Morecambe Offshore Windfarm: Generation Assets

Environmental Statement

Volume 5

Chapter 11 Marine Mammals (Tracked)

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MORECAMBE

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Glossary of Acronyms

AC	Alternating Current
ADD	Acoustic Deterrent Device
AfL	Agreement