adequate, effective and appropriate measures, if required, are put in place to reduce the significant disturbance of harbour porpoise in the Southern North Sea SAC. The SIP will be developed in the pre-construction period, in accordance with the Outline Southern North Sea SAC SIP (Document Reference: 7.8) and will be based upon best available information and methodologies at that time, in consultation with the relevant SNCBs and MMO.
PEMP in accordance with the Outline PEMP (Document Reference: 7.6)	
PEMP for vessel good practice measures	The PEMP includes vessel management measures to reduce disturbance and collision risk to marine mammals. Vessel movements, where possible, will follow set vessel routes and hence areas where marine mammals are accustomed to vessels, in order to reduce any increased collision risk. Additionally, vessel operators will use good practice to reduce any risk of collisions with marine mammals, such as following Defra's *Marine and coastal wildlife code: advice for visitors*[23].

[23] Marine and coastal wildlife code: advice for visitors - GOV.UK (www.gov.uk)

696. Summary reports will be provided following all activities as outlined above, to provide detail on the activities and mitigation undertaken. The summary reports will also provide detail on any marine mammal presence during each of the relevant activities.

12.9 Cumulative effects

12.9.1 Identification of potential cumulative effects

697. The first step in the CEA process is the identification of which residual effects assessed for North Falls on their own have the potential for a cumulative effect with other plans, projects and activities.

698. All potential cumulative impacts are detailed in Table 12.94, and a rationale for either screening in or out to the cumulative assessment is provided. For all cumulative impacts screened in, further information and assessment is provided in the following sections.

699. The cumulative effects that have screened in for assessment are;

- Impact 1: Disturbance due to underwater noise;
- Impact 2: Cumulative barrier effects from disturbance of wind farms;
- Impact 3: Increased collision risk with vessels;
- Impact 4: Disturbance at seal haul-out sites;
- Impact 5: Changes to prey resources.

Table 12.94 Potential cumulative effects

Impact	Potential for cumulative effect	Rationale
Permanent auditory injury due to underwater noise	No	If there is the potential for any PTS, from any project, suitable mitigation would be put in place to reduce any risk to marine mammals. Therefore, this has been screened out from further consideration in the CEA. The potential risk of PTS in marine mammals from cumulative impacts has been screened out from further consideration in the CEA. See Section 1.2.1 of Appendix 12.6 (Document Reference: 3.3.11) for more information.
Temporary auditory injury	No	Temporary auditory injury would be mitigated as per permanent auditory injury (see above). While the potential for a temporary auditory injury has not been screened in in its own right, the potential for TTS/fleeing ranges has been considered within the assessment for the potential for disturbance. See Section 1.2.2 of Appendix 12.6 (Document Reference: 3.3.11) for more information.
Disturbance from underwater noise	Yes	Disturbance is likely to have greater effect range and area than TTS, and the risk of TTS will be within disturbance ranges for marine mammals. Where there is little information on the potential disturbance ranges for marine mammals, TTS has been used to indicate possible fleeing response. Therefore, the potential risk of TTS in marine mammals from cumulative effects will be considered alongside that of disturbance from underwater noise, and the highest known potential

Impact	Potential for cumulative effect	Rationale
		effect ranges (of either TTS or disturbance) will be used to the inform the cumulative assessment. The potential for disturbance to marine mammals from underwater noise has been screened into the CEA. See Section 12.9.3.1 for the full assessment.
Barrier effects due to underwater noise disturbance of wind farms	Yes	The potential for cumulative projects to cause a barrier effect has been screened into the CEA due to the cumulative underwater noise disturbance of multiple OWFs. See Section 12.9.3.2 for the full assessment.
Increased collision risk with vessels	Yes	The potential for an increase in vessel collision risk due to an increase in vessels across cumulative projects has been considered further in Section 12.9.3.3.
Disturbance at seal haul-out sites	Yes	Due to an increase in vessels across cumulative projects the potential for disturbance at seal haul-out sites has been screened into the CEA. See Section 12.9.3.4 for the full assessment.
Changes to water quality	No	No likely significant effects with regard to water quality are expected as a result of North Falls. All other projects would be required to have equivalent mitigation and prevention as North Falls and therefore have no likely significant effects. Any changes to water quality as a result of aggregate extraction and dredging would be very localised and temporary. Changes to water quality (including from aggregate extraction and dredging) has been screened out from the CEA. See Section 1.2.6 of Appendix 12.6 (Document Reference: 3.3.11) for more information.
Changes to prey resources	Yes	Dur to an increase in cumulative noise from multiple OWF activity the potential changes to prey resources, has been considered further in Section 12.9.3.5.

12.9.2 Other plans, projects and activities

700. The second step in the cumulative assessment is the identification of the other plans, projects and activities that may result in cumulative effects for inclusion in the CEA (described as 'project screening'). This information is set out in Appendix 12.6 (Document Reference: 3.3.11).

701. The project screening has been informed by the development of a CEA project list which forms an exhaustive list of plans, projects and activities within the study area (Section 12.3.1) relevant to North Falls. The list has been appraised, based on the confidence in being able to undertake an assessment from the information and data available, enabling individual plans, projects and activities to be screened in or out. The cut off for inclusion of other OWFs into the CEA was the end of January 2024, as agreed with the marine mammal ETG. This means that updates are not included for OWFs for which PEIRs became available or the ES was submitted beyond this date. Project tiers and status listed in Table 12.95 reflects the status at the time of writing.

702. The full CEA screening process for marine mammals is provided in Appendix 12.5 (Document Reference: 3.3.10). The below sections and tables provide the conclusions of the full screening. The projects screened in are assessed in Section 12.9.3, and listed in Table 12.95.

Table 12.95 Summary of projects considered for the CEA in relation to marine mammal ecology (project screening)

Project	Tier	Status	Closest distance (km) from: Array area(km)	Offshore cable corridor	Confidence in Data	Included in the CEA (Y/N)	Rationale
Offshore wind farms							
Dudgeon Extension	3	Consented	156	152	Medium – cumulative assessment based on submitted assessments.	Y	Potential for overlapping construction phases.
East Anglia Hub (East Anglia ONE North)	3	Consented	65.4	70.7			
Hornsea Project Four	3	Consented	230	227			
Hornsea Project Three	3	Consented	218	217			
Norfolk Vanguard	3	Consented	120.5	125.4			
Sheringham Shoal Extension	3	Consented	161.5	153			
Berwick Bank	4	Application submitted	555	554	Medium – cumulative assessment based on submitted assessments.	Y	Potential for overlapping construction phases.
Galatea-Galene	4	Application submitted	1,021	1,025			
Rampion 2	4	Application submitted	201	215			
West Of Orkney	4	Concept & Early Planning	885	891			
Dunkerque	4	Concept & Early Planning	62.7	74.9	Low - Project specific assessment unavailable, generic approach used to inform the assessment.	Y	Potential for overlapping construction phases.
Nordlicht I	4	Concept & Early Planning	393	400			

Project	Tier	Status	Closest distance (km) from:		Confidence in Data	Included in the CEA (Y/N)	Rationale
			Array area(km)	Offshore cable corridor			
Nordsee Cluster A - N-3.7	4	Concept & Early Planning	448	554			
Nordsee Cluster A - N-3.8	4	Concept & Early Planning	448	554			
Dogger Bank South (East and West)	5	Concept & Early Planning	285	278	Low - cumulative assessment is based on PEIR findings.	Y	Potential for overlapping construction phases.
Five Estuaries	5	Concept & Early Planning[24]	0	13.3			
Outer Dowsing	5	Concept & Early Planning[24]	196	200			
Nordlicht II	5	Concept & Early Planning	388	395	Low - Project specific assessment unavailable, generic approach used to inform the assessment.	Y	Potential for overlapping construction phases
Aggregate extraction and dredging projects							
Greenwich Light East (473/1; CUML)	N/A	Production	171	184	Low - Project specific assessment unavailable, generic approach used to inform the assessment.	Y	Potential for overlapping activities.
Greenwich Light East (473/2; CUML)	N/A	Production	163	177			

[24] Status is correct at the time of writing (it is acknowledged that the DCO will be submitted prior to the North Falls submission, but it was not available at the time of writing)

Project	Tier	Status	Closest distance (km) from:		Confidence in Data	Included in the CEA (Y/N)	Rationale
			Array area(km)	Offshore cable corridor			
Greenwich Light East (473/2; Hanson Aggregates Marine Ltd)	N/A	Production Agreement Area	163	177			
Greenwich Light East (473/1; Hanson Aggregates Marine Ltd)	N/A	Production Agreement Area	171	184			
Median Deep (461; Volker Dredging Ltd)	N/A	Production	190	204			
West Wight (522; CUML)	N/A	Production	311	325			
Subsea cables and pipelines							
Sea Link	4	Concept & Early Planning	5.26km	0km	Low to medium – cumulative assessment is based on project specific assessments where available, and using a generic approach where not.	Y	Potential for overlapping construction phases

12.9.3 Assessment of cumulative effects

709. The CEA screening identified that there is the potential for cumulative effects on marine mammals as a result of disturbance from underwater noise during piling and other construction activities. Other potential impacts, such as PTS from underwater noise, were screened out of the CEA (see Appendix 12.5, (Document Reference: 3.3.10)).

710. The potential sources of cumulative underwater noise which could disturb marine mammals and which are screened into the CEA are:

- Piling at OWFs;
- Other construction activities at OWFs (vessels, cable installation works, dredging, seabed preparation and rock placement);
- Vessels associated with O&M of OWFs;
- Geophysical surveys for OWFs;
- Aggregate extraction and dredging;
- Oil and gas installation projects;
- Oil and gas seismic surveys;
- Subsea cable and pipelines; and
- UXO clearance.

711. Where a quantitative assessment has been undertaken, the potential magnitude of disturbance has been based on the number of marine mammals at risk of disturbance, based on the Project specific reporting (such as PEIRs and ESs).

712. Where there is no Project specific information available, or where the location of the project or activity is unknown, the density estimates for either the relevant SCANS-IV survey block or Assessment Unit (for harbour porpoise), or the SCANS-IV block or survey area (for minke whale) has been used, as a worst case. For harbour porpoise, the AU density would be 0.55/km^2 for the North Sea, and for minke whale, the density would be 0.0085/km^2, for the whole of the SCANS-IV area (Gilles *et al*., 2023). For grey and harbour seal, densities will be calculated for the entire area of the relevant MU, based on the grid cells that overlap with the area, and using the most recent grey and harbour seal population estimates to convert the Carter *et al*. (2022) relative densities to absolute densities. This is 0.296 grey seal per km^2 (for both seal MUs 8 and 9) and 0.065 harbour seal per km^2 (for seal MU 9).

713. It should be noted that a large amount of uncertainty is inherent in the CEA. At the project level, uncertainty in the assessment process has been expressed as a level of the confidence in the data used in the assessment. This relates to confidence in both the understanding of the consequences of the potential impacts on marine mammals, but also the information used to inform the predicted magnitude and significance of project impacts on marine mammals. As outlined in the tier approach, there is more information and certainty for lower tiers, compared to higher tiers (JNCC and Natural England, 2013).

714. In the CEA, the potential for impacts over wider spatial and temporal scales means that the uncertainty arising from the consideration of a large number of

plans or projects leads to a lower confidence in the information used in the assessment, but also the conclusions of the assessment itself. To take this uncertainty into account, where practicable, a precautionary approach has been taken at multiple stages of the assessment process.

715. The approach to dealing with uncertainty has led to a highly precautionary assessment of the cumulative effects, especially for pile driving, as the CEA is based on the worst case scenarios for all projects included. It should therefore be noted that building precaution can lead to unrealistic worst case scenarios within the assessment.

716. Therefore, the assessment is based on the most realistic worst case scenario to reduce any uncertainty and avoid the presentation of highly unrealistic worst case scenarios, while still providing a conservative assessment. Careful consideration has been given to determine the most realistic worst case scenario for the CEA.

717. At this stage, on a precautionary basis, an assessment is undertaken for each species in relation to the relevant reference population. The assessment has then determined how many individuals may be affected by each impact as a percentage of the reference population. In the case of a medium or high magnitude being identified, based on the initial assessment approach, further assessment has been undertaken to determine the population level consequence of the impact in the form of population modelling, the approach is discussed further below from paragraph 735.

12.9.3.1 Cumulative impact 1: Disturbance from underwater noise

12.9.3.1.1 Cumulative impact 1a: Assessment of underwater noise from piling at other OWFs

718. Following the initial screening of UK and European OWFs, the next stage of the screening exercise was undertaken on those projects that have been identified as having the potential for overlapping construction phases. This stage of the screening is based on known construction periods of UK and European OWF projects, including known piling and /or construction timings, in order to determine a more realistic, but still worst case, list of UK and European OWF projects that may have the potential for overlapping piling with North Falls.

719. Of the 20 UK and European OWFs screened in for having a potentially overlapping construction period with the Project, six OWFs could be piling at the same time. Currently, pilling activities for North Falls are estimated to take place from 2030 to 2031.

- Berwick Bank (for harbour porpoise and minke whale);
- Dogger Bank South (East and West) (for all marine mammal species);
- Dudgeon Extension (for all marine mammal species);
- Five Estuaries (for all marine mammal species);
- Outer Dowsing (for all marine mammal species); and
- Sheringham Shoal Extension (for all marine mammal species).

720. This more realistic short list of OWF projects that could be piling at the same time as North Falls could change as projects develop, but this is the best available information at the time of writing, and more accurately reflects the limitations and constraints to project delivery.

721. The commitment to the mitigation agreed through the Draft MMMP (Document Reference: 7.7) for piling, as outlined above (Section 12.8), would reduce the risk of physical injury or permanent auditory injury (PTS) for all marine mammals.

Sensitivity

722. As outlined in Section 12.6.1.1.4, all harbour porpoise and minke whale are assessed as having medium sensitivity to disturbance from underwater noise sources, while grey seal and harbour seal have a sensitivity of low.

Magnitude

723. The magnitude of the potential disturbance from piling activities has been estimated for each individual project screened in for assessment. For harbour porpoise, grey seal and harbour seal at North Falls, this is based on the disturbance numbers gained from the dose response approach, as the most realistic assessment. For minke whale at North Falls, this is based on the numbers at risk of TTS. For other OWFs, it has been based on the worst-case numbers at risk, provided within each project's relevant documents.

724. It should be noted that the potential areas of disturbance assume that there is no overlap in the areas of disturbance between different projects and are therefore highly conservative.

725. The approach to the CEA for piling at OWFs is based on the potential for single piling at each wind farm at the same time as single piling at North Falls. This approach allows for some of the OWFs not to be piling at the same time, while others could be simultaneously piling (further information is available in Appendix 12.5 (Document Reference: 3.3.10)). This is considered to be the most realistic worst case scenario, as it is highly unlikely that all other wind farms would be simultaneously piling at exactly the same time as piling at North Falls.

726. It is important to note the actual duration for active piling time which could disturb marine mammals is only a very small proportion of the potential construction period, of up to approximately 103 days for North Falls, based on the estimated maximum duration to install individual piles (Table 12.1).

727. For harbour porpoise, the potential worst case scenario of other OWFs piling at the same time as North Falls is assessed in Table 12.96. The potential magnitude of the temporary impact is assessed as medium, with up to 8.1% of the reference population potentially disturbed, however, this is very precautionary, as it is unlikely that all projects could be simultaneously piling at exactly the same time as piling at North Falls and all other OWF projects.

728. In practice, the potential temporary impacts would be less than those predicted in this assessment as there is likely to be a great deal of variation in timing, duration, and hammer energies used throughout the various OWF project construction periods.

Table 12.96 Quantitative assessment for cumulative disturbance for harbour porpoise due to piling at other OWFs (magnitude levels based on the percentage of the reference population affected, as set out in

Table 12.9) [number of individuals at risk of disturbance is based on project specific reporting, and rounded up to nearest whole number]

Project	Approach to disturbance assessment	Maximum number of individuals potentially disturbed during single piling
North Falls	*Based on dose response*	*1,072*
Berwick Bank (Seagreen Charlie Delta Echo)[25]	Based on underwater noise contours	1,754
Dogger Bank South (East and West)[26]	Based on dose response	12,208
Dudgeon Extension[27]	Based on dose response	804
Five Estuaries[28]	Based on dose response	7,031
Outer Dowsing[29]	Based on dose response	3,981
Sheringham Shoal Extension[27]	Based on dose response	582
Total number of harbour porpoise		**27,432**
Percentage of NS MU		**8.09%**
Magnitude of cumulative impact		***Medium***

729. For minke whales, the potential magnitude of the temporary impact is assessed as low, with 1.5% of the reference population potentially disturbed (Table 12.97).

Table 12.97 Quantitative assessment for cumulative disturbance for minke whale from piling at other OWFs (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9) [number of individuals at risk of disturbance is based on project specific reporting, and rounded up to nearest whole number]

Project	Approach to disturbance assessment	Maximum number of individuals potentially disturbed during single piling
North Falls	*Based on TTS as a proxy for disturbance*	*37*
Berwick Bank (Seagreen Charlie Delta Echo)[25]	Based on underwater noise contours	82
Dogger Bank South (East and West)[26]	Based on TTS assessment	148
Dudgeon Extension[30]	Based on TTS assessment	11
Five Estuaries[28]	Not assessed by Project	-
Outer Dowsing[29]	Based on dose response	17
Sheringham Shoal Extension[30]	Based on TTS assessment	11
Total number of minke whale		**306**

[25] Based on single piling (Berwick Bank Wind Limited, 2022)
[26] Based on a single pile at Dogger Bank South East and Dogger Bank South West in isolation (RWE Renewables UK Dogger Bank South (West) Limited and RWE Renewables UK Dogger Bank South (East) Limited, 2023)
[27] Based on single piling (Equinor New Energy, 2023)
[28] Based on single piling (Five Estuaries Wind Farm Ltd, 2023)
[29] Based on single piling (Outer Dowsing Offshore Wind, 2023)
[30] Based on single piling (Equinor New Energy Ltd, 2022)

Project	Approach to disturbance assessment	Maximum number of individuals potentially disturbed during single piling
Percentage of CGNS MU		**1.52%**
Magnitude of cumulative impact		**Low**

730. For grey and harbour seal, based on a single pile installation at each of the OWFs including North Falls, the potential magnitude for the cumulative impact of piling is assessed as medium for grey seal, with 5.8% of the reference population disturbed, and low for harbour seal, with 3.4% of the reference population potentially disturbed (Table 12.98).

Table 12.98 Quantitative assessment for cumulative disturbance for grey seal and harbour seal from piling at other OWFs (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9) [number of individuals at risk of disturbance is based on project specific reporting, and rounded up to nearest whole number]

Project	Approach to disturbance assessment	Maximum number of grey seal potentially disturbed during single piling	Maximum number of harbour seal potentially disturbed during single piling
North Falls	*Based on dose response*	*112*	*7*
Dogger Bank South (East and West)[26]	Based on dose response	1,968	4
Dudgeon Extension[27]	Based on dose response	374	43
Five Estuaries[28]	Based on dose response	112	2
Outer Dowsing[29]	Based on dose response	377	25
Sheringham Shoal Extension[27]	Based on dose response	338	84
Total number of seals		**3,281**	**165**
Percentage of wider reference population		**5.81%**	**3.38%**
Magnitude of cumulative impact		**Medium**	**Low**

731. If all included OWFs were single piling at the same time as North Falls, there is the potential for a low to medium magnitude of impact (dependent on species), however, as outlined above, it is highly unlikely that all OWFs could be simultaneously piling at exactly the same time.

732. Taking into account the medium receptor sensitivity for harbour porpoise and minke whale, and low for both seal species, the cumulative effect assessment for disturbance to marine mammals from piling at other OWFs, including North Falls, is moderate adverse for harbour porpoise, minor adverse for minke whale and grey seal, and negligible for harbour seal. This is deemed to be a conservative assessment based on the worst case scenario for all OWFs single piling at the same time as North Falls.

733. As noted in Section 12.9.3, further assessment has therefore been undertaken for harbour porpoise and grey seal, with magnitudes of medium (more than 5% of the relevant populations potentially disturbed) to determine whether the indicated effects would result in population level consequences. While the assessments do not show the potential for a likely significant effect to minke

whale or harbour seal, population modelling has also been undertaken for this species.

Population modelling

734. Population modelling has been conducted for harbour porpoise, minke whale, harbour seal and grey seal. The interim Population Consequences of Disturbance (iPCoD) framework (Harwood *et al.,* 2014, King *et al*., 2015) has been used to estimate the potential medium- and long-term population consequences of the predicted amount of disturbance resulting from piling at North Falls. iPCoD uses a stage-structured model of population dynamics with nine age classes and one stage class (adults 10 years and older). The model is used to run a number of simulations of future population trajectory with and without the predicted level of impact. This allows an understanding of the potential future population-level consequences of predicted behavioural responses to auditory injury; further details on the modelling can be found in Section 12.6.1.1.4 and Appendix 12.6 (Document Reference: 3.3.11)).

735. At this stage, uncertainty exists around the exact piling schedule that will be used for construction at North Falls, however the periods during which piling is likely to occur are known. Therefore, the required number of piling days for each construction scenario have been distributed randomly within the known piling periods.

736. The piling parameters for North Falls included 57 days of mono piling for foundations and two days of mono piling for OSP/OCP installation (model assumes one pile per day as a worst case scenario) within 2030 (days were distributed randomly as exact piling days are not known). Number of piling days and piling schedules were gained from published reports for other OWFs, for all OWFs the days were distributed randomly within the known years that piling may take place, further details can be found in Appendix 12.6 (Document Reference: 3.3.11). The reference populations and number of individuals at risk of PTS or disturbance (due to piling at North Falls) used in the modelling were the same as those presented in the baseline assessment within this chapter. The number of individuals at risk of PTS or disturbance due to piling at other OWFs were taken from their own project specific reporting.

Harbour porpoise

737. For harbour porpoise, taking into account the cumulative scenario assessed (see Appendix 12.6 (Document Reference: 3.3.11) for details of the projects considered, and their parameters) using the reference population (338,918) of the NS MU, the iPCoD model predicts there to be a negligible effect on the harbour porpoise population over time due to piling (Plate 12.15 and Table 12.99).

738. The median population size was predicted to be 100% of the un-impacted population size at the end of 2028 (1 year after the piling from all cumulative projects has commenced in the wider area). By the end of 2032 (the year piling ends for all cumulative projects) the median population size for the impacted population is predicted to be 99.26% of the un-impacted population size. Beyond 2032, the impacted population is expected to maintain the same stable trajectory as the un-impacted population (as far as 2052 which is the end point of the modelling, at which point the median impacted to un-impacted ratio is 99.23%; Table 12.99).

739. For harbour porpoise, the potential magnitude of impact for the CEA for disturbance from underwater noise from piling is assessed as negligible, due to there being less than a 1% population level impact on average per year over both the first six years and 25 year modelled periods.

Table 12.99 Results of the iPCoD modelling for the cumulative assessment, giving the mean population size of the harbour porpoise population (wider reference population) for years up to 2053 for both impacted and un-impacted populations in addition to the median ratio between their population sizes.

Year	Un-impacted population mean	Impacted population mean	Median impacted as % of un-impacted
Start	338,920	338,920	100.00
End of 2028	338,500	338,500	100.00
End of 2029	337,899	337,383	99.94
End of 2032	338,403	334,311	99.26
End of 2037	337,367	333,065	99.21
End of 2047	336,291	332,063	99.23
End of 2052	338,129	333,888	99.23

Plate 12.13 Simulated worst-case harbour porpoise population sizes for both the un-impacted and the impacted populations for the cumulative assessment

Minke whale

740. For minke whale, taking into account the cumulative scenario assessed (see Appendix 12.6 (Document Reference: 3.3.11) for details of the projects considered, and their parameters) using the reference population (20,118) of the CGNS MU, the iPCoD model predicts there to be a low effect on the minke whale population over time due to piling (Plate 12.14 and Table 12.100).

741. The median population size was predicted to be 100% of the un-impacted population size at the end of 2028 (1 year after the piling from all cumulative projects has commenced in the wider area). By the end of 2032 (the year piling ends for all cumulative projects) the median population size for the impacted population is predicted to be 96.94% of the un-impacted population size. Beyond 2032, the impacted population is expected to maintain the same stable

trajectory as the un-impacted population (as far as 2052 which is the end point of the modelling, at which point the median impacted to un-impacted ratio is 92.22%; Table 12.100).

742. For minke whale, the potential magnitude of impact for the CEA for disturbance from underwater noise from piling is assessed as low, due to there being less than a 1% population level impact on average per year over the first six years, with a total predicted decline of 7.78% over the full 25 year modelled period.

Table 12.100 Results of the iPCoD modelling for the cumulative assessment, giving the mean population size of the minke whale population (wider reference population) for years up to 2053 for both impacted and un-impacted populations in addition to the median ratio between their population sizes.

Year	Un-impacted population mean	Impacted population mean	Median impacted as % of un-impacted
Start	20,120	20,120	100.00
End of 2028	20,124	20,124	100.00
End of 2029	20,118	20,013	99.66
End of 2032	20,137	19,371	96.94
End of 2037	20,122	18,735	94.11
End of 2047	20,176	18,436	92.42
End of 2052	20,180	18,394	92.22

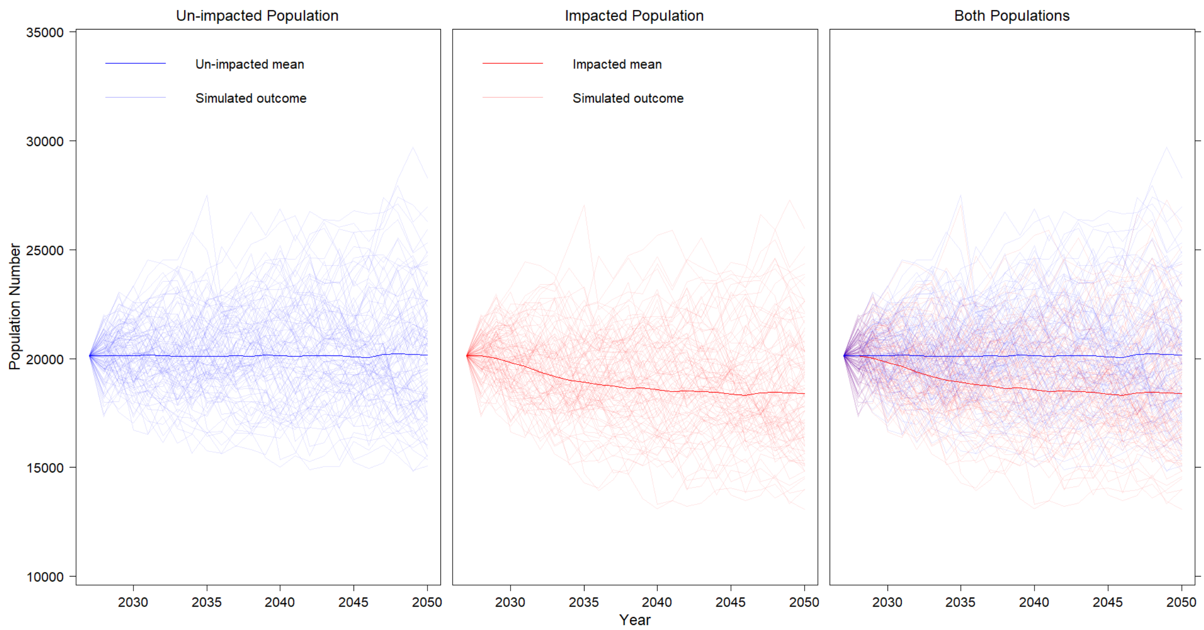

Plate 12.14 Simulated worst-case minke whale population sizes for both the un-impacted and the impacted populations for the cumulative assessment

Grey seal

743. For grey seal, with the cumulative project scenario assessed (see Appendix 12.6 (Document Reference: 3.3.11) for details of the projects considered, and their parameters) and using the wider reference population (of 56,505 for both the SE and NE MUs), the iPCoD model predicts there to be no effect on the grey seal population over time (Plate 12.15 and Table 12.101).

744. The median population size was predicted to be 100% of the un-impacted population size at the end of 2028, and by the end of 2032, the median

population size for the impacted population is predicted to be 100% of the un-impacted population size. Beyond 2032, the impacted population is expected to maintain the same stable trajectory as the un-impacted population (as far as 2052 which is the end point of the modelling, at which point the median impacted to un-impacted ratio is 100%; Table 12.101).

Table 12.101 Results of the iPCoD modelling for the cumulative assessment, giving the mean population size of the grey seal population (wider reference population) for years up to 2053 for both impacted and un-impacted populations in addition to the median ratio between their population sizes.

Year	Un-impacted population mean	Impacted population mean	Median impacted as % of un-impacted
Start	56,502	56,502	100.00
End of 2028	57,069	57,069	100.00
End of 2029	57,536	57,538	100.00
End of 2032	59,425	59,423	100.00
End of 2037	62,572	62,571	100.00
End of 2047	69,001	68,999	100.00
End of 2052	72,148	72,146	100.00

Plate 12.15 Simulated worst-case grey seal (based on wider reference population) population sizes for both the un-impacted and the impacted populations for the cumulative assessment

745. Additional population modelling was undertaken for grey seal, for just the SE MU reference population (30,592). Again, the iPCoD model predicts no effect on the grey seal population over time (Plate 12.16 and Table 12.102).

746. The median population size was predicted to be 100% of the un-impacted population size at the end of 2028 and by the end of 2032, the median population size for the impacted population is predicted to be 100% of the un-impacted population size. Beyond 2032, the impacted population is expected to maintain the same stable trajectory as the un-impacted population (as far as 2052 which is the end point of the modelling, at which point the median impacted to un-impacted ratio is 100%; Table 12.102).

747. For grey seal, the potential magnitude of the CEA for disturbance from underwater noise from piling on both the SE MU and wider reference population is assessed as negligible, due to there being less than a 1% population level effect on average per year over both the first six years and 25 year modelled periods.

Table 12.102 Results of the iPCoD modelling for the cumulative assessment, giving the mean population size of the grey seal population (SE MU) for years up to 2053 for both impacted and un-impacted populations in addition to the median ratio between their population sizes.

Year	Un-impacted population mean	Impacted population mean	Median impacted as % of un-impacted
Start	30,594	30,594	100.00
End of 2028	30,957	30,957	100.00
End of 2029	31,331	31,331	100.00
End of 2032	32,243	32,240	100.00
End of 2037	33,829	33,826	100.00
End of 2047	37,530	37,527	100.00
End of 2052	39,565	39,563	100.00

Plate 12.16 Simulated worst-case grey seal (based on SE MU) population sizes for both the un-impacted and the impacted populations for the cumulative assessment

Harbour seal

748. For harbour seal, the cumulative scenario assessed (see Appendix 12.6 (Document Reference: 3.3.11) for details of the projects considered, and their parameters) using the reference population of 4,868, the iPCoD model predicts no effect on the harbour seal population over time (Plate 12.17 and Table 12.103).

749. The median population size was predicted to be 100% of the un-impacted population size at the end of 2028. By the end of 2032, the median population size for the impacted population is predicted to be 100.31% of the un-impacted population size. Beyond 2032, the impacted population is expected to maintain the same stable trajectory as the un-impacted population (as far as 2052 which

is the end point of the modelling, at which point the median impacted to un-impacted ratio is 100%; Table 12.103).

750. For harbour seal, the potential magnitude of the CEA for disturbance from underwater noise from piling is assessed as negligible due to there being less than a 1% population level effect on average per year over both the first six years and 25 year modelled periods.

Table 12.103 Results of the iPCoD modelling for the cumulative assessment, giving the mean population size of the harbour seal population for years up to 2053 for both impacted and un-impacted populations in addition to the median ratio between their population sizes

Year	Un-impacted population mean	Impacted population mean	Median impacted as % of un-impacted
Start	4,866	4,866	100.00
End of 2028	3,994	3,994	100.00
End of 2029	3,278	3,280	100.06
End of 2032	1,801	1,806	100.31
End of 2037	667	669	100.28
End of 2047	92	92	100.00
End of 2052	34	34	100.00

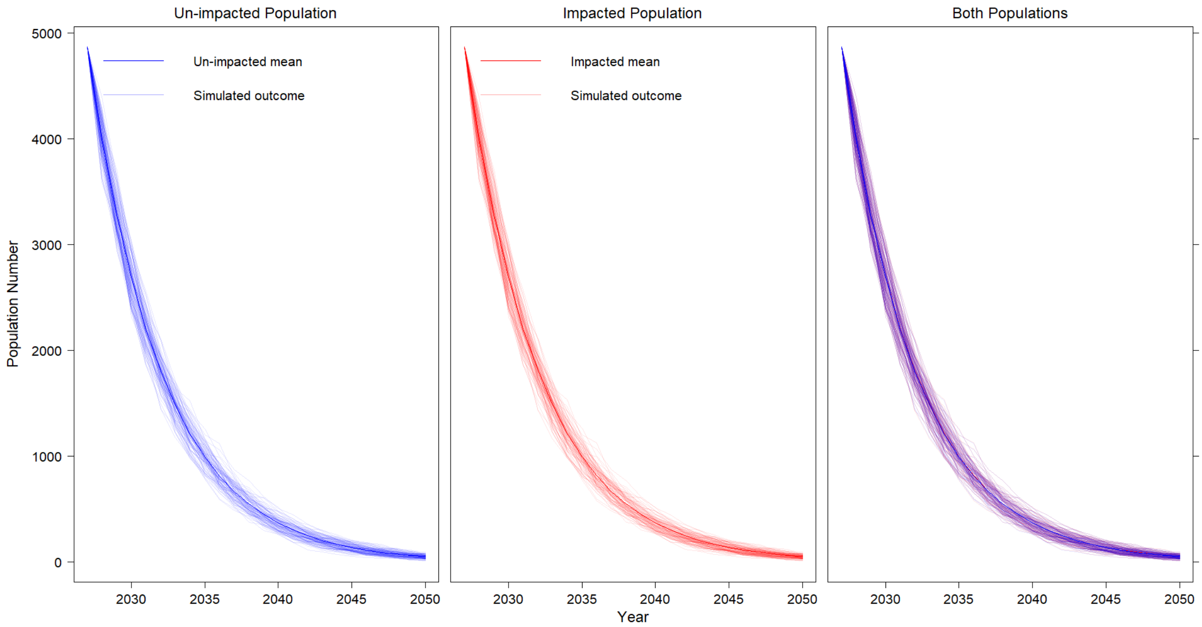

Plate 12.17 Simulated worst-case harbour seal population sizes for both the un-impacted and the impacted populations for the cumulative assessment

Effect significance

751. If all included OWFs were piling at the same time as North Falls, there is the potential for a negligible magnitude of impact for harbour porpoise, grey seal and harbour seal, and low for minke whale.

752. Therefore, taking into account the medium receptor sensitivity for harbour porpoise and minke whale, and low for grey seal and harbour seal, the overall cumulative effect for disturbance to marine mammals from piling at other OWFs is minor adverse for harbour porpoise and minke whale, and negligible for grey seal and harbour seal (Table 12.104).

Table 12.104 Assessment of effect significance for the potential for cumulative disturbance due to other OWFs piling at the same time as North Falls

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual effect
Harbour porpoise	Medium	Negligible	Minor adverse	None required.	Minor adverse
Minke whale	Medium	Low	Minor adverse		Minor adverse
Grey seal and harbour seal	Low	Negligible	Negligible		Negligible

Mitigation

753. With the implementation of any management measures for the Southern North Sea SAC (such as the SIP), the potential impacts could be reduced. Any mitigation measures to reduce the disturbance of harbour porpoise in the project specific SIPs could also reduce the potential disturbance of minke whale, grey seal and harbour seal.

12.9.3.1.2 Cumulative impact 1b: Assessment of underwater noise from other activities and vessels at other OWFs

754. All OWFs with construction dates that have the potential to overlap with the construction dates for North Falls have the potential for other construction activities (such as seabed preparation, dredging, trenching, cable installation, rock placement, drilling and vessels) to occur at the same time as other construction activities at North Falls. It is also assumed that these projects would have similar decommissioning programmes to that of North Falls (i.e. they may be undergoing decommissioning at the same time as North Falls).

755. OWFs screened in for other activities that could have a cumulative effect with other construction (or decommissioning) activities at North Falls are:

- Dunkerque for harbour porpoise and minke whale;
- East Anglia Hub (East Anglia ONE North) for all marine mammal species;
- Galatea-Galene for minke whale;
- Hornsea Project Four for all marine mammal species;
- Hornsea Project Three for all marine mammal species;
- Nordlicht I for harbour porpoise and minke whale;
- Nordlicht II for harbour porpoise and minke whale;
- Nordsee Cluster A - N-3.7 for harbour porpoise and minke whale;
- Nordsee Cluster A - N-3.8 for harbour porpoise and minke whale;
- Norfolk Vanguard for all marine mammal species;
- Rampion 2 for harbour porpoise and minke whale; and
- West of Orkney for harbour porpoise and minke whale.

756. While the other OWFs that have been assessed under the cumulative piling assessment (Section 12.9.3.1.1) have the potential for overlapping construction phases, as well as those listed above, they are already assessed under a worst case of piling overlaps.

Sensitivity

757. As outlined in Section 12.6.1.2.4, harbour porpoise and minke whale are assessed as having medium sensitivity to disturbance, while grey seal and harbour seal have a low sensitivity for the disturbance from other construction activities, relating to OWF development.

Magnitude

758. The CEA includes all projects that could have non-piling construction activities during the North Falls construction period.

759. The potential disturbance from OWFs during non-piling construction (or decommissioning) activities, such as vessel noise, seabed preparation, rock placement and cable installation, has been based on project specific data wherever available. For European projects, it has not been possible to obtain project specific data, and therefore a generic approach has been used, with the densities for either the relevant SCANS-IV survey block, or for the relevant area using the Carter *et al*. (2022) density maps for seals. In these cases, the potential area of impact is based on the same as for North Falls alone; 201.4km^2, for up to four activities at once.

760. For harbour porpoise, based on the worst case scenario, for all OWFs that could be constructing (or decommissioning) at the same time as North Falls, the potential magnitude of the temporary impact is assessed as negligible, with less than 1% of the population at risk of disturbance (Table 12.105).

Table 12.105 Quantitative assessment for cumulative disturbance for harbour porpoise due to construction (or decommissioning) activities at other OWFs (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9) [number of individuals at risk of disturbance is based on project specific reporting, and rounded up to nearest whole number]

Project	Harbour porpoise density (/km^2)	impact area (km^2)	Maximum number of individuals potentially disturbed
North Falls	*Based on dose response as worst-case*		*1,072*
Dunkerque*	0.1045	201.1	21
East Anglia ONE North[31]	Taken from projects' own assessment		4
Hornsea Project Four[32]	Not quantitively assessed		-
Hornsea Project Three[33]	Not quantitively assessed		-
Nordlicht I*	0.8034	201.1	162
Nordlight II*	0.8034	201.1	162
Nordsee Cluster A - N-3.7*	0.6158	201.1	124
Nordsee Cluster A - N-3.8*	0.6158	201.1	124

[31] Possible behavioural response due to multiple vessels (East Anglia ONE North Limited, 2021)
[32] Not quantitively assessed in Project's own assessment (Orsted Power (UK) Ltd, 2019)
[33] Not quantitively assessed in Project's own assessment (Orsted Power (UK) Ltd, 2018)

Project	Harbour porpoise density (/km²)	impact area (km²)	Maximum number of individuals potentially disturbed
Norfolk Vanguard[34]	Taken from projects' own assessment		906
Rampion 2[35]	Not quantitively assessed		-
West of Orkney[36]	Not quantitively assessed		-
Total number of harbour porpoise			**2,575**
Percentage of NS MU			**0.76%**
Magnitude of cumulative impact			**Negligible**

* Project specific assessment unavailable, generic approach used to inform the assessment

761. Based on the OWFs that could be undergoing construction (or decommissioning) at the same time as the North Falls, the magnitude of the temporary impact is assessed as negligible for minke whale, with 0.22% of the reference population at risk of a disturbance impact (Table 12.106).

Table 12.106 Quantitative assessment for cumulative disturbance for minke whale due to construction activities (or decommissioning) at other OWFs (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9) [number of individuals at risk of disturbance is based on project specific reporting, and rounded up to nearest whole number]

Project	Minke whale density (/km²)	impact area (km²)	Maximum number of individuals potentially disturbed
North Falls	*Based on TTS as a proxy for disturbance*		*37*
Dunkerque*	0.0 (minke whale not present)	201.1	0
East Anglia ONE North[37]	Minke whale not assessed		-
Galatea-Galene[38]	Minke whale not assessed		-
Hornsea Project Four[32]	Not quantitively assessed		-
Hornsea Project Three[33]	Not quantitively assessed		-
Nordlicht I*	0.0153	201.1	4
Nordlight II*	0.0153	201.1	4
Nordsee Cluster A - N-3.7*	0.0 (minke whale not present)	201.1	0
Nordsee Cluster A - N-3.8*	0.0 (minke whale not present)	201.1	0
Norfolk Vanguard[39]	Minke whale not assessed		-
Rampion 2[35]	Not quantitively assessed		-
West of Orkney[36]	Not quantitively assessed		-
Total number of minke whale			**45**

[34] Based on all individuals within windfarm areas at risk of disturbance from other activities (Norfolk Vanguard Limited, 2018)
[35] Not quantitively assessed in Project's own assessment (Rampion Extension Development Limited, 2023)
[36] Not quantitively assessed in Project's own assessment (Offshore Wind Power Limited, 2023)
[37] East Anglia ONE North Limited, 2021
[38] OX2 AB, 2021
[39] Norfolk Vanguard Limited, 2018

Project	Minke whale density (/km^2)	impact area (km^2)	Maximum number of individuals potentially disturbed
Percentage of CGNS MU			**0.22%**
Magnitude of cumulative impact			**Negligible**

* Project specific assessment unavailable, generic approach used to inform the assessment

762. Based on the projects that could have construction (or decommissioning) overlapping with North Falls, the potential magnitude for the cumulative disturbance impact is assessed as negligible for both grey seal and harbour seal, with less than 1% of the reference population temporarily disturbed (Table 12.107).

Table 12.107 Quantitative assessment for cumulative disturbance for grey seal and harbour seal due to construction activities (or decommissioning) at other OWFs (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9) [number of individuals at risk of disturbance is based on project specific reporting, and rounded up to nearest whole number]

Project	Approach to assessment	Maximum number of GS individuals potentially disturbed	Maximum number of HS individuals potentially disturbed
North Falls	*Base on dose response*	*112*	*7*
East Anglia ONE North[40]	Taken from projects' own assessment	0.07	0.02
Hornsea Project Four[32]	Not quantitively assessed	-	-
Hornsea Project Three[33]	Not quantitively assessed	-	-
Norfolk Vanguard[34]	Taken from projects' own assessment	39	24
Total number of seals		**152**	**32**
Percentage of wider reference population		**0.27%**	**0.66%**
Magnitude of cumulative impact		**Negligible**	**Negligible**

Effect significance

763. If all included OWFs were undertaking other construction activities at the same time as North Falls, there is the potential for a negligible magnitude of impact for all marine mammal species.

764. Therefore, taking into account the medium receptor sensitivity for harbour porpoise and minke whale, and low sensitivity for grey seal and harbour seal, the overall cumulative effect for disturbance to marine mammals from construction activities at other OWFs is minor adverse for harbour porpoise and minke whale, and negligible for grey seal and harbour seal (Table 12.108). This is deemed to be a conservative assessment based on the worst case scenario for OWFs constructing at the same time as North Falls.

[40] TTS due to multiple vessels (East Anglia ONE North Limited, 2021)

Table 12.108 Assessment of effect significance for the potential for cumulative disturbance due to other OWFs constructing (or decommissioning) at the same time as North Falls

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual effect
Harbour porpoise and minke whale	Medium	Negligible	Minor adverse	None required.	Minor adverse
Grey seal and harbour seal	Low	Negligible	Negligible		Negligible

Mitigation

765. With the implementation of any management measures for the Southern North Sea SAC, the potential impacts could be reduced. Any mitigation measures to reduce the disturbance of harbour porpoise in the project specific SIPs could also reduce the potential disturbance of minke whale, grey seal and harbour seal.

12.9.3.1.3 Cumulative impact 1c: Assessment of disturbance from other activities

766. During the construction period for North Falls, there is the potential for disturbance to marine mammals associated with other potential noise sources, including:

- Geophysical surveys associated with other OWFs;
- Aggregate extraction and dredging;
- Oil and gas installation projects;
- Oil and gas seismic surveys;
- Subsea cable and pipelines;
- Other marine renewable projects (such as wave and tidal projects);
- Disposal sites; and
- UXO clearance.

767. The magnitude of impact from each of these activities is considered in the following sections, and an overall assessment of effect significance provided in Table 12.115 below.

768. For the installation of oil and gas infrastructure, marine renewable projects, and disposal sites, all potential projects have been screened out. Further information on the CEA screening (and these results) are provided in Appendix 12.6 (Document Reference: 3.3.11).

769. As outlined in Section 12.6.1.1.4 and 12.6.1.2.4, all marine mammal species are assessed as having medium sensitivity to disturbance from underwater noise sources.

Magnitude of disturbance

Disturbance from geophysical surveys

770. It is currently not possible to estimate the number of potential OWF geophysical surveys that could be undertaken at the same time as construction and potential piling activity at North Falls. As these surveys can have very short lead-in times, this would not be known until much closer to the construction being undertaken.

771. As outlined in Appendix 12.5 (Document Reference: 3.3.10), OWF geophysical surveys using Sub-Bottom Profilers (SBPs) and Ultra-Short Base Line (USBL) systems have the potential to disturb marine mammals and have therefore been screened into the CEA, as a precautionary approach.

772. The potential disturbance range used in the cumulative assessment is based on the SNCB guidance for assessment for harbour porpoise.

773. Assessments for the Review of Consents (RoC) HRA for the Southern North Sea SAC (BEIS, 2020) modelled the potential for disturbance due to the use of a SBP, and results indicated that there is the potential for a possible behavioural response in harbour porpoise at up to 3.77km (44.65km^2) from the source. The current guidance for assessing the significance of noise disturbance for harbour porpoise SACs (JNCC *et al.,* 2020) recommends the use of an EDR of 5km (78.54km^2) for geophysical surveys.

774. As a worst case, it has been assumed that all marine mammals within 5km of the survey source, a total area of 78.54km^2, could be disturbed.

775. For geophysical surveys with sub-bottom profilers, it is realistic and appropriate to base the assessments on the potential impact area around the vessel, as the potential for disturbance would be around the vessel at any one time. Marine mammals would not be at risk throughout the entire area surveyed in a day, as animals would return once the vessel had passed, and the disturbance had ceased.

776. However, as a precautionary approach, the assessment of the potential disturbance of harbour porpoise in the Southern North SAC in the RIAA will also include the possible disturbance from the survey area as assessed in the RoC HRA for the Southern North Sea SAC (BEIS, 2020).

777. It is currently not possible to estimate the location or number of potential OWF geophysical surveys that could be undertaken at the same time as construction and potential piling activity at North Falls. It is therefore assumed, as a worst case scenario, that there could potentially be up to two geophysical surveys in the North Sea at any one time, during construction of North Falls, with a total disturbance area of 157.1km^2.

778. As the location of the potential geophysical surveys is currently unknown, the following assessments are based on the density estimates as discussed in Section 12.9.3, with a density estimate of 0.55/km^2 for harbour porpoise (based on the North Assessment Unit), and 0.0085/km^2 for minke whale, as per the density estimate for the entire SCANS-IV survey area (Gilles *et al*., 2023). For grey seal and harbour seal, the density estimates are based on average Carter *et al*. (2022) estimate for the whole of the relevant MU, with an estimate of 0.296/km^2 for grey seal, and 0.065/km^2 for harbour seal.

779. For up to two geophysical surveys, with no other cumulative activities, the magnitude of impact would be negligible for all marine mammal species (Table 12.109).

Table 12.109 Quantitative assessment for cumulative disturbance of marine mammals due to up to two geophysical surveys at OWFs (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Potential cumulative effect	Marine mammal species	Marine mammal density (/km^2)	Potential cumulative impact area (km^2)	Maximum number of individuals potentially disturbed (% of reference population)	Potential magnitude of cumulative impact
Up to two geophysical surveys	Harbour porpoise	0.55	157.08	87 (0.03%)	Negligible
	Minke whale	0.0085		2 (0.01%)	Negligible
	Grey seal	0.296		47 (0.15%)	Negligible
	Harbour seal	0.065		11 (0.23%)	Negligible

Disturbance from aggregate extraction and dredging

780. Taking into account the small potential impact ranges, and distances of the aggregate extraction and dredging projects from North Falls, the potential for contribution to cumulative effects is very small. Therefore, risk of PTS or TTS for all marine mammal species from aggregate extraction and dredging has been screened out from further consideration in the CEA.

781. As a precautionary approach, a total of six aggregate extraction and dredging projects are included in the CEA for the potential cumulative disturbance (see Appendix 12.5 (Document Reference: 3.3.10).

782. As outlined in the Department for Business, Energy and Industrial Strategy BEIS (2020) RoC HRA for the Southern North Sea SAC, studies have indicated that harbour porpoise may be displaced by dredging operations within 600m of the activities (Diederichs *et al.,* 2010). As a worst case assessment, a disturbance range of 600m for up to six operational aggregate projects at the same time as North Falls construction has been used. A disturbance range of 600m would result in a potential disturbance area of 1.13km^2 for each project, or up to 6.8km^2 for all six aggregate projects. Only five of those aggregate projects are within the relevant Mus for both seal species, and therefore for seals, the potential disturbance area is 5.7km^2 (Table 12.110).

783. The densities for each marine mammal species are as outlined in Section 12.9.3.

784. For the potential cumulative disturbance from aggregate and dredging projects, the magnitude of impact would be negligible for harbour porpoise, minke whale, grey seal and harbour seal (Table 12.110).

Table 12.110 Quantitative assessment for cumulative disturbance of marine mammals due to aggregate and dredging projects (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Potential cumulative effect	Marine mammal species	Marine mammal density (/km^2)	Potential cumulative impact area (km^2)	Maximum number of individuals potentially disturbed (% of reference population)	Potential magnitude of cumulative effect
Aggregate and dredging projects (1.13km^2 disturbance area per project)	Harbour porpoise	0.55	6.78	4 (0.001%)	Negligible
	Minke whale	0.0085		0.1 (0.0003%)	Negligible
	Grey seal	0.296	5.70	2 (0.004%)	Negligible
	Harbour seal	0.065		0.4 (0.008%)	Negligible

Disturbance from oil and gas seismic surveys

785. It is currently not practicable to estimate the number of potential oil and gas seismic surveys that could be undertaken at the same time as construction and potential piling activity at North Falls. Therefore, it has been assumed that at any one time, up to two seismic surveys could be taking place at the same time.

786. This assessment for the potential disturbance due to oil and gas seismic surveys is based on the following for each marine mammal species:

- Harbour porpoise
    - The potential impact area during seismic surveys, based on a radius of 12km (452.4km^2 per survey, or 904.8km^2 for two surveys), following the current SNCB guidance for the assessment of impact on harbour porpoise in the Southern North Sea SAC.
- Minke whale
    - There is little available information on the potential for disturbance from seismic surveys, however, as noted in Section 12.6.1.1.4, observations of behavioural changes in other baleen whale species have shown avoidance reactions at up to 30km for a seismic survey (Richardson *et al.,* 1999). A potential disturbance range of 30km will therefore be applied to minke whale due to a lack of species-specific information (resulting in a disturbance area of 2,827.4km^2 for one survey, and up to 5,654.8km^2 for two seismic surveys).
- Grey seal and harbour seal

787. As minke whale, there is little available information on the potential for disturbance from seismic surveys for either grey seal or harbour seal, however, observations of behavioural changes in other seal species have shown avoidance reactions up to 3.6km from the source for a seismic survey (Harris *et al.,* 2001). A more recent assessment of potential for disturbance to seal species, as a result of seismic surveys, shows potential disturbance ranges from 13.3km to 17.0km from source (BEIS, 2020). These ranges are based on modelled impact ranges, using the NMFS Level B harassment threshold of 160dB, for a noise source of 3,070 cubic inches, 4,240 cubic inches, or 8,000 cubic inches.

- A potential disturbance range of 17.0km (or disturbance area of 907.9km² for one survey, and 1,815.8km² for up to two seismic surveys) will therefore be applied to both grey seal and harbour seal due to a lack of species-specific information.

788. The densities for each marine mammal species are as outlined in Section 12.9.3.

789. For oil and gas seismic surveys, with no other cumulative activities, the magnitude of impact would be negligible for harbour porpoise, minke whale, and grey seal, and low for harbour seal.

Table 12.111 Quantitative assessment for cumulative disturbance of marine mammals due to up to two oil and gas seismic surveys (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Potential cumulative effect	Marine mammal species	Marine mammal density (/km²)	Potential cumulative effect area (km²)	Maximum number of individuals potentially disturbed (% of reference population)	Potential magnitude of cumulative effect
Up to two seismic surveys	Harbour porpoise	0.55	904.8	498 (0.15%)	Negligible
	Minke whale	0.0085	5,654.8	49 (0.24%)	Negligible
	Grey seal	0.296	1,815.8	476 (0.84%)	Negligible
	Harbour seal	0.065		89 (1.83%)	Low

Disturbance from subsea cables and pipelines

790. Only one subsea pipeline has been screened into the cumulative assessment; Sea Link Interconnector. Published findings for the Sea Link project indicate the maximum disturbance range from construction activities will be up to 5km (with a disturbance area of 78.54km²).

791. The densities for Sea Link for harbour porpoise and minke whale have been taken from the PEIR findings (Sea Link, 2023), and seals species the densities are as outlined in Section 12.9.3.

792. For disturbance from subsea cables and pipeline projects, and no other cumulative activities, the magnitude of impact would be negligible for all marine mammal species (Table 12.112).

Table 12.112 Quantitative assessment for cumulative disturbance of marine mammals due to cable and pipeline projects (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Potential cumulative effect	Marine mammal species	Marine mammal density (/km²)	Potential cumulative impact area (km²)	Maximum number of individuals potentially disturbed (% of reference population)	Potential magnitude of cumulative effect
Cable and pipeline projects	Harbour porpoise	0.68 (Sea Link)	78.54	54 (0.02%)	Negligible
	Minke whale	0.01 (Sea Link)		0.8 (0.004%)	Negligible
	Grey seal	0.296		24 (0.04%)	Negligible

Potential cumulative effect	Marine mammal species	Marine mammal density (/km^2)	Potential cumulative impact area (km^2)	Maximum number of individuals potentially disturbed (% of reference population)	Potential magnitude of cumulative effect
	Harbour seal	0.065		6 (0.12%)	Negligible

Disturbance from UXO clearance

793. As for piling, the potential risk of PTS in marine mammals from cumulative effects has been screened out from further consideration in the CEA; if there is the potential for any PTS, suitable mitigation would be put in place to reduce any risk to marine mammals. Therefore, the CEA only considers potential disturbance impacts.

794. This assessment has been based on the potential for disturbance due to UXO clearance activities for other projects, cumulatively with the construction of North Falls.

795. It is currently not possible to estimate the number of potential UXO clearance events that could be undertaken at the same time as construction and potential piling activity at North Falls, and therefore, on a worst case basis, the potential for one high-order clearance and one low-order clearance has been assessed as having the potential to take place at the same time.

796. The magnitude of the potential disturbance from UXO clearance has been estimated based on the following:

- Harbour porpoise
    - The potential impact area of 2,123.7km^2 per project, based on 26km EDR for UXO high order detonation, and 78.5km^2 for low-order detonation, following the current SNCB guidance for the assessment of impact to harbour porpoise in the Southern North Sea SAC.
- Minke whale
    - The potential impact area during a single UXO clearance event, based on the modelled worst case impact range at North Falls for TTS / fleeing response (weighted SEL) of 110.0km (38,013.3km^2) for high-order clearance and 4.5km (63.62km^2) for low-order clearance.
- Grey seal and harbour seal
    - The potential impact area during a single UXO clearance event, based on the modelled worst case impact range at North Falls for TTS / fleeing response (weighted SEL) of 22.0km (1,520.5km^2) for high-order clearance and 0.8km (2.01km^2) for low-order clearance.

797. However, as outlined in the BEIS (2020) RoC HRA, due to the nature of the sound arising from the detonation of UXO, i.e., each blast lasting for a very short duration, marine mammals, including harbour porpoise, are not predicted to be significantly displaced from an area, any changes in behaviour, if they occur, would be an instantaneous response and short-term. Existing guidance suggests that disturbance behaviour is not predicted to occur from UXO clearance if undertaken over a short period of time (JNCC, 2010a).

798. Mitigation measures required for UXO clearance include the use of low-order clearance techniques, which could include a small donor charge, rather than full high-order detonation which is only used as a last resort. It is therefore highly unlikely that more than one UXO high-order detonation would occur at exactly the same time or on the same day as another UXO high-order detonation, even if they had overlapping UXO clearance operation durations. The CEA is therefore based on potential for disturbance from one UXO high-order detonation without additional mitigation (worst case), as well as one low-order clearance event.

799. The densities for each marine mammal species are as outlined in Section 12.9.3.

800. For UXO clearance, with no other cumulative activities, the magnitude of impact would be negligible for harbour porpoise, and low for minke whale, grey seal and harbour seal (Table 12.113).

Table 12.113 Quantitative assessment for cumulative disturbance of marine mammals due to UXO clearance (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Potential cumulative effect	Marine mammal species	Marine mammal density (/km^2)	Potential cumulative impact area (km^2)	Maximum number of individuals potentially disturbed	Potential magnitude of cumulative impact
One high-order (HO) and one low order (LO) UXO detonation	Harbour porpoise	0.55	HO: 2,123.7 LO: 78.5	HO: 1,168 LO: 44 Total: 1,212 (0.36%)	Negligible
	Minke whale	0.0085	HO: 38,013.3 LO: 63.62	HO: 324 LO: 0.5 Total: 325 (1.62%)	Low
	Grey seal	0.296	HO: 1,520.5 LO: 2.01	HO: 451 LO: 0.6 Total: 452 (1.48%)	Low
	Harbour seal	0.065		HO: 99 LO: 0.1 Total: 100 (2.05%)	Low

Magnitude of impact due to the disturbance from all potential noise sources (other than construction of OWF)

801. Each of the above described other noise sources are quantitively assessed together in Table 12.114.

802. For harbour porpoise, for noisy activities (other than OWF) with the potential for cumulative disturbance impacts together with piling at North Falls, the magnitude of impact is negligible, with up to 0.86% of the population at risk of disturbance.

803. For minke whale, for noisy activities (other than OWF) with the potential for cumulative disturbance impacts together with piling at North Falls, the magnitude of impact is low, with 1.88% of the population at risk of disturbance.

804. For noisy activities (other than OWF) with the potential for cumulative disturbance impacts together with piling at North Falls, the magnitude of impact is low for grey seal, with 1.78% of the population at risk of disturbance, and for

harbour seal, the magnitude of impact is low, with up to 4.29% of the reference population at risk.

Table 12.114 Quantitative assessment for all noisy activities with the potential for cumulative disturbance impacts for marine mammals (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Impact	Number of individuals			
	Harbour porpoise	Minke whale	Grey seal	Harbour seal
Worst case disturbance at North Falls	*1,072*	*37*	*112*	*7*
Up to two geophysical surveys (Table 12.109)	87	2	47	11
Aggregates and dredging (Table 12.110)	4	1	2	1
Up to two oil and gas seismic surveys (Table 12.111)	1,570	49	476	89
Subsea cables and pipelines (Table 12.112)	54	0.8	24	6
UXO clearance (Table 12.113)	1,212	325	452	100
Total number of individuals	**2,927**	**378**	**1,001**	**207**
Percentage of MU	**0.86%**	**1.88%**	**1.77%**	**4.25%**
Magnitude of cumulative impact	**Negligible**	**Low**	**Low**	**Low**

Effect significance for disturbance from all underwater noise sources (other than OWF)

805. If all included noisy activities (other than those associated with OWF construction) were taking place at the same time as piling at North Falls, there is the potential for a negligible to low magnitude of impact, for all marine mammal species.

806. Therefore, taking into account the medium receptor sensitivity for harbour porpoise and minke whale, and low sensitivity for grey seal and harbour seal, the overall cumulative effect for disturbance to marine mammals from construction activities at other OWFs is minor adverse for harbour porpoise, minke whale and grey seal, and negligible for harbour seal (Table 12.115).

Table 12.115 Assessment of effect significance for the potential for cumulative disturbance due to noisy activities (other than OWF)

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual effect
Harbour porpoise	Medium	Negligible	Minor adverse	None required.	Minor adverse
Minke whale	Medium	Low	Minor adverse		Minor adverse
Grey seal and arbour seal	Low	Low	Negligible		Negligible

Mitigation

807. The North Falls SIP for the Southern North Sea SAC will manage and reduce the potential for significant disturbance of harbour porpoise from cumulative underwater noise during OWF piling. This could also reduce the potential for disturbance for all other marine mammal species. It is highly likely that other OWFs within the Southern North Sea SAC would also require a SIP to manage the effect of cumulative disturbance, further reducing the potential for significant disturbance.

12.9.3.1.4 Summary of cumulative effect 1: assessment of disturbance from all noisy activities associated with offshore industries

808. Each of the above described sound sources are quantitively assessed together in Table 12.116.

809. For harbour porpoise, for all noisy activities with the potential for cumulative disturbance effects, the magnitude of impact is low, with up to 2% of the population at risk of disturbance.

810. For minke whale, for all noisy activities with the potential for cumulative disturbance effects, the magnitude of impact is low, with less than 5% of the population at risk of disturbance.

811. For all noisy activities with the potential for cumulative disturbance effects, the magnitude of impact is low for grey seal, with less than 1.9% of the population at risk of disturbance, and for harbour seal, the magnitude of impact is low, with up to 4.8% of the reference population at risk.

Table 12.116 Quantitative assessment for all noisy activities with the potential for cumulative disturbance effects for marine mammals (magnitude levels based on the percentage of the reference population affected, as set out in Table 12.9)

Impact	Number of individuals			
	Harbour porpoise	Minke whale	Grey seal	Harbour seal
Worst case disturbance at North Falls	<1% population level impact over first six years (Table 12.99)	3.06% population level impact over first six years (Table 12.100)	0% population level impact over first six years (Table 12.101; Table 12.102)	0% population level impact over first six years (Table 12.103)
Piling at other OWFs (Table 12.96; Table 12.97; Table 12.98)				
Construction (or decommissioning) activities at other OWFs (Table 12.105; Table 12.106; Table 12.107)	1,503	8	40	25
Up to two geophysical surveys (Table 12.109)	87	2	47	11
Aggregates and dredging (Table 12.110)	4	0.1	2	0.4
Up to two oil and gas seismic surveys (Table 12.111)	498	49	476	89

Impact	Number of individuals			
	Harbour porpoise	Minke whale	Grey seal	Harbour seal
Subsea cables and pipelines (Table 12.112)	54	0.8	24	6
UXO clearance (Table 12.113)	1,212	325	452	100
Total number of individuals	**3,358**	**385**	**1,041**	**232**
Percentage of MU	**1.99%** *(including 1% population effect from piling)*	**4.97%** *(including 3.06% population effect from piling)*	**1.84%**	**4.75%**
Magnitude of cumulative impact	**Low**	**Low**	**Low**	**Low**

Effect significance

812. If all included potentially noisy activities were undertaken at the same time as North Falls, there is the potential for a low magnitude of impact for all species.

813. Therefore, taking into account the medium receptor sensitivity for harbour porpoise and minke whale, and the sensitivity of low for grey seal and harbour seal, the overall cumulative effect for disturbance to marine mammals from other noisy industries, including North Falls, is minor adverse for all species (Table 12.117). This is deemed to be a conservative assessment based on the worst case scenario for OWFs constructing at the same time as North Falls.

814. It should be noted that while the projects included within the cumulative assessment for disturbance from other projects and activities taking place at the same time were based on the current knowledge of their possible construction or activity windows, and it is very unlikely that all activities would be taking place on the same day or in the same season, and therefore this likely represents an over-precautionary and worst case estimate of the marine mammals that could be at risk of disturbance during the two year construction of North Falls.

Table 12.117 Assessment of effect significance for the potential of a cumulative disturbance effect due to all other noisy projects and activities

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual effect
Harbour porpoise and minke whale	Medium	Low	Minor adverse	None required.	Minor adverse
Grey seal and harbour seal	Low	Low	Minor adverse		Minor adverse

Mitigation

815. The North Falls SIP for the Southern North Sea SAC could manage and reduce the potential for significant disturbance of harbour porpoise from cumulative underwater noise during OWF piling. This could also reduce the potential for disturbance for all other marine mammal species.

12.9.3.2 Cumulative impact 2: Barrier effects

816. The sensitivity of marine mammals due to barrier effects is medium for a barrier effect due to underwater noise (see Section 12.6.1.4.1).

817. For the assessment of the potential for barrier effects due to underwater noise from projects undergoing construction, the effect to marine mammal species would be as per the assessments provided in Section 12.9.3.1.4, for cumulative disturbance effects due to all noisy activities, with a residual effect of minor adverse for all marine mammal species, with mitigation (Table 12.117).

818. It is important to note that the OWFs and other noise sources included in the CEA are spread over the wider area of the North Sea.

819. The maximum underwater impact ranges for disturbance at Five Estuaries could overlap with disturbance ranges at North Falls, taking into account the maximum underwater impact ranges for disturbance from monopiling at North Falls and Five Estuaries (as provided in Five Estuaries Wind Farm Ltd., 2023). Therefore, there is a potential for underwater noise from North Falls and Five Estuaries to result in a barrier of movement to marine mammals.

820. The potential magnitude of cumulative impact for a barrier to marine mammals, as a result of cumulative underwater noise impacts, is low, due to the short-term nature of the impact, and that there is sufficient space for marine mammals to move through the area, while avoiding potential disturbance areas, in the case of both North Falls and Five Estuaries undertaking activities at the same time. In addition, the offshore project area is not located on any known migration routes for marine mammals, and the disturbance ranges do not overlap with any seal haul out sites.

821. The potential magnitude for a cumulative barrier impact due to underwater noise is therefore assessed as low as a precautionary approach.

822. Therefore, with the sensitivity of medium for harbour porpoise and minke whale, and low for both grey seal and harbour seal for barrier effects due to underwater noise, the effect significance for all marine mammal species would be negligible to minor adverse (Table 12.118).

Table 12.118 Assessment of effect significance for the potential of a cumulative barrier effect

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual effect
Cumulative barrier effect with other projects					
Harbour porpoise and minke whale	Medium	Low	Minor adverse	None required.	Minor adverse
Grey seal and harbour seal	Low	Low	Negligible		Negligible

823. No mitigation is required for the potential for cumulative barrier effects from underwater noise.

12.9.3.3 Cumulative impact 3: Impacts due to vessel presence

12.9.3.3.1 Impact 3a: Disturbance from vessels associated with operational OWFs

824. While it is unknown exactly how many vessels would be on any OWF site during their operation, it is expected that impacts associated with underwater noise and disturbance from vessels during operation would be less than those during construction as assessed above.

825. If the response is displacement from the area, marine mammals will return once the vessel has passed, and therefore any impacts from vessel presence will be both localised and temporary. Therefore, there is unlikely to be the potential for any significant disturbance effect on marine mammals.

826. As an example, an increase of 22 vessels (at any one time) within North Falls during operation is significantly less than the Heinänen and Skov (2015) threshold of 80 vessels per day within $5km^2$ (22 vessels within the $223.4km^2$ project area would be less than 0.1 vessels per km^2, or 0.5 vessels per $5km^2$, per day). There is likely to be a similar level of vessel presence across all operational wind farms within the North Sea, and therefore it is unlikely there would be any potential for a significant effect for harbour porpoise.

827. Currently available monitoring studies for operational wind farms suggests that marine mammals are not significantly disturbed, and that any impact is localised and temporary (e.g. Diederichs *et al.,* 2008; Teilmann *et al.,* 2006; McConnell *et al.,* 2012). Harbour porpoise and seals have also been found to continue to forage within operational wind farm sites (Lindeboom *et al.,* 2011; Russell *et al.,* 2014). These monitoring studies suggest that there is no significant disturbance from operational wind farms, which may have a number of vessels present at any one time.

828. Vessels associated with offshore wind farm operation are likely to undertake similar activities to those for construction, albeit with much lower frequency. Russel (2016) found that harbour seal foraged within an area undergoing offshore wind farm construction. Benhemma-Le Gall *et al*. (2021) found that harbour porpoise could be disturbed up to 4km from construction related vessels, although a higher proportion are disturbed at 2km.

829. It is expected that the vessel movements to an operational OWF, and from any port, will be incorporated within existing vessel routes and therefore to areas where marine mammals may already be accustomed to their presence. The increase in vessel presence from operational OWFs is expected to be relatively small compared to the baseline levels of vessel movements in the area. It is also expected that good practice measures, as implemented for North Falls, would be in place for all operational OWFs, further limiting the potential for disturbance.

830. Once on-site, OWF vessels would be stationary or slow moving, as they undertake the activity they are associated with, and therefore the potential for disturbance would be minimal.

831. The potential for vessel disturbance is considered to be localised and temporary, and marine mammals are expected to return to the project areas shortly after vessels have left the area. Therefore, a magnitude of low (as a precautionary basis) is appropriate.

832. With the sensitivity of medium for harbour porpoise and minke whale, and low for both seal species, this would result in an overall impact assessment of negligible to minor adverse (Table 12.119).

Table 12.119 Assessment of effect significance for the potential of a cumulative disturbance effect from vessels associated with operational OWFs

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual effect
Harbour porpoise and minke whale	Medium	Low	Minor adverse	None required.	Minor adverse
Grey seal and harbour seal	Low	Low	Negligible		Negligible

833. No mitigation is proposed for underwater noise from operation and maintenance vessels, as the risk of any effect is minor adverse or negligible. However, vessel movements, where practicable, will be incorporated into recognised vessel routes and hence to areas where marine mammals are accustomed to vessels, in order to reduce any impacts, including increased disturbance.

12.9.3.3.2 Impact 3b: Increased collision risk with vessels

834. As outlined in Sections 12.6.1.5 and 12.6.2.5, the increased collision risk even using a very precautionary approach, has an effect significance of minor adverse (with mitigation), with a low number of marine mammals at risk (with 7 harbour porpoise at risk during the construction phase being the highest number at risk).

835. Vessel movements to and from any port will be incorporated within existing vessel routes and therefore there would be no increased collision risk as the increase in the number of OWF vessels would be relatively small compared to the baseline levels of vessel movements in these areas.

836. Once on-site, OWF vessels would be stationary or slow moving, as they undertake the activity they are associated with. Therefore, the risk of any increased collision risk for marine mammals would be negligible, if any.

837. Vessels associated with aggregate extraction and dredging are large and typically slow moving, using established transit routes to and from ports. Therefore, the potential increased collision risk with vessels is considered to be extremely low or negligible. Therefore, increased collision risk from aggregate extraction and dredging has been screened out from further consideration in the CEA.

838. Good practice measures, as implemented for North Falls, would ensure any risk of vessels colliding with marine mammals is avoided.

839. Therefore, with the sensitivity of low for all marine mammal species, except for minke whale which has been assessed as medium, and the expected magnitude level of low to medium, the effect significance for all marine mammal species would be negligible to minor adverse (Table 12.120).

Table 12.120 Assessment of effect significance for the potential for increased collision risk with vessels

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual effect
Harbour porpoise and grey seal	Low	Low	Negligible	Vessel good practice measures to manage collision risk	Negligible
Harbour seal	Low	Medium	Minor adverse		Minor adverse

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual effect
Minke whale	Medium	Medium	Moderate adverse		Minor adverse

840. No mitigation is required for the potential for increased collision risk due to cumulative projects, over and above those that would be undertaken for the Project alone (see Sections 12.6.1.5 and12.6.2.5). However, it is expected that all projects would utilise vessel good practice measures to reduce the potential for impact.

12.9.3.4 Cumulative impact 4: Disturbance at seal haul-out sites

841. The sensitivity of grey seal and harbour seal to disturbance at haul-out sites is medium (see Section 12.6.1.5.3).

842. As stated in Section 12.6.1.5.3, due to the baseline vessel traffic being relatively high, and the closest distance of North Falls to any seal haul-out site being 11km, it is not expected that North Falls would have any likely significant effect to seal at haul-out sites, with an effect significance of minor adverse. In addition, good practice measures would be implemented by North Falls, such as reducing vessel transit speeds wherever practicable, and the avoidance of transiting within 1km of any seal haul-out site.

843. It is assumed that all other projects would follow the same good practice measures with regards to avoiding disturbance at haul-out sites. In addition, where seal haul-out sites are near to a vessel corridor, the seals present in that area would be used to vessels transiting past the area. It is therefore considered that there would be limited potential for any cumulative disturbance effect at any seal haul-out site, and the cumulative magnitude of impact would be negligible.

844. Therefore, with the sensitivity of medium for both seal species, and the expected magnitude level of negligible (at worst), the effect significance for cumulative disturbance at seal haul-out sites would be minor adverse (Table 12.121).

Table 12.121 Assessment of effect significance for the potential for disturbance at seal haul-out sites

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual effect
Grey seal and harbour seal	Medium	Negligible	Minor adverse	None required.	Minor adverse

845. No mitigation is required for the potential for cumulative disturbance at seal haul-out sites, over and above those that would be undertaken for the Project alone (see Section 12.3.3).

12.9.3.5 Cumulative impact 5: Changes to prey resources

846. For any potential changes to prey resources, it has been assumed that any potential impacts on marine mammal prey species from underwater noise, including piling, would be the same or less than those for marine mammals. Therefore, there would be no additional cumulative impacts other than those assessed for marine mammals, i.e., if prey is disturbed from an area as a result of underwater noise, marine mammals will be disturbed from the same or

greater area. As a result any changes to prey resources would not affect marine mammals as they would already be disturbed from the area.

847. Any impacts to prey species are likely to be intermittent, temporary and highly localised, with potential for recovery following cessation of the disturbance activity. Any permanent loss or changes of prey habitat will typically represent a small percentage of the potential habitat for prey species in the surrounding area.

848. Taking into account the assessment for North Falls alone (Sections 12.6.1.7.3 and 12.6.2.8), and assuming similar impacts for other projects and activities, along with the range of prey species taken by marine mammals and the extent of their foraging ranges, there would be no potential for cumulative impact on marine mammal populations as a result of changes to prey resources. Therefore, the cumulative magnitude is considered to be negligible.

849. With the sensitivity of low to medium for harbour porpoise and minke whale, and low for grey and harbour seal, and the expected magnitude level of negligible (at worst), the effect significance for all marine mammal species would be negligible to minor adverse.

Table 12.122 Assessment of effect significance for the potential for changes to prey resources

Marine mammal species	Sensitivity to potential effect	Magnitude of impact	Likely effect significance	Mitigation	Residual effect
Harbour porpoise and minke whale	Low to medium	Negligible	Negligible to minor adverse	None required.	Negligible to minor adverse
Grey seal and harbour seal	Low	Negligible	Negligible		Negligible

850. No mitigation is required for the potential for cumulative effects to prey species.

12.10 Transboundary effects

851. The highly mobile nature of marine mammals included within this assessment means that there is the potential for transboundary effects to the marine mammal populations included. The potential transboundary effects are those that can have far ranging effects, or those where foraging individuals may transit to areas of effect. These are;

- Auditory injury and disturbance or behavioural effects resulting from underwater noise during;
  - Piling;
  - UXO clearance;
  - Other construction and O&M activities;
  - Vessel presence; and
  - Operational WTGs.
- Barrier effects as a result of underwater noise;
- Vessel interaction (collision risk); and
- Changes to prey resource.

852. It is not expected that there would be any transboundary effects at seal haul-out sites in other countries due to the Projects location and potential transit

routes, or that there would be any potential for transboundary effects due to water quality changes (due to the very localised and temporary nature of any such effect).

853. The potential for a transboundary effect , under all the above effect pathways, has been taken into account throughout the assessments, as the study area for each species is based on their relevant MU (or area within which the same individuals are considered to part of one larger overall population).

854. The MUs (and therefore reference populations) for each species covers an area wider than the UK (Table 12.123). This approach has been taken through all of the assessments, and therefore any potential effects on marine mammals in other countries are already considered within the assessments. Further detail on which species have been included within assessments and why can be found in the Marine Mammal Baseline Appendix 12.2 (Document Reference: 3.3.7).

Table 12.123 Other countries considered in the marine mammal assessments through the relevant MU reference populations

Country	Marine mammal species	Inclusion within assessments
Netherlands	Harbour porpoise	Part of the NS MU for harbour porpoise.
	Minke whale	Part of the CGNS MU for minke whale.
Germany	Harbour porpoise	Part of the NS MU for harbour porpoise.
	Minke whale	Part of the CGNS MU for minke whale.
France	Harbour porpoise	Part of the NS MU for harbour porpoise.
	Minke whale	Part of the CGNS MU for minke whale.
	Grey seal and harbour seal	Not part of the grey seal and harbour seal reference population area, and therefore no potential for transboundary impacts.
Belgium	Harbour porpoise	Part of the NS MU for harbour porpoise.
	Minke whale	Part of the CGNS MU for minke whale.
	Grey seal and harbour seal	Not part of the grey seal and harbour seal reference population area, and therefore no potential for transboundary impacts.
Denmark	Harbour porpoise	Part of the NS MU for harbour porpoise.
	Minke whale	Part of the CGNS MU for minke whale.
Sweden	Harbour porpoise	Part of the NS MU for harbour porpoise.
	Minke whale	Part of the CGNS MU for minke whale.
	Grey seal and harbour seal	Not part of the grey seal and harbour seal reference population area, and therefore no potential for transboundary impacts.
Norway	Harbour porpoise	Part of the NS MU for harbour porpoise.
	Minke whale	Part of the CGNS MU for minke whale.
	Grey seal and harbour seal	Not part of the grey seal and harbour seal reference population area, and therefore no potential for transboundary impacts.

855. There is a substantial level of marine development being undertaken, and being planned, by other countries in the southern North Sea. Each of these countries have their own independent environmental assessment requirements and

controls. As noted above, marine mammals are highly mobile and there is therefore the potential for transboundary effects to marine mammal populations, especially with regard to noise.

856. In addition, if there is potential for North Falls to affect marine mammals from other designated sites, this is assessed in the HRA.

857. The potential for transboundary effects has been assessed with the other cumulative effects, as these are based on the wide MU areas; and European wind farms, where relevant, are included in the CEA.

12.11 Interactions

858. For marine mammals, potential interactions between impact pathways are already covered as part of the marine mammal assessments provided above. Table 12.124 provides a signposting to where these potential interaction impacts have already been assessed.

Table 12.124 Marine mammal interactions

Topic and description	Related chapter (Volume 3.1)	Where addressed in this chapter	Rationale
Construction			
Underwater noise from vessels	ES Chapter 15 Shipping and Navigation (Document Reference: 3.1.17)	Section 12.6.1.3	Increased vessel traffic associated with North Falls could affect the level of disturbance for marine mammals.
Increased risk of collision with vessels	ES Chapter 15 Shipping and Navigation (Document Reference: 3.1.17)	Section 12.6.1.5	Increased vessel traffic associated with North Falls could affect the level of collision risk for marine mammals.
Changes to water quality	ES Chapter 9 Marine Water and Sediment Quality (Document Reference: 3.1.11)	Section 493	Potential changes to water quality, such as increased SSC, could affect marine mammals directly or indirectly as a result of impacts on prey species.
Changes to prey resources	ES Chapter 11 Fish and Shellfish Ecology (Document Reference: 3.1.13)	Section 12.6.1.7.3	Potential effects on fish species could affect the prey resource for marine mammals.
Operation			
Underwater noise from vessels	ES Chapter 15 Shipping and Navigation (Document Reference: 3.1.17)	Section 12.6.2.2.3	Increased vessel traffic associated with North Falls could affect the level of disturbance for marine mammals.
Increased risk of collision with vessels	ES Chapter 15 Shipping and Navigation (Document Reference: 3.1.17)	Section 12.6.2.5	Increased vessel traffic associated with North Falls could affect the level of collision risk for marine mammals.
Changes to water quality	ES Chapter 9 Marine Water and Sediment Quality (Document Reference: 3.1.11)	Section 12.6.2.7	Potential changes to water quality, such as increased SSC, could affect marine mammals directly or

Topic and description	Related chapter (Volume 3.1)	Where addressed in this chapter	Rationale
			indirectly as a result of impacts on prey species.
Changes to prey resources	ES Chapter 11 Fish and Shellfish Ecology (Document Reference: 3.1.13)	Section 12.6.2.8	Potential effects on fish species could affect the prey resource for marine mammals.
Decommissioning			
Underwater noise from vessels	ES Chapter 15 Shipping and Navigation (Document Reference: 3.1.17)	Section 12.6.2.8	Increased vessel traffic associated with North Falls could affect the level of disturbance for marine mammals.
Increased risk of collision with vessels	ES Chapter 15 Shipping and Navigation (Document Reference: 3.1.17)	Section 12.6.2.8	Increased vessel traffic associated with North Falls could affect the level of collision risk for marine mammals.
Changes to water quality	ES Chapter 9 Marine Water and Sediment Quality (Document Reference: 3.1.11)	Section 12.6.2.8	Potential changes to water quality, such as increased SSC, could affect marine mammals directly or indirectly as a result of impacts on prey species.
Changes to prey resources	ES Chapter 11 Fish and Shellfish Ecology (Document Reference: 3.1.13)	Section 12.6.2.8	Potential effects on fish species could affect the prey resource for marine mammals.

12.12 Inter-relationships

859. The impacts identified and assessed in this chapter have the potential to inter-relate with each other. The areas of potential inter-relationships between the impacts assessed through this chapter are presented in Table 12.125. This provides a screening tool for which impacts have the potential to interrelate. Table 12.126 provides an assessment for each receptor (or receptor group) as related to these impacts.

860. The worst case impacts assessed within the chapter take these inter-relationships into account, and therefore the impact assessments are considered conservative and robust. Synergistic impacts of potential disturbance from underwater noise during construction from all potential noise sources have been assessed as potential barrier effects in the following tables.

861. Within Table 12.126 the impacts are assessed relative to each development phase (i.e., construction, operation or decommissioning) to see if (for example) multiple construction impacts affecting the same receptor could increase the significance of effect upon that receptor. Following this, a lifetime assessment is undertaken which considers the potential for impacts to affect receptors across all development phases.

862. The significance of each individual impact is determined by the sensitivity of the receptor and the magnitude of impact; the sensitivity is constant whereas the magnitude may differ. Therefore, when considering the potential for impacts to

be additive it is the magnitude of impact which is important – the magnitudes of the different impacts are combined upon the same sensitivity receptor.

Table 12.125 Inter-relationships between impacts – screening

Project inter-relationships	Auditory injury from UXO	UXO Disturbance	Construction impact 1a & b	Construction impact 1c & d	Operation impact 1a & b	Operation impact 1c	Impact 2a & b	Impact 2c	Impact 3a & b	Impact 3c	Impact 4	Impact 5	Impact 6	Impact 7	Impact 8
Construction															
Auditory injury from underwater noise associated with UXO clearance (Appendix 12.5 (Document Reference: 3.3.10))	-	Yes	Yes	Yes			Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Disturbance from underwater noise associated with UXO clearance (Appendix 12.5 (Document Reference: 3.3.10))	Yes	-	Yes	Yes			Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Impact 1a & 1b: auditory injury due to piling (Section 12.6.1.1.2 and 12.6.1.1.3)	Yes	Yes	-	No			Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Impact 1c & d: disturbance from due to piling and ADD activation (Section 12.6.1.1.4 and 12.6.1.1.5)	Yes	Yes	No	-			Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Impact 2a & 2b: auditory injury due to other construction activities (Section 12.6.1.2.2 and 337)	Yes	Yes	Yes	Yes			-	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Impact 2c: disturbance due to other construction activities (Section 12.6.1.2.4)	Yes	Yes	Yes	Yes			No	-	Yes	Yes	Yes	No	Yes	Yes	Yes
Impact 3a & b: auditory injury due to construction vessels (Section 12.6.1.3.2 and 399)	Yes	Yes	Yes	Yes			Yes	Yes	-	No	Yes	No	Yes	Yes	Yes
Impact 3c: disturbance due to construction vessels (Section 12.6.1.3.4)	Yes	Yes	Yes	Yes			Yes	Yes	No	-	Yes	No	Yes	Yes	Yes
Impact 4: barrier effects as a result of underwater noise (Section 12.6.1.4)	Yes	Yes	Yes	Yes			Yes	Yes	Yes	Yes	-	No	Yes	Yes	Yes
Impact 5: vessel interaction (collision risk) (Section 12.6.1.5)	No	No	No	No			No	No	No	No	No	-	No	No	No
Impact 6: disturbance at seal haul-out sites (Section 12.6.1.5.3)	Yes	Yes	Yes	Yes			Yes	Yes	Yes	Yes	Yes	No	-	No	Yes
Impact 7: changes to water quality (Section 493)	Yes	Yes	Yes	Yes			Yes	Yes	Yes	Yes	Yes	No	No	Yes	-

Project inter-relationships	Auditory injury from UXO	UXO Disturbance	Construction impact 1a & b	Construction impact 1c & d	Operation impact 1a & b	Operation impact 1c	Impact 2a & b	Impact 2c	Impact 3a & b	Impact 3c	Impact 4	Impact 5	Impact 6	Impact 7	Impact 8
Impact 8: changes to prey resources (Section 12.6.1.7.3)	Yes	Yes	Yes	Yes			Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Operation															
Impact 1a & b: auditory injury due to operational wind turbines (Section 12.6.2.1.2 and 548)					-	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Impact 1c: disturbance due to operational wind turbines (Section 561)					No	-	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Impact 2: auditory injury due to maintenance activities (Section 12.6.2.1.6)					Yes	Yes	-	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Impact 3a & b: auditory injury due to operation and maintenance vessels (Section 12.6.2.3.1)					Yes	Yes	Yes	Yes	-	No	Yes	No	Yes	Yes	Yes
Impact 3c: disturbance due to operation and maintenance vessels (Section 12.6.2.3.212.6.1.3.4)					Yes	Yes	Yes	Yes	No	-	Yes	No	Yes	Yes	Yes
Impact 4: barrier effects as a result of underwater noise (Section 12.6.2.4)					Yes	Yes	Yes	Yes	Yes	Yes	-	No	Yes	Yes	Yes
Impact 5: vessel interaction (collision risk) (Section 12.6.2.5)					No	No	No	No	No	No	No	-	No	No	No
Impact 6: disturbance at seal haul-out sites (Section 12.6.2.5.3)					Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	-	No	Yes
Impact 7: changes to water quality (Section 12.6.2.7)					Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	-
Impact 8: changes to prey resources (Section 12.6.2.8)					Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes

Table 12.126 Inter-relationships between impacts – phase and lifetime assessment

Receptor	Highest residual significance level			Phase assessment	Lifetime assessment
	Construction	Operation	Decommissioning		
Harbour porpoise, minke whale, grey seal and harbour seal	Minor adverse	Minor adverse	Minor adverse	**Construction** The Draft MMMP (for both UXO and piling) will reduce the risk of injury for mammals, and therefore during UXO clearance or piling there will be no pathway for interaction of potential injury with disturbance effects (i.e., all individuals are assumed to be disturbed if within range and excluded from the disturbance footprint). The assessment of potential effects to marine mammals during piling (Section 12.6.1.1) represents the worst case scenario for underwater noise, based on the maximum potential area for piling. Any potential effects from other construction activities and vessels are likely to be within the worst case effect area assessed for piling. However, as a precautionary approach, the spatial worst case for the maximum area over which potential disturbance could occur at any one time has been determined. For harbour porpoise the maximum area for potential disturbance is the 26km EDR for a single monopile installation at North Falls as assessed in Section 12.6.1.1. The array area is a total of $95km^2$, with an offshore cable corridor area of approximately $57km^2$,. Therefore, the $2,123.7km^2$ area for the 26km EDR would cover the whole offshore project area. As a result, there would be no additional disturbance of harbour porpoise from construction or vessel noise sources in addition to the 26km EDR. This would include ADD activation which would also be within the 26km EDR. There would be no further additional impacts as any potential changes in prey resources would be within the maximum impact area assessed for harbour porpoise. For the other marine mammal species, for which there are no EDRs and it is not applicable to use the 26km EDR, the overall potential effects have been based on the maximum	No greater than individually assessed impact The greatest magnitude of impact will be the spatial footprint of construction noise (i.e., UXO clearance and piling). Once this disturbance impact has ceased all further impact during construction and operation will be small scale, highly localised and episodic. There is no evidence of long term displacement of marine mammals from operational OWFs. It is therefore considered that over the Project lifetime these impacts would not combine and represent an increase in the significance level.

Receptor	Highest residual significance level			Phase assessment	Lifetime assessment
	Construction	Operation	Decommissioning		
				potential disturbance during piling at the same time as other potential construction activities, including vessels, in the offshore cable corridor. For minke whale, the maximum potential area for overall effects from underwater noise during construction is encompassed by the maximum TTS SEL_{cum} area for piling at two simultaneous locations 2,400km^2, as assessed in Section 12.6.1.1.3. As outlined above for harbour porpoise and the 26km EDR, this range and area would include the whole offshore project area, and therefore all activities and noise sources within the area, including ADD activation and other construction activities, including vessels. For minke whale, there would be no further additional impacts as any potential changes in prey resources would be within the maximum impact area assessed. For grey seal and harbour seal, the maximum potential overall impact area is the maximum predicted impact area for disturbance due to piling at two simultaneous locations, of up to 3,927km^2 as assessed in Section 12.6.1.1.4. This is greater than other potential areas of effect for seal species. This area would include the whole offshore project area, and therefore all activities and noise sources within the area, including ADD activation and other construction activities, including vessels. There would be no further additional impacts as the maximum impact area during construction has been assessed for all species. Likewise, there is no pathway for vessel interaction or effects on prey resource to interact with noise impacts as it is assumed that individuals will be excluded from the disturbance footprint (i.e., there cannot be a vessel interaction if the individual is excluded from the vicinity of the construction works). Once noisy activities have ceased, the footprint of disturbance and changes to prey resource will be highly localised.	

Receptor	Highest residual significance level			Phase assessment	Lifetime assessment
	Construction	Operation	Decommissioning		
				It is therefore considered that the interaction of these impacts would not represent an increase in the significance level.	
				Operation Operational noise impacts from WTGs will be highly localised to within 0.1km of each WTG, whilst the majority of change to habitat for prey species will also be confined to the immediate footprint of wind turbine. The magnitude of impact is negligible and relates to largely the same spatial footprint. There would be no further effects during operation and maintenance phase of North Falls, as the assessment for any potential disturbance as a result of underwater noise represents the worst case. Therefore, there is no greater impact as a result of any interaction of these impacts. There is potential for interaction with maintenance noise disturbance and vessel interaction, but given the negligible magnitudes of impact and episodic nature of these impacts it is not considered that that the interaction of these impacts would represent an increase in the significance level. Any potential impacts during operation and maintenance from underwater noise, changes in prey resources or water quality would be localised, temporary and negligible. **Decommissioning** The magnitude of decommissioning impacts will be comparable to or less than the construction phase. Therefore, there would not be an increase in the significance level from that determined during construction.	

12.13 Summary

863. This chapter has provided a baseline characterisation of marine mammals, based on both site-specific survey data and desk-based sources. Harbour porpoise are the most common marine mammal species in the vicinity of the Project, with both grey seal and harbour present in lower numbers in the array area, with relatively higher presence along the coast. Minke whale are also present, albeit in lower number.

864. The potential impacts on marine mammals during the construction, operation, maintenance and decommissioning phases of North Falls, including the potential for cumulative effects are summarised in Table 12.127.

865. For North Falls alone, while there is the potential for a significant effect due to underwater noise effects of piling (for harbour porpoise and minke whale), from vessels (for harbour porpoise), these effects can be managed with mitigation, and therefore the residual effects for all species would be negligible to minor adverse.

866. Mitigation is required for UXO clearance and piling following JNCC guidelines which will be adapted to cover PTS ranges. ADDs will also be used as part of mitigation for piling and UXO clearance. All mitigation and monitoring requirements will be secured through the MMMP, SIP and PEMP, further details are provided in Section 12.8.

867. For North Falls cumulatively with other projects, an initial assessment found the potential for a significant effect due to multiple OWFs piling at the same time for both harbour porpoise and grey seal, however population modelling for these species shows that this would not cause a population level impact, with less than a 1% reduction in the harbour porpoise population, and no change to the grey seal population over the next 25 years as a result of these OWFs.

868. All other cumulative effects were assessed as negligible to minor adverse.

869. Transboundary interactions between marine mammals with other topics, include:

- ES Chapter 9 Marine Water and Sediment Quality (Document Reference: 3.1.11)
- ES Chapter 11 Fish and Shellfish Ecology (Document Reference: 3.1.13)
- ES Chapter 15 Shipping and Navigation (Document Reference: 3.1.17)

870. None of the potential inter-relationships identified with respect to Marine Mammals are expected to result in a synergistic or greater impact than those assessed in Section 12.6.

Table 12.127 Summary of potential effects to marine mammals

Potential impact	Receptor	Sensitivity	Magnitude of impact	Significance of effect	Additional mitigation measures	Residual effect
Construction						
Impact 1a: PTS due to a single strike of a monopile or jacket pin pile at maximum hammer energy	Harbour porpoise	High	Low	Moderate adverse	Draft MMMP for piling will significantly reduce any potential for marine mammals to be within the PTS effect area.	Minor adverse
	Minke whale, grey seal and harbour seal		Negligible	Minor adverse		Minor adverse
Impact 1a: PTS due to the cumulative exposure of three sequential monopiles or six sequential jacket pin piles in a 24 hour period	Harbour porpoise	High	Medium	Major adverse		Minor adverse
	Minke whale		Low	Moderate adverse		Minor adverse
	Grey seal and harbour seal		Negligible	Minor adverse		Minor adverse
Impact 1a: PTS due to the cumulative exposure of simultaneous monopile or jacket pin pile installations	Harbour porpoise and minke whale	High	Medium	Major adverse	Draft MMMP for piling will reduce any potential for marine mammals to be within the PTS effect area.	Minor adverse
	Grey seal and harbour seal		Negligible	Minor adverse		Minor adverse
Impact 1b: TTS due to a single strike of a monopile or a jacket pin pile at maximum hammer energy	Harbour porpoise, minke whale, grey seal and harbour seal	Medium	Negligible	Minor adverse	None required.	Minor adverse
Impact 1b: TTS due to cumulative exposure of three sequential monopiles in a 24 hour period	Harbour porpoise, minke whale, grey seal and harbour seal	Medium	Negligible	Minor adverse	None required.	Minor adverse
Impact 1b: TTS due to cumulative exposure of six sequential jacket pin piles in a 24 hour period	Harbour porpoise	Medium	Low	Minor adverse	None required.	Minor adverse

Potential impact	Receptor	Sensitivity	Magnitude of impact	Significance of effect	Additional mitigation measures	Residual effect
	Minke whale, grey seal and harbour seal		Negligible			
Impact 1b: TTS due to the cumulative exposure of simultaneous monopile or jacket pin pile installations	Harbour porpoise	Medium	Low	Minor adverse	None required.	Minor adverse
	Minke whale, grey seal and harbour seal		Negligible			
Impact 1c: Potential for disturbance based on known effect ranges for monopiles or jacket pin piles	Harbour porpoise	Medium	Low	Minor adverse	None required.	Minor adverse
	Minke whale (based on TTS / fleeing response)		Negligible	Minor adverse		Minor adverse
	Grey seal and harbour seal	Low	Negligible	Negligible		Negligible
Impact 1c: Potential for disturbance based on a dose-response curve for monopiles or jacket pin piles	Harbour porpoise	Medium	Negligible	Minor adverse	None required.	Minor adverse
	Grey seal and harbour seal	Low	Negligible	Negligible		Negligible
Impact 1c: Reduction in foraging due to noise disturbance	Harbour porpoise and minke whale	Medium	Low	Minor adverse	None required.	Minor adverse
	Grey seal and harbour seal	Low	Low	Negligible	None required.	Negligible
Impact 1d: Potential for disturbance due to ADD activation	Harbour porpoise and minke whale	Medium	Negligible	Minor adverse	None required.	Minor adverse
	Grey seal and harbour seal	Low	Negligible	Negligible		Negligible

Potential impact	Receptor	Sensitivity	Magnitude of impact	Significance of effect	Additional mitigation measures	Residual effect
<u>Impact 2a:</u> PTS due to other construction activities	Harbour porpoise, minke whale, grey seal and harbour seal	High	Negligible	Minor adverse	None required.	Minor adverse
<u>Impact 2b:</u> TTS due to other construction activities	Harbour porpoise, minke whale, grey seal and harbour seal	Medium	Negligible	Minor adverse	None required.	Minor adverse
<u>Impact 2c:</u> Disturbance due to other construction activities	Harbour porpoise and minke whale	Medium	Negligible	Minor adverse	None required.	Minor adverse
	Grey seal and harbour seal	Low	Negligible	Negligible		Negligible
<u>Impact 3a:</u> PTS due to construction vessels	Harbour porpoise	High	Negligible to low	Minor to moderate adverse	Vessel good practice measures will be in place.	Minor adverse
	Minke whale, grey seal and harbour seal	High	Negligible	Minor adverse		Minor adverse
<u>Impact 3b:</u> TTS due to construction vessels	Harbour porpoise, minke whale, grey seal and harbour seal	Medium	Negligible	Minor adverse	None required, but vessel good practice measures be in place.	Minor adverse
<u>Impact 3c:</u> Disturbance due to construction vessels	Harbour porpoise and minke whale	Medium	Negligible	Minor adverse	None required, but vessel good practice measures will reduce disturbance.	Minor adverse
	Grey seal and harbour seal	Low	Negligible	Negligible		Negligible
	Harbour porpoise and minke whale	Medium	Negligible	Minor adverse	None required.	Minor adverse

Potential impact	Receptor	Sensitivity	Magnitude of impact	Significance of effect	Additional mitigation measures	Residual effect
<u>Impact 4:</u> Potential for a barrier effect due to underwater noise	Grey seal and harbour seal	Low	Negligible	Negligible		Negligible
<u>Impact 5:</u> Potential for an increase in collision risk due to increased vessel presence	Harbour porpoise and grey seal	Low	Low	Negligible	Vessel good practice measures to manage collision risk.	Negligible
	Minke whale	Medium	Low	Minor adverse		Minor adverse
	Harbour seal	Low	Medium	Minor adverse		Minor adverse
<u>Impact 6</u>: Potential for disturbance at seal haul-out sites	Grey seal and harbour seal	Medium	Low	Minor adverse	None required, but vessel good practice measures would reduce disturbance.	Negligible
<u>Impact 7:</u> Potential for indirect effects to marine mammals through changes to water quality	Harbour porpoise, minke whale, grey seal and harbour seal	Negligible	Low	Negligible	None required.	Negligible
<u>Impact 8</u>: Potential of an indirect effect to marine mammals through changes to prey resources: Physical disturbance and temporary habitat loss Increased suspended sediments and sediment deposition Re-mobilisation of contaminated sediment Underwater noise from piling Underwater noise from other construction activities Underwater noise from UXO clearance Changes in fishing activity	Harbour porpoise and minke whale	Low to medium	Negligible to low	Negligible to Minor adverse	None required.	Negligible to Minor adverse
	Grey seal and harbour seal	Low				

Potential impact	Receptor	Sensitivity	Magnitude of impact	Significance of effect	Additional mitigation measures	Residual effect
Operation						
Impact 1a: PTS due to operational WTGs, from either a single WTG or all WTGs	Harbour porpoise, minke whale, grey seal and harbour seal	High	Negligible	Minor adverse	None required.	Minor adverse
Impact 1b: TTS due to operational WTGs, from either a single WTG or all WTGs	Harbour porpoise, minke whale, grey seal and harbour seal	Medium	Negligible	Minor adverse	None required.	Minor adverse
Impact 1c: Disturbance due to operational WTGs, from either a single WTG or all WTGs	Harbour porpoise, grey seal and harbour seal	Low	Negligible	Negligible	None required.	Negligible
	Minke whale	Medium	Negligible	Minor adverse		Minor adverse
Impact 2a: PTS due to maintenance activities	Harbour porpoise, minke whale, grey seal and harbour seal	High	Negligible	Minor adverse	None required.	Minor adverse
Impact 2b: TTS due to maintenance activities	Harbour porpoise, minke whale, grey seal and harbour seal	Medium	Negligible	Minor adverse	None required.	Minor adverse
Impact 2c: Disturbance due to maintenance activities	Harbour porpoise and minke whale	Medium	Negligible	Minor adverse	None required.	Minor adverse
	Grey seal and harbour seal	Low	Negligible	Negligible		Negligible
Impact 2d: Reduction in foraging due to noise disturbance	Harbour porpoise and minke whale	Medium	Low	Minor adverse	None required.	Minor adverse
	Grey seal and harbour seal	Low	Negligible	Negligible		Negligible

Potential impact	Receptor	Sensitivity	Magnitude of impact	Significance of effect	Additional mitigation measures	Residual effect
Impact 3a: PTS due to operation and maintenance vessels	Harbour porpoise, minke whale, grey seal and harbour seal	High	Negligible	Minor adverse	Vessel good practice measures will be in place.	Minor adverse
Impact 3a: TTS due to operation and maintenance vessels	Harbour porpoise, minke whale, grey seal and harbour seal	Medium	Negligible	Minor adverse	None required, but vessel good practice measures be in place.	Minor adverse
Impact 3b: Disturbance due to operation and maintenance vessels	Harbour porpoise and minke whale	Medium	Negligible	Minor adverse	None required, but vessel good practice measures would reduce disturbance.	Minor adverse
	Grey seal and harbour seal	Low	Negligible	Negligible		Negligible
Impact 4: Potential for a barrier effect due to underwater noise	Minke whale	Medium	Negligible	Minor adverse	None required, but vessel good practice measures would reduce disturbance.	Minor adverse
	Harbour porpoise, grey seal and harbour seal	Low	Negligible	Negligible		Negligible
Impact 5: Potential for an increase in collision risk due to increased vessel presence	Harbour porpoise and grey seal	Low	Low	Negligible	Vessel good practice measures to manage collision risk.	Negligible
	Harbour seal	Low	Medium	Minor adverse		Minor adverse
	Minke whale	Medium	Low	Minor adverse		Minor adverse
Impact 6: Potential for disturbance at seal haul-out sites	Grey seal and harbour seal	Medium	Negligible	Minor adverse	None required, but vessel good practice measures would reduce disturbance.	Minor adverse
Impact 7: Potential for indirect effects to marine mammals through changes to water quality	Harbour porpoise, minke whale, grey seal and harbour seal	Negligible	Negligible	Negligible	None required	Negligible

Potential impact	Receptor	Sensitivity	Magnitude of impact	Significance of effect	Additional mitigation measures	Residual effect
Impact 8: Potential of an indirect effect to marine mammals through changes to prey resources: Physical disturbance and temporary habitat loss Increased suspended sediments and sediment deposition Re-mobilisation of contaminated sediment Long-term habitat loss Underwater noise and vibration EMF Changes in fishing activity	Harbour porpoise and minke whale	Low to medium	Negligible to low	Negligible to Minor adverse	None required.	Negligible to Minor adverse
	Grey seal and harbour seal	Low		Negligible		Negligible
Impact 8: Potential of an indirect effect to marine mammals through changes to prey resources: Introduction of hard substrate	Harbour porpoise and minke whale	Low to medium	Negligible (beneficial)	Negligible to Minor beneficial		Negligible to Minor beneficial
	Grey seal and harbour seal	Low	Negligible (beneficial)	Negligible beneficial		Negligible beneficial
Decommissioning						
Impact 1: PTS onset from decommissioning activities	Harbour porpoise, minke whale, grey seal and harbour seal	High	Negligible	Minor adverse	None required.	Minor adverse
Impact 1: TTS onset from decommissioning activities	Harbour porpoise, minke whale, grey seal and harbour seal	Medium	Negligible	Minor adverse	None required.	Minor adverse

Potential impact	Receptor	Sensitivity	Magnitude of impact	Significance of effect	Additional mitigation measures	Residual effect
Impact 1: Disturbance from decommissioning activities	Harbour porpoise, minke whale, grey seal and harbour seal	Low to medium	Negligible	Negligible to minor adverse	None required.	Negligible to minor adverse
Impact 2: PTS from vessels	Harbour porpoise, minke whale, grey seal and harbour seal	High	Negligible to low	Minor to moderate adverse	Vessel good practice measures will be in place.	Minor adverse
Impact 2: TTS from vessels	Harbour porpoise, minke whale, grey seal and harbour seal	Medium	Negligible	Minor adverse	None required, but vessel good practice measures be in place.	Minor adverse
Impact 2: Disturbance from vessels	Harbour porpoise, minke whale, grey seal and harbour seal	Low to medium	Negligible	Negligible to minor adverse	None required, but vessel good practice measures be in place.	Negligible to minor adverse
Impact 3: Barrier effects as a result of underwater noise	Harbour porpoise and minke whale	Medium	Negligible	Minor adverse	None required.	Minor adverse
	Grey seal and harbour seal	Low				
Impact 4: Increased collision risk with vessels	Harbour porpoise and grey seal	Low	Low	Minor adverse	None required, but vessel good practice measures be in place.	Minor adverse
	Minke whale	Medium	Low			
	Harbour seal	Low	Medium			
Impact 5: Disturbance at seal haul-out sites	Grey seal	Low	Low	Negligible	None required.	Minor adverse
	Harbour seal	Low	Low			
Impact 6: Changes to water quality	Harbour porpoise, minke whale, grey	Negligible	Low	Negligible	None required.	Negligible

Potential impact	Receptor	Sensitivity	Magnitude of impact	Significance of effect	Additional mitigation measures	Residual effect
	seal and harbour seal					
Impact 7: Changes to prey resource	Harbour porpoise, minke whale, grey seal and harbour seal	Low to medium	Negligible to low	Negligible to minor adverse	None required	Negligible to minor adverse
Cumulative						
Impact 1a: Cumulative disturbance due to other OWFs piling at the same time as North Falls	Harbour porpoise and minke whale	Medium	Negligible	Minor adverse	None required.	Minor adverse
	Grey seal and harbour seal	Low	Negligible	Negligible		Negligible
Impact 1b: Cumulative disturbance due to other OWFs constructing at the same time as North Falls	Harbour porpoise and minke whale	Medium	Negligible	Minor adverse	None required.	Minor adverse
	Grey seal and harbour seal	Low	Negligible	Negligible		Negligible
Impact 1c: Cumulative disturbance due to noisy activities (other than OWF)	Harbour porpoise	Medium	Negligible	Minor adverse	None required.	Minor adverse
	Minke whale	Medium	Low	Minor adverse		Minor adverse
	Grey seal and arbour seal	Low	Low	Negligible		Negligible
Impact 1: Cumulative disturbance effect due to all other noisy projects and activities	Harbour porpoise and minke whale	Medium	Low	Minor adverse	None required.	Minor adverse
	Grey seal and harbour seal	Low	Low	Minor adverse		Minor adverse
Impact 2: Cumulative barrier effect with other	Harbour porpoise and minke whale	Medium	Low	Minor adverse	None required.	Minor adverse

Potential impact	Receptor	Sensitivity	Magnitude of impact	Significance of effect	Additional mitigation measures	Residual effect
projects due to underwater noise	Grey seal and harbour seal	Low	Low	Negligible		Negligible
Impact 3a: Disturbance due to vessels associated with operational OWFs	Harbour porpoise and minke whale	Medium	Low	Minor adverse	None required.	Minor adverse
	Grey seal and harbour seal	Low	Low	Negligible		Negligible
Impact 3b: Increase in cumulative collision risk	Harbour porpoise and grey seal	Low	Low	Negligible	Vessel good practice measures to manage collision risk	Negligible
	Minke whale	Medium	Medium	Moderate adverse		Minor adverse
	Harbour seal	Low	Medium	Minor adverse		
Impact 4: Cumulative disturbance at seal haul-out sites	Grey seal and harbour seal	Medium	Negligible	Minor adverse	None required.	Minor adverse
Impact 5: Cumulative indirect effects to marine mammals through changes to prey resources	Harbour porpoise and minke whale	Low to medium	Negligible	Negligible to minor adverse	None required.	Negligible to minor adverse
	Grey seal and harbour seal	Low	Negligible	Negligible		Negligible

12.14 References

Arnould, J.P., Monk, J., Ierodiaconou, D., Hindell, M.A., Semmens, J., Hoskins, A.J., Costa, D.P., Abernathy, K. and Marshall, G.J., (2015). Use of anthropogenic sea floor structures by Australian fur seals: potential positive ecological impacts of marine industrial development?. PLoS One, 10(7), p.e0130581.
ASCOBANS (2015). Recommendations of ASCOBANS on the Requirements of Legislation to Address Monitoring and Mitigation of Small Cetacean Bycatch. October 2015.
Bäcklin, B. M., Moraeus, C., Roos, A., Eklöf, E., & Lind, Y. (2011). Health and age and sex distributions of Baltic grey seals (Halichoerus grypus) collected from bycatch and hunt in the Gulf of Bothnia. *ICES Journal of Marine Science*, *68*(1), 183-188.
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*.
Beatrice Offshore Wind Farm Ltd (2018). Beatrice Offshore Wind Farm Piling Strategy Implementation Report. Available from: http://marine.gov.scot/sites/default/files/lf000005-rep-2397_bowlpilingstrategyimplementationreport_rev1_redacted.pdf
BEIS (2020). Record of the Habitats Regulations Assessment undertaken under Regulation 65 of the Conservation of Habitats and Species 2017, and Regulation 33 of the Conservation of Offshore Marine Habitats and Species Regulations 2017. Review of Consented Offshore Wind Farms in the Southern North Sea Harbour Porpoise SAC. September 2020. Department for Business, Energy and Industrial Strategy.
BEIS (2021) Draft National Policy Statement for Renewable Energy Infrastructure (EN 3). Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1015236/en-3-draft-for-consultation.pdf
BEIS (2022a). UK Offshore Energy Strategic Environmental Assessment. Future Leasing/licensing for Offshore Renewable Energy, Offshore Oil & Gas and Gas Storage and Associated Infrastructure. March 2022. OESEA4 Environmental Report.
BEIS (2022b). UK Offshore Energy Strategic Environmental Assessment 4 (OESEA4) Appendix A1a.8 Marine mammals and otter.
Benhemma-Le Gall, A., Graham, I.M., Merchant, N.D. and Thompson, P.M. (2021). Broad-Scale Responses of Harbor Porpoises to Pile-Driving and Vessel Activities During Offshore Windfarm Construction. Front. Mar. Sci. 8:664724. doi: 10.3389/fmars.2021.664724.
Berwick Bank Wind Limited. (2022). Berwick Bank Wind Farm Environmental Impact Assessment Report Volume 2, Chapter 10: Marine Mammals. Available from: https://marine.gov.scot/sites/default/files/eor0764.pdf
Birchenough, S.N. and Degraer, S., 2020. Science in support of ecologically sound decommissioning strategies for offshore man-made structures: taking stock of

current knowledge and considering future challenges. ICES Journal of Marine Science, 77(3), pp.1075-1078.
Blix, A.S. and Folkow, L.P. (1995). Daily energy expenditure in free living minke whales. Acta Physio. Scand., 153: 61-66.
Bonner, D (2021) - Grey Seal Disturbance in Cornwall, England.
Booth, C., Donovan, C., Plunkett, R. & Harwood, J. (2016). Using an interim PcoD protocol to assess the effects of disturbance associated with US Navy exercises on marine mammal populations. Final Report to the US Office of Naval Research.
Brandt, M. J., Diederichs, A. and Nehls, G. (2009). Investigations into the effects of pile driving at the offshore wind farm Horns Rev II and the FINO III research platform. Report to DONG Energy.
Brandt, M., Diederichs, A., Betke, K. and Nehls, G. (2011). Responses of harbour porpoises to pile driving at the Horns Rev II offshore windfarm in the Danish North Sea. Marine Ecology Progress Series, 421: 205-215.
Brandt, M.J., Dragon, C.A., Diederichs, A., Bellmann, M.A., Wahl, V., Piper, W., Nabe-Nielsen, J. and Nehls G. (2018). Disturbance of harbour porpoises during construction of the first seven offshore wind farms in Germany. Marine Ecology Progress Series, 596: 213-232.
Brandt, M.J., Dragon, C.A., Diederichs, A., Schubert, A., Kosarev, V., Nehls G., Wahl, V., Michalik A., Braasch, A., Hinz, C., Ketzer, C., Todeskino, D., Gauger, M., Laczny, M., Piper, W. (2016). Effects of offshore pile driving on harbour porpoise abundance in the German Bight. Assessment of Noise Effects. Prepared for Offshore Forum Windenergie. Husum.
British Standards Institution (BSI) (2015). Environmental Impact Assessment for offshore renewable energy project – guide. PD 6900:2015.
Carter MID, Boehme L, Cronin MA, Duck CD, Grecian WJ, Hastie GD, Jessopp M, Matthiopoulos J, McConnell BJ, Miller DL, Morris CD, Moss SEW, Thompson D, Thompson PM and Russell DJF (2022) Sympatric Seals, Satellite Tracking and Protected Areas: Habitat-Based Distribution Estimates for Conservation and Management. Front. Mar. Sci. 9:875869.
Carter, M.I.D., Boehme, L., Duck, C.D., Grecian, W.J., Hastie, G.D., McConnell, B.J., Miller, D.L., Morris, C.D., Moss, S.E.W., Thompson, D., Thompson, P.M. and Russell, D.J.F. (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.
Cates, K., & Acevedo-Gutiérrez, A. (2017). Harbor seal (Phoca vitulina) tolerance to vessels under different levels of boat traffic. *Aquatic Mammals*, *43*(2), 193.
Cefas (Centre for the Environment and Fisheries and Aquaculture Science) (20121). Guidelines for Data Acquisition to Support Marine Environmental Assessments of Offshore Renewable Energy Projects. Contract report: ME5403, September 20121.
Christiansen, F., Rasmussen, M. H., & Lusseau, D. (2014). Inferring energy expenditure from respiration rates in minke whales to measure the effects of whale watching boat interactions. Journal of Experimental Marine Biology and Ecology, 459, 96-104.

Christiansen, F., Rasmussen, M.H. and Lusseau, D. (2013). Inferring activity budgets in wild animals to estimate the consequences of disturbances. Behavioural Ecology, 24(6), pp.1415-1425.
CIEEM (Chartered Institute of Ecology and Environmental Management) (20189). Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater, Coastal and Marine. [redacted]
Cox, T. (2021). Report on 2021 Seal Surveys in the Greater Thames Estuary.
Cox, T., Barker, J., Bramley, J., Debney, A., Thompson, D., & Cucknell, A. C. (2020). Population trends of harbour and grey seals in the Greater Thames Estuary. *Mammal Communications*, *6*, 42-51.
CSIP (2004). Trends in Cetacean Strandings around the UK Coastline and Cetacean and Marine Turtle Post-Mortem Investigations for the Year 2003 (Contract Cro 238).
CSIP (2005). Trends in Cetacean Strandings around the UK Coastline, Cetacean and Marine Turtle Post-Mortem Investigations 2004.
CSIP (2006). Cetaceans Strandings Investigation and Co-ordination in the UK Report to Defra for the period 1st January 2000 - 31st December 2004.
CSIP (2011). Final Report for the period 1st January 2005 – 31st December 2010. Compiled by R. Deaville and P.D. Jepson (ZSL). [redacted]
CSIP (2016). Annual Report for the period 1st January – 31st December 2015. Compiled by R. Deaville (ZSL). http://ukstrandings.org/csip-reports/
Cucknell, A., Moscrop. A, Boisseau, O. & McLanaghan, R. (2020) Confirmation of the presence of harbour porpoise (Phocoena phocoena) within the tidal Thames and Thames Estuary. Mammal Communications 6: 21-28, London.
Davis, G.E., Baumgartner, M.F., Corkeron, P.J., Bell, J., Berchok, C., Bonnell, J.M., Bort Thornton, J., Brault, S., Buchanan, G.A., Cholewiak, D.M. and Clark, C.W. (2020). Exploring movement patterns and changing distributions of baleen whales in the western North Atlantic using a decade of passive acoustic data. *Global change biology*, *26*(9), pp.4812-4840.
DECC (2011). NPS for Renewable Energy Infrastructure (EN-3)
DECC (now Department for Business, Energy and Industrial Strategy (BEIS)) (2016), UK Offshore Energy Strategic Environmental Assessment 3 (OESEA3)
Defra (Department for Environment, Food and Rural Affairs) (2003). UK small cetacean bycatch response strategy. Department for Environment, Food and Rural Affairs. March 2003.
Defra (Department for Environment, Food and Rural Affairs) (2010). The Marine Strategy Regulations 2010. Department for Environment, Food and Rural Affairs. July 2010.
Defra (Department for Environment, Food and Rural Affairs) (2019). Marine Strategy Part One; UK updated assessment and Good Environmental Status. Available at:

https://assets.publishing.service.gov.uk/media/5f6c8369d3bf7f7238f23151/marine-strategy-part1-october19.pdf. October 2019.
Defra (Department for Environment, Food and Rural Affairs) (2021). Marine Strategy Part Three; UK Programme of Measures. Available at: https://consult.defra.gov.uk/uk-marine-strategy-programme-of-measures-3/uk-marine-strategy-part-3/supporting_documents/UKMS3%20Consultation%20Document.pdf. September 2021.
Defra (Department for Environment, Food and Rural Affairs) (2022). Marine Strategy Part Two; UK updated monitoring programmes. Available at: https://assets.publishing.service.gov.uk/media/63a08d10d3bf7f37598edab2/uk-marine-strategy-part-two-monitoring-programmes-2021.pdf. October 2022.
Delefosse, M., Rahbek, M.L., Roesen, L. and Clausen, K.T., (2018). Marine mammal sightings around oil and gas installations in the central North Sea. Journal of the Marine Biological Association of the United Kingdom, 98(5), pp.993-1001.
Devault, D.A., Beilvert, B. and Winterton, P., 2017. Ship breaking or scuttling? A review of environmental, economic and forensic issues for decision support. Environmental Science and Pollution Research, 24, pp.25741-25774.
Diederichs, A., Brandt, M., and Nehls, G. (2010). Does sand extraction near Sylt affect harbour porpoises? Wadden Sea Ecosystem, 26:199–203.
Diederichs, A., Nehls, G., Dähne, M., Adler, S., Koschinski, S. and Verfuß, U. (2008). Methodologies for measuring and assessing potential changes in marine mammal behaviour, abundance or distribution arising from the construction, operation and decommissioning of offshore windfarms. Commissioned by COWRIE Ltd, 231.
Donovan, C., J. Harwood, S. King, C. Booth, B. Caneco, and C. Walker. (2016). Expert elicitation methods in quantifying the consequences of acoustic disturbance from offshore renewable energy developments. Pages 231-237 The Effects of Noise on Aquatic Life II. Springer.
DOWL (2016). Dudgeon Offshore Wind Farm - Piling Summary and Lessons Learned. August 2016.
Duck, C.D. and Morris, C.D. (2016). Surveys of harbour and grey seals on the south-east (border to Aberlady Bay) and south-west (Sound of Jura to Solway Firth) coasts of Scotland, in Shetland, in the Moray Firth and in the Firth of Tay in August 2015. Scottish Natural Heritage Commissioned Report no. 929, 36 pp.
Dunlop, R. A., Noad, M. J., McCauley, R. D., Scott-Hayward, L., Kniest, E., Slade, R., ... & Cato, D. H. (2017). Determining the behavioural dose–response relationship of marine mammals to air gun noise and source proximity. *Journal of Experimental Biology*, *220*(16), 2878-2886.
Durbach, I. N., Harris, C. M., Martin, C., Helble, T. A., Henderson, E. E., Ierley, G., ... & Martin, S. W. (2021). Changes in the movement and calling behavior of minke whales (Balaenoptera acutorostrata) in response to navy training. *Frontiers in Marine Science*, *8*, 660122.
East Anglia ONE North Limited. (2021). East Anglia ONE North Offshore Windfarm Chapter 11 Marine Mammals Environmental Statement Volume 1.

Available from: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010077/EN010077-001158-6.1.11%20EA1N%20Environmental%20Statement%20Chapter%2011%20Marine%20Mammals.pdf
EDRen, S. M., Andersen, S. M., Teilmann, J., Carstensen, J., Harders, P. B., Dietz, R., & Miller, L. A. (2010). The effect of a large Danish offshore wind farm on harbour and gray seal haul-out behavior. *Marine Mammal Science*, *26*(3), 614-634.
Equinor New Energy Ltd. (2022). Sheringham Shoal and Dudgeon Offshore Wind Farm Extension Projects Environmental Statement Volume 1 Chapter 10 - Marine Mammal Ecology. Available from: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010109/EN010109-000228-6.1.10%20Chapter%2010%20Marine%20Mammal%20Ecology.pdf
Equinor New Energy Ltd. (2023). Sheringham Shoal and Dudgeon Offshore Wind Farm Extension Projects: Marine Mammals Technical Note and Addendum (Revision B) (Clean). Available from: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010109/EN010109-002028-16.14%20Marine%20Mammals%20Technical%20Note%20and%20Addendum%20(Revision%20B)%20(Clean).pdf
European Commission. (2023). European Marine Observation and Data Network (EMODnet). Available at: [redacted]
Evans, D., & Arvela, M. (2012). Assessment and reporting under Article 17 of the Habitats Directive. Explanatory Notes & Guidelines for the period 2007-2012. Available from: [redacted]
Evans, P. G., & Bjørge, A. (2013). Impacts of climate change on marine mammals. MCCIP Science Review, 2013, 134-148.Evans, P.G.H. and Bjørge, A. (2013). Impacts of climate change on marine mammals. Marine Climate Change Impacts Partnership (MCCIP) Annual Report Card 2011-2012 Scientific Review: 1-34.
Evans, P. G., Baines, M.E., and Anderwald. P. (2011). Risk Assessment of Potential Conflicts between Shipping and Cetaceans in the ASCOBANS Region. 18th ASCOBANS Advisory Committee Meeting AC18/Doc.6-04 (S) rev.1 UN Campus, Bonn, Germany, 4-6 May 2011 Dist. 2 May 2011.
Five Estuaries Wind Farm Ltd. (2023). Five Estuaries Offshore Wind Farm Preliminary Environmental Information Report Volume 2, Chapter 7: Marine Mammal Ecology. Available from: [redacted]
Gilles, A., Viquerat, S., Becker, E. A., Forney, K. A., Geelhoed, S. C. V., Haelters, J., Nabe-Nielsen, J., Scheidat, M., Siebert, U., Sveegaard, S., van Beest, F. M., van Bemmelen, R.and Aarts, G. (2016). Seasonal habitat-based density models for a marine top predator, the harbour porpoise, in a dynamic environment. Ecosphere 7(6):e01367. 10.1002/ecs2.1367.
Godin, O.A., 2008. Sound transmission through water–air interfaces: New insights into an old problem. Contemporary Physics, 49(2), pp.105-123.

Graham, I. M., E. Pirotta, N. D. Merchant, A. Farcas, T. R. Barton, B. Cheney, G. D. Hastie, and P. M. Thompson. (2017). Responses of bottlenose dolphins and harbor porpoises to impact and vibration piling noise during harbor construction. Ecosphere 8(5):e01793. 10.1002/ecs2.1793

Graham, I.M., Merchant, N.D., Farcas, A., Barton, T.R., Cheney, B., Bono, S. and Thompson, P.M. (2019). Harbour porpoise responses to pile-driving diminish over time. R. Soc. Open sci. 6: 190335. http://dx.doi.org/10.1098/rsos.190335.

Hammond, P.S., Lacey, C., Gilles, A., Viquerat, S., Boerjesson, P., Herr, H., Macleod, K., Ridoux, V., Santos, M.B., Scheidat, M., Teilmann, J., Vingada, J. and Øien, N. (2021). Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys. June 2021. Available from: [redacted]

Hammond, P.S., Macleod, K., Berggren, P., Borchers, D.L., Burt, M.L., Cañadas, A., Desportes, G., Donovan, G.P., Gilles, A., Gillespie, D., Gordon, J., Hedley, S., Hiby, L., Kuklik, I., Leaper, R., Lehnert, K., Leopold, M., Lovell, P., Øien, N., Paxton, C., Ridoux, V., Rogan, E., Samarra, F., Scheidat, M., Sequeira, M., Siebert, U., Skov, H., Swift, R., Tasker, M.L., Teilmann, J., Van Canneyt, O. and Vázquez, J.A. (2013). Cetacean abundance and distribution in European Atlantic shelf waters to inform conservation and management. Biological Conservation 164: 107-122.

Harding, K. C., Fujiwara, M., Axberg, Y., & Härkönen, T. (2005). Mass-dependent energetics and survival in harbour seal pups. *Functional Ecology*, *19*(1), 129-135.

Harris, R.E., Miller, G. W. and Richardson, W. J. (2001). Seal responses to air gun sounds during summer seismic surveys in the Alaskan Beaufort Sea. Mar Mam Sci. 17:795-812.

Harwood, J., S. King, R. Schick, C. Donovan, and C. Booth. (2014). A Protocol For Implementing The Interim Population Consequences Of Disturbance (PCoD) Approach: Quantifying And Assessing The Effects Of UK Offshore Renewable Energy Developments On Marine Mammal Populations. Report Number SMRUL-TCE-2013-014. Scottish Marine and Freshwater Science, 5(2).

Hastie, G. D., Lepper, P., McKnight, J. C., Milne, R., Russell, D. J., & Thompson, D. (2021). Acoustic risk balancing by marine mammals: anthropogenic noise can influence the foraging decisions by seals. *Journal of Applied Ecology*, *58*(9), 1854-1863.

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.

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.

HiDef. (2021). Digital video aerial surveys of seabirds and marine mammals at North Falls: Two-year report. March 2019 to February 2021. Issue V3.

HM Government (2011). Marine Policy Statement. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69322/pb3654-marine-policy-statement-110316.pdf.

HM Government (2014). The East Inshore and East Offshore Marine Plans.
Huon, M., Jones, E. L., Matthiopoulos, J., McConnell, B., Caurant, F., & Vincent, C. (2015). Habitat selection of gray seals (Halichoerus grypus) in a marine protected area in France. The Journal of Wildlife Management, 79(7), 1091–1100. doi:10.1002/jwmg.92
IAMMWG. (2023). Review of Management Unit boundaries for cetaceans in UK waters (2023). JNCC Report 734. JNCC, Peterborough, ISSN 0963-8091. https://hub.jncc.gov.uk/assets/b48b8332-349f-4358-b080-b4506384f4f7.
Jansen, J.K., Boveng, P.L., Dahle, S.P. and Bengston, J.L. (2010). Reaction of harbor seals to cruise ships. Journal of Wildlife Management,74,1186–1194. [redacted]
JNCC (2010a). JNCC guidelines for minimising the risk of injury to marine mammals from using explosives. August 2010.
JNCC (2010b). Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise. August 2010.
JNCC (2019). Article 17 Habitats Directive Report 2019: Species Conservation Status Assessments 2019. Available at: https://jncc.gov.uk/our-work/article-17-habitats-directive-report-2019-species/#regularly-occurring-species-vertebrate-species-mammals-marine
JNCC (2023). Draft JNCC guidelines for minimising the risk of injury to marine mammals from explosive use in the marine environment.
JNCC and Natural England (2013). Suggested Tiers for Cumulative Impact Assessment.
JNCC, DAERA (Department of Agriculture, Environment and Rural Affairs) and Natural England (2020). Guidance for assessing the significance of noise disturbance against Conservation Objectives of harbour porpoise SACs (England, Wates and Northern Ireland). Dated June 2020.
JNCC, Natural England and CCW (2010). Draft EPS Guidance - 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. Joint Nature Conservation Committee, Natural England and Countryside Council for Wales. October 2010.
Johnston, D.W., Westgate, A.J. and Read, A.J. (2005). Effects of fine-scale oceanographic features on the distribution and movements of harbour porpoises Phocoena in the Bay of Fundy. Marine Ecology Progress Series, 295, pp.279-293.
Jones AR, Hosegood P, Wynn RB, De Boer MN, Butler-Cowdry S, Embling CB (2014) Fine scale hydrodynamics influence the spatio-temporal distribution of harbour porpoises at a coastal hotspot. Prog Oceanogr 128: 30-48
Jones, D. and Marten, K. (2016). Dredging sound levels, numerical modelling and EIA. Maritime Solutions for a Changing World, p.21.
Jones, E.L., Hastie, G.D., Smout, S., Onoufriou, J., Merchant, N.D., Brookes, K.L. and Thompson, D. (2017). Seals and shipping: quantifying population risk and individual exposure to vessel noise. Journal of applied ecology, 54(6), pp.1930-1940.

Jones, E.L., Sparling, C.E., McConnell, B.J., Morris, C.D. and Smout, S., 2017a. Fine-scale harbour seal usage for informed marine spatial planning. Scientific Reports, 7(1), pp.1-11.
Kastelein, R. A., Gransier, R., Hoek, L. and Olthuis, J. (2012). Temporary threshold shifts and recovery in a harbor porpoise (*Phocoena phocoena*) after octave-band noise at 4 kHz. J. Acoust. Soc. Am. 132, 3525–3537.
Kastelein, R.A., Hardemann, J. and Boer, H. (1997). Food consumption and body weight of harbour porpoises (*Phocoena phocoena*). In The biology of the harbour porpoise Read, A.J., Wiepkema, P.R., Nachtigall, P.E (1997). Eds. Woerden, The Netherlands: De Spil Publishers. pp. 217–234.
King, S. L., R. S. Schick, C. Donovan, C. G. Booth, M. Burgman, L. Thomas, and J. Harwood. (2015). An interim framework for assessing the population consequences of disturbance. Methods in Ecology and Evolution 6:1150-1158.
Koski WR, Johnson SR (1987) Responses of bowhead whales to an offshore drilling operation in the Alaskan Beaufort Sea, Autumn 1986: behavioural studies and aerial photo grammetry. LGL Ltd., King City, ON.
Lacey, C., Gilles, A., Herr, H., MacLeod, K., Ridoux, V., Santos, M.B., Sheidat, M., Teilmann, J., Sveegaard, S., Vingada, J. and Viquerat, S., (2022). Modelled density surfaces of cetaceans in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys. University of St Andrews. https://scans3.wp.st-andrews.ac.uk/resources/
Laist, D.W., Knowlton, A.R., Mead, J.G., Collet, A.S. and Podesta, M. (2001). Collisions between ships and whale'. Marine Mammal Science 17 (1) 30-75.
Learmonth, J.A., Macleod, C.D., Santos, M.B., Pierce, G.J., Crick, H.Q.P. and Robinson, R.A. (2006). Potential effects of climate change on marine mammals. Oceanography and Marine Biology: An Annual Review 44, 429-462.
Lindeboom, H.J., Kouwenhoven, H.J., Bergman, M.J.N., Bouma, S., Brasseur, S., Daan, Fijn, R.C., de Haan, D., Dirksen, S., van Hal, R, Hille Ris Lambers, R, ter Hofstede, Krijgsveld, R.K.L., Leopold, M. and Scheidat, M. (2011). Short-term ecological effects of an offshore wind farm in the Dutch coastal zone; a compilation. Environ. Res. Lett. 6 (3).
Ljungblad, D. K., Würsig, B., Swartz, S. L., & Keene, J. M. (1988). Observations on the behavioural responses of bowhead whales (Balaena mysticetus) to active geophysical vessels in the Alaskan Beaufort Sea. *Arctic*, 183-194.
Lonergan, M., Duck, C., Moss, S., Morris, C., & Thompson, D. (2013). Rescaling of aerial survey data with information from small numbers of telemetry tags to estimate the size of a declining harbour seal population. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *23*(1), 135-144.
Lusseau, D. (2003). Male and female bottlenose dolphins Tursiops spp. have different strategies to avoid interactions with tour boats in Doubtful Sound, New Zealand. Marine Ecology Progress Series 257:267-274.
Lusseau, D. (2006). The short-term behavioural reactions of bottlenose dolphins to interactions with boats in Doubtful Sound, New Zealand. Marine Mammal Science 22:802-818.

Machernis, A. F., Powell, J. R., Engleby, L., & Spradlin, T. R. (2018). An updated literature review examining the impacts of tourism on marine mammals over the last fifteen years (2000-2015) to inform research and management programs.
Madsen, P. T., Wahlberg, M., Tougaard, J., Lucke, K. and Tyack, P. (2006). Wind turbine underwater noise and marine mammals: implications of current knowledge and data needs. Mar Ecol Prog Ser, 309; 279-295.
Malme, C. I., & Miles, P. R. (1983). Acoustic testing procedures for determining the potential impact of underwater industrial noise on migrating gray whales. *The Journal of the Acoustical Society of America*, *74*(S1), S54-S54.
Malme, C. I., & Miles, P. R. (1987). The influence of sound propagation conditions on the behavioural response of whales to underwater industrial noise. *The Journal of the Acoustical Society of America*, *82*(S1), S97-S98.
Malme, C. I., Miles, P. R., Clark, C. W., Tyack, P., & Bird, J. E. (1984). *Investigations of the potential effects of underwater noise from petroleum-industry activities on migrating gray-whale behavior. Phase 2: January 1984 migration* (No. PB-86-218377/XAB; BBN-5586). Bolt, Beranek and Newman, Inc., Cambridge, MA (USA).
Malme, C.I., Miles, P.R., Miller, G.W., Richardson, W.J., Roseneau, D.G., Thomson, D.H. and Greene, C.R. (1989). Analysis and ranking of the acoustic disturbance potential of petroleum industry activities and other sources of noise in the environment of marine mammals in Alaska. Final Report No. 6945 to the US Minerals Management Service, Anchorage, AK. BBN Systems and Technologies Corp. Available at: <http://www.mms.gov>.
Marine Scotland (2012). MS Offshore Renewables Research: Work Package A3: Request for advice about the displacement of marine mammals around operational offshore windfarms. Available at: http://www.gov.scot/Resource/0040/00404921.pdf.
Marmo, B., Roberts, I., Buckingham, M.P., King, S., and Booth, C. (2013). Modelling of Noise Effects of Operational Offshore Wind Turbines including noise transmission through various foundation types. Report to Marine Scotland. 108 pp.
McCauley, R. D., Jenner, M-N., Jenner, C., McCabe, K. A., & Murdoch, J. (1998). The response of humpback whales (Megaptera novaeangliae) to offshore seismic survey noise: Preliminary results of observations about a working seismic vessel and experimental exposures. Australian Petroleum Production and Exploration Association Journal, 38, 692-707.
McConnell, B., Lonergan, M. and Dietz, R. (2012). Interactions between seals and offshore wind farms. The Crown Estate. ISBN: 978-1-906410-34-5.
McDonald, M. A., Hildebrand, J. A., & Webb, S. C. (1995). Blue and fin whales observed on a seafloor array in the Northeast Pacific. The Journal of the Acoustical Society of America, 98(2), 712-721.Macdonald, M.A., Hildebrand, J.A. and Webb, S.C. (1995). Blue and fin whales observed on a seafloor array in the Northeast Pacific. J Acoust Soc Am. 98:712-721.
McGarry, T., Boisseau, O., Stephenson, S. and Compton, R. (2017). Understanding the Effectiveness of Acoustic Deterrent Devices on Minke Whale (*Balaenoptera acutorostrata*), a low frequency cetacean. ORJIP Project 4, Phase

2. RPS Report EOR0692. Prepared on behalf of The Carbon Trust. November 2017.

McGarry, T., De Silva, R., Canning, S., Mendes, S., Prior, A., Stephenson, S. and Wilson, J. (2020). Evidence base for application of Acoustic Deterrent Devices (ADDs) as marine mammal mitigation (Version 2.0). JNCC Report No. 615, JNCC, Peterborough. ISSN 0963-8091.

Merchant, N. D., Pirotta, E., Barton, T. R., & Thompson, P. M. (2014). Monitoring ship noise to assess the impact of coastal developments on marine mammals. *Marine Pollution Bulletin*, *78*(1-2), 85-95.

Miller, G. W., Moulton, V. D., Davis, R. A., Holst, M., Millman, P., MacGillivray, A., et al. (2005). Monitoring seismic effects on marine mammals – southeastern Beaufort Sea, 2001-2002. In S. L. Armsworthy, P. J. Cranford, & K. Lee (Eds.), Offshore oil and gas environmental effects monitoring: Approaches and technologies (pp. 511-542). Columbus, OH: Battelle Press.

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

Nabe-Nielsen, J., van Beest, F.M., Grimm, V., Sibly, R.M., Teilmann, J. and Thompson, P.M. (2018). Predicting the impacts of anthropogenic disturbances on marine populations. Conserv Lett. 2018;e12563. https://doi.org/10.1111/conl.12563.

Natural England and Department for Environment Food and Rural Affairs (Defra) (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.R., Langworthy, J. and Howell, D. (2003). Assessment of subsea noise and vibration from offshore wind turbines and its impact on marine wildlife. Initial measurements of underwater noise during construction of offshore wind farms, and comparisons with background noise. Subacoustech Report No. 544R0423, published by COWRIE, May 2003.

NIRAS Consulting Ltd and SMRU Consulting (2019). Reducing Underwater Noise, Report on Behalf of The Crown Estate. [redacted]/b07[redacted]

NMFS (National Marine Fisheries Service). (2018). 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. U.S. Dept. of Commer., NOAA. NOAA Technical Memorandum NMFS-OPR-59, 167 p.

Norfolk Vanguard Limited. (2018). Norfolk Vanguard Offshore Wind Farm Chapter 12 Marine Mammals Environmental Statement. Available from: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010079/EN010079-001500-Chapter%2012%20Marine%20Mammals%20Norfolk%20Vanguard%20ES.pdf

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.

NRW (2023). NRW's Position on Assessing the effects of Hearing Injury from Underwater Noise on Marine Mammals.
Oakley, J. A., Williams, A. T., & Thomas, T. (2017). Reactions of harbour porpoise (Phocoena phocoena) to vessel traffic in the coastal waters of South West Wales, UK. *Ocean & Coastal Management*, *138*, 158-169.
Offshore Wind Power Limited, 2023. West of Orkney Windfarm Offshore EIA Report Volume 1, Chapter 12 - Marine Mammals and Megafauna. Available from: https://marine.gov.scot/sites/default/files/west_of_orkney_windfarm_offshore_eia_report_-_chapter_12_-_marine_mammals_and_megafauna.pdf
Onoufriou, J., Jones, E., Hastie, G. and Thompson, D. (2016). Investigations into the interactions between harbour seals (*Phoca vitulina*) and vessels in the inner Moray Firth. Marine Scotland Science.
Orsted Power (UK) Ltd. (2018). Hornsea Project Three Offshore Wind Farm Environmental Statement: Volume 2, Chapter 4 – Marine Mammals. Available form: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010080/EN010080-000534-HOW03_6.2.4_Volume%202%20-%20Ch%204%20-%20Marine%20Mammals.pdf
Orsted Power (UK) Ltd. (2019). Hornsea Project Four: Environmental Statement (ES) PINS Document Reference: A2.4 APFP Regulation: 5(2)(a) Volume A2, Chapter 4: Marine Mammals. Available from: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010098/EN010098-000706-A2.4%20ES%20Volume%20A2%20Chapter%204%20Marine%20Mammals.pdf
OSPAR (2009). Overview of the impacts of anthropogenic underwater sound in the marine environment. London: OSPAR Commission Biodiversity Series. Publication no. 441/2009. 133 pp.
OSPAR (2021). OSPAR List of Substances Used and Discharged Offshore which Are Considered to Pose Little or No Risk to the Environment (PLONOR) – Update 2021.
Otani, S., Naito, T., Kato, A. and Kawamura, A. (2000). Diving behaviour and swimming speed of a free-ranging harbour porpoise (*Phocoena phocoena*). Marine Mammal Science, Volume 16, Issue 4, pp 811-814, October 2000.
Outer Dowsing Offshore Wind (2023). Outer Dowsing Offshore Wind Preliminary Environmental Information Report Volume 1, Chapter 11: Marine Mammals. Available from: [redacted]
OX2 AB. (2021). Evironmental Impact Statement: Galatea-Galene. Available from: [redacted]
Parker, J., Banks, A., Fawcett, A., Axelsson, M., Rowell, H., Allen, S., Ludgate, C., Humphrey, O., Baker, A. & Copley, V. (2022a). 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. Version 1.1. 79 pp.
Parker, J., Fawcett, A., Rowson, T., Allen, S., Hodgkiss, R., Harwood, A., Caldow, R., Ludgate, C., Humphrey, O. & Copley, V. (2022b). Offshore Wind Marine

Environmental Assessments: Best Practice Advice for Evidence and Data Standards. Phase IV: Expectations for monitoring and environmental requirements at the post-consent phase. Natural England. Version 1.0. 117 pp

Paterson, W.D., Russell, D.J.F., Wu, Gi-Mick, McConnell, B.J., Currie, J., McCafferty, D. and Thompson, D. (2019). Post-disturbance haul-out behaviour of harbour seals. Aquatic Conservation: Marine and Freshwater Ecosystems. Doi: 10.1002/aqc.3092.

Paxton, A.B., Steward, D.A.N., Harrison, Z.H. and Taylor, J.C., 2022. Fitting ecological principles of artificial reefs into the ocean planning puzzle. Ecosphere, 13(2), p.e3924.

Paxton, C.G.M., Scott-Hayward, L., Mackenzie, M., Rexstad, E. and Thomas, L. (2016). Revised Phase III Data Analysis of Joint Cetacean Protocol Data Resources with Advisory Note, JNCC Report 517, ISSN 0963-8091: http://jncc.defra.gov.uk/page-7201.

Pierce, G.J., Santos, M.B., Reid, R.J., Patterson, I.A.P. and Ross, H.M., 2004. Diet of minke whales Balaenoptera acutorostrata in Scottish (UK) waters with notes on strandings of this species in Scotland 1992–2002. Journal of the Marine Biological Association of the United Kingdom, 84(6), pp.1241-1244.

Pirotta, E., Brookes, K. L., Graham, I. M., & Thompson, P. M. (2014). Variation in harbour porpoise activity in response to seismic survey noise. *Biology letters*, *10*(5), 20131090.

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

Planning Inspectorate (2018). Advice Note Nine: Rochdale Envelope https://infrastructure.planninginspectorate.gov.uk/wp-content/uploads/2013/05/Advice-note-9.-Rochdale-envelope-web.pdf

Planning Inspectorate (2019). Advice Note Seventeen: Cumulative effects assessment relevant to nationally significant infrastructure projects. Version 2 August 2019. https://infrastructure.planninginspectorate.gov.uk/wp-content/uploads/2015/12/Advice-note-17V4.pdf

Polacheck, T and Thorpe, L. (1990). The swimming direction of harbour porpoise in relation to a survey vessel. Report of the International Whaling Commission, 40: 463-470.

Popper, A.N., Hawkins, A.D., Fay, R.R., Mann, D.A., Bartol, S., Carlson, T.J., Coombs, S., Ellison, W.T., Gentry, R.L., Halvorsen, M.B. and Løkkeborg, S., (2014). ASA S3/SC1. 4 TR-2014 Sound exposure guidelines for fishes and sea turtles: A technical report prepared by ANSI-Accredited standards committee S3/SC1 and registered with ANSI. Springer.

Rampion Extension Development Limited. (2023). Rampion 2 Wind Farm Category 6: Environmental Statement Volume 2, Chapter 11: Marine mammals. Available from: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010117/EN010117-000312-6.2.11%20Rampion%202%20ES%20Volume%202%20Chapter%2011%20Marine%20mammals.pdf

Ransijn, J.M., Booth, C. and Smout, S.C. (2019). A calorific map of harbour porpoise prey in the North Sea. JNCC Report No. 633. JNCC, Peterborough, ISSN 0963 8091.

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

Read AJ, Hohn AA (1995) Life in the fast lane: the life history of harbour porpoises from the Gulf of Maine. Mar Mamm Sci 11: 423-440

Richardson, J., Greene, C.R., Malme, C.I. and Thomson, D.H. (1995). Marine Mammals and Noise. San Diego California: Academic Press.

Richardson, W. J., Miller, G. W., & Greene, C. R., Jr. (1999). Displacement of migrating bowhead whales by sounds from seismic surveys in shallow waters of the Beaufort Sea. Journal of the Acoustical Society of America, 106, 2281.

Richardson, W. J., Würsig, B., & Greene Jr, C. R. (1986). Reactions of bowhead whales, B alaenamysticetus, to seismic exploration in the Canadian Beaufort Sea. *The Journal of the Acoustical Society of America*, *79*(4), 1117-1128.

Robinson, S.P., Theobald, P.D., Hayman, G., Wang, L.S., Lepper, P.A., Humphrey, V. and Mumford, S. (2011). Measurement of underwater noise arising from marine aggregate dredging operations. Marine Aggregate Levy Sustainability Fund MEPF report 09/P108.

Rose, A., Brandt, M., Vilela, R., Diederichs, A., Schubert, A., Kosarev, V., Nehls, G. and Freund, C.K. (2019). Effects of noise-mitigated offshore pile driving on harbour porpoise abundance in the German Bight 2014-2016 (Gescha 2). *Report by IBL Umweltplanung GmbH*.

Rosen, D. A., & Renouf, D. (1997). Seasonal changes in blubber distribution in Atlantic harbor seals: indications of thermodynamic considerations. *Marine Mammal Science*, *13*(2), 229-240.

Russell, D.J., Hastie, G.D., Thompson, D., Janik, V.M., Hammond, P.S., Scott-Hayward, L.A., Matthiopoulos, J., Jones, E.L. and McConnell, B.J. (2016). Avoidance of wind farms by harbour seals is limited to pile driving activities. *Journal of Applied Ecology*, *53*(6), pp.1642-1652.

Russell, D.J.F (2016a). Movements of grey seal that haul out on the UK coast of the southern North Sea. Report for the Department of Energy and Climate Change (OESEA-14-47).

Russell, D.J.F, Jones, E.L. and Morris, C.D. (2017). Updated Seal Usage Maps: The Estimated at-sea Distribution of Grey and Harbour Seals. Scottish Marine and Freshwater Science Vol 8 No 25, 25pp. DOI: 10.7489/2027-1.

Russell, D.J.F. (2016b). Activity Budgets: Analysis of seal behaviour at sea. Draft report for the Department of Energy and Climate Change (OESEA-15-66).

Russell, D.J.F. and McConnell, B.J. (2014). Seal at-sea distribution, movements and behavior. Report to DECC. URN: 14D/085. March 2014 (final revision).

Russell, D.J.F., Brasseur, S.M.J.M., Thompson, D., Hastie, G.D., Janik, V.M., Aarts, G., McClintock, B.T., Matthiopoulos, J., Moss, S.E.W. and McConnell, B.

(2014). Marine mammals trace anthropogenic structures at se'. Current Biology Vol 24 No 14: R638–R639.
RWE Renewables UK Dogger Bank South (West) Limited & RWE Renewables UK Dogger Bank South (East) Limited. (2023). Dogger Bank South Offshore Wind Farms Preliminary Environmental Information Report Chapter 11 – Marine Mammals. Available from:[redacted]
Santos MB, Pierce GJ (2003) The diet of harbour porpoise (Phocoena phocoena) in the eastern North Atlantic. Oceanography and Mar Biol: An Annual Review 41: 355-390
Santos MB, Pierce GJ, Learmonth JA, Reid RJ, Ross HM, Patterson IAP, Reid DG, Beare D (2004) Variability in the diet of harbor porpoises (Phocoena phocoena) in Scottish waters 1992–2003. *Mar Mamm Sci* 20: 1-27
SCANS-II (2008). Small cetaceans in the European Atlantic and North Sea. Final Report submitted to the European Commission under project LIFE04NAT/GB/000245, SMRU, St Andrews.
Scheidat, M., Tougaard, J., Brasseur, S., Carstensen, J., van Polanen Petel, T., Teilmann, J., and Reijnders, P. (2011). Harbour porpoise (*Phocoena phocoena*) and wind farms: a case study in the Dutch North Sea. Environ. Res. Lett. 6 (April-June 2011) 025102.
Schop J., Abel C., Brasseur S., Galatius A., Jeß A., Meise K., Meyer J., van Neer A., Stejskal O., Siebert U., Teilmann J., Thøstesen C. B. (2022) Grey Seal Numbers in the Wadden Sea and on Helgoland in 2021-2022. Common Wadden Sea Secretariat, Wilhelmshaven, Germany. Available at: [redacted]
SCOS (2020). Scientific Advice on Matters Related to the Management of Seal Populations: 2020. Available at: h[redacted]
SCOS (2021). Scientific Advice on Matters Related to the Management of Seal Populations: 2021. Available [redacted]/
Sea Watch Foundation (2021). Reports of cetacean sightings eastern England: [redacted]
Sharples R.J., Matthiopoulos, J. and Hammond, P.S. (2008). Distribution and movements of harbour seals around the coast of Britain: Outer Hebrides, Shetland, Orkney, the Moray Firth, St Andrews Bay, The Wash and the Thames, Report to DTI July 2008.
Sigray, P., and Andersson, M. H. (2011). Particle motion measured at an operational wind turbine in relation to hearing sensitivity in fish. The Journal of the Acoustical Society of America 130, 200-207[redacted].
Sinclair, R. R., Sparling, C. E., & Harwood, J. (2020). Review Of Demographic Parameters and Sensitivity Analysis To Inform Inputs And Outputs Of Population Consequences Of Disturbance Assessments For Marine Mammals. Scottish Marine and Freshwater Science, 11(14), 74.
Sinclair, R; Booth, C, Harwood, J. & Sparling, C. (2019). Helpfile For The Interim Pcod V5 Model. March 2019.

SMASS (2009-2020) Marine Mammal Strandings Co-ordination and Investigation (Scotland). Available at: [redacted]
SMRU Ltd (Sea Mammal Research Unit Ltd) (2010). Approaches to Marine Mammal Monitoring at Marine Renewable Energy Developments. Final Report on behalf of The Crown Estate.
Southall, B.L., Bowles, A.E., Ellison, W.T., Finneran, J.J., Gentry, R.L., Greene Jr., C.R., Kastak, D., Ketten, D.R., Miller, J.H., Nachtigall, P.E., Richardson, W.J., Thomas, J.A., and Tyack, P.L. (2007). Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. Aquatic Mammals, 33 (4), pp. 411-509.
Southall, B.L., Finneran, J.J., Reichmuth, C., Nachtigall, P.E., Ketten, D.R., Bowles, A.E., Ellison, W.T., Nowacek, D.P. and Tyack, P.L. (2019). Marine mammal noise exposure criteria: updated scientific recommendations for residual hearing effects. Aquatic Mammals, 45(2), pp.125-232.
Southall, B.L., Nowacek, D.P., Bowles, A.E., Senigaglia, V., Bejder, L. and Tyack, P.L. (2021). Marine mammal noise exposure criteria: assessing the severity of marine mammal behavioural responses to human noise. Aquatic Mammals, 47(5), pp.421-464. DOI 10.1578/AM.47.5.2021.421.
Sparling, C., Sams, C., Stephenson, S., Joy, R., Wood, J., Gordon, J., Thompson, D., Plunkett, R., Miller, B. and Götz, T. (2015). The use of Acoustic Deterrents for the mitigation of Evidence base for application of Acoustic Deterrent Devices (ADDs) as marine mammal mitigation injury to marine mammals during pile driving for offshore wind farm construction. ORJIP Project 4, Stage 1 of Phase 2. Final Report.
Stöber, U. and Thomsen, F. (2021). How could operational underwater sound from future offshore wind turbines impact marine life? The Journal of the Acoustical Society of America, 149(3), pp.1791-1795. Available online at: [redacted]
Strong, P. and Morris, S.R. (2010). Grey seal (*Halichoerus grypus*) disturbance, ecotourism and the Pembrokeshire Marine Code around Ramsey Island. J. Ecotourism 9(2): 117–132.
Sveegaard, S., Nabe-Nielsen, J., Stæhr, K.J., Jensen, T.F., Mouritsen, K.N. and Teilmann, J., 2012. Spatial interactions between marine predators and their prey: herring abundance as a driver for the distributions of mackerel and harbour porpoise. Marine Ecology Progress Series, 468, pp.245-253.
Teilmann, J., Carstensen, J., Dietz, R., Edrén, S. and Andersen, S. (2006). Final report on aerial monitoring of seals near Nysted Offshore Wind Farm Technical report to Energi E2 A/S. Ministry of the Environment Denmark.
Theobald, P.D., Robinson, S.P., Lepper, P.A., Hayman, G., Humphrey, V.F., Wang, L. and Mumford, S.E. (2011). The measurement of underwater noise radiated by dredging vessels during aggregate extraction operations. 4th International Conference and Exhibition on Underwater Acoustic Measurements: Technologies & Results.
Thompson, P.M., Hastie G. D., Nedwell, J., Barham, R., Brookes, K., Cordes, L., Bailey, H. and McLean, N. (2012). Framework for assessing the impacts of pile-driving noise from offshore windfarm construction on the Moray Firth harbour seal population. Seal assessment Framework Technical Summary, 6th June 2012.

Thomsen, F., Lüdemann, K., Kafemann, R. and Piper, W. (2006). Effects of offshore windfarm noise on marine mammals and fish, on behalf of COWRIE Ltd.
Todd, S., Lien, J., Marques, F., Stevick, P., & Ketten, D. (1996). Behavioural effects of exposure to underwater explosions in humpback whales (Megaptera novaeangliae). *Canadian Journal of Zoology*, *74*(9), 1661-1672.
Todd, V.L.G., Todd, I.B., Gardiner, J.C., Morrin, E.C.N., MacPherson, N.A., DiMarzio, N.A. and Thomsen, F. (2014). A review of impacts of marine dredging activities on marine mammals. – ICES Journal of Marine Science, doi: 10.1093/icesjms/fsu187.
Tougaard, J., Carstensen, J. and Teilmann, J. (2009b). Pile driving zone of responsiveness extends beyond 20km for harbour porpoises (*Phocoena phocoena* (L.)) (L). J. Acoust. Soc. Am., 126, pp. 11-14.
Tougaard, J., Carstensen, J., Wisch, M.S., Teilmann, J., Bech, N., Skov, H. and Henriksen, O.D. (2005). Harbour porpoises on Horns reef—effects of the Horns Reef Wind farm. Annual Status Report 2004 to Elsam. NERI, Roskilde (Also available at: www.hornsrev.dk).
Tougaard, J., Henriksen, O.D. and Miller. L.A. (2009a). Underwater noise from three types of offshore wind turbines: estimation of impact zones for harbour porpoise and harbour seals. Journal of the Acoustic Society of America 125(6): 3766.
Tougaard, J., Hermannsen, L. and Madsen, P.T. (2020). How loud is the underwater noise from operating offshore wind turbines? J. Acoust. Soc. Am. 148 (5). doi.org/10.1121/10.0002453.
Trigg, L.E., Chen, F., Shpiro, G/I., Ingram, S.N., Vincent, C., Thompson, D., Russell, D.J.F., Carter, M.I.D. and Embling, C.B. (2020). Predicting the exposure of diving grey seals to shipping noise. The Journal of the Acoustical Society of America 148, 1014 (2020); doi: 10.1121/10.0001727. [redacted]
Tyack, P. L., & Thomas, L. (2019). Using dose–response functions to improve calculations of the impact of anthropogenic noise. Aquatic Conservation: Marine and Freshwater Ecosystems, 29, 242-253.
Vasquez, Mickaël & Allen, Harriet & Manca, Eleonora & Castle, Lewis & Lillis, Helen & Agnesi, Sabrina & Al-Hamdani, Zyad & Aldo, Annunziatellis & Natalie, Askew & Bekkby, Trine & Bentes, Luis & Doncheva, Valentina & Drakopoulou, Paraskevi & Graeme, Duncan & Gonçalves, Jorge & Inghilesi, R. & Laamanen, Leena & Loukaidi, Vassiliki & Martin, Simon & Virtanen, Elina. (2021). EUSeaMap 2021. A European broad-scale seabed habitat map. 10.13155/83528.
Verfuss, U.K., Sinclair, R.R. and Sparling, C.E. (2019). A review of noise abatement systems for offshore wind farm construction noise, and the potential for their application in Scottish waters. Scottish Natural Heritage Research Report No. 1070. Available from: [redacted]
Waggitt, J.J., Evans, P.G., Andrade, J., Banks, A.N., Boisseau, O., Bolton, M., Bradbury, G., Brereton, T., Camphuysen, C.J., Durinck, J. and Felce, T. (2019).

Distribution maps of cetacean and seabird populations in the North-East Atlantic. Journal of Applied Ecology, 57(2), pp.253-269.
Whyte, K. F., Russell, D. J., Sparling, C. E., Binnerts, B., & Hastie, G. D. (2020). Estimating the effects of pile driving sounds on seals: Pitfalls and possibilities. *The Journal of the Acoustical Society of America*, *147*(6), 3948-3958.
Wilhelmsson, D., Malm, T., and Öhman, M.C. (2006). The influence of offshore windpower on demersal fish, ICES Journal of Marine Science, 63: pp. 775-784.
Wilson, B. Batty, R. S., Daunt, F. and Carter, C. (2007). Collision risks between marine renewable energy devices and mammals, fish and diving birds. Report to the Scottish Executive. Scottish Association for Marine Science, Oban, Scotland, PA37 1QA.
Wilson, L.J. and Hammond, P.S., 2019. The diet of harbour and grey seals around Britain: Examining the role of prey as a potential cause of harbour seal declines. Aquatic Conservation: Marine and Freshwater Ecosystems, 29, pp.71-85.
Windsland, K., Lindstrøm, U., Nilssen, K.T. and Haug, T., 2007. Relative abundance and size composition of prey in the common minke whale diet in selected areas of the north-eastern Atlantic during 2000-04. J. Cetacean Res. Manage, 9(3), pp.167-178.
Wisniewska DM, Johnson M, Teilmann J, Rojano-Doñate L, Shearer J, Sveegaard S, Miller LA, Siebert U, Madsen PT (2016) Ultra-high foraging rates of harbour porpoises make them vulnerable to anthropogenic disturbance. Curr Biol 26: 1441-1446
Wisniewska, D. M., Johnson, M., Teilmann, J., Siebert, U., Galatius, A., Dietz, R., & 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*(1872), 20172314.
WWT (2009). Distributions of Cetaceans, Seals, Turtles, Sharks and Ocean Sunfish recorded from Aerial Surveys 2001-2008. The Wildfowl and Wetlands Trust.

HARNESSING THE POWER OF NORTH SEA WIND

North Falls Offshore Wind Farm Limited

A joint venture company owned equally by SSE Renewables and RWE.

To contact please email contact@northfallsoffshore.com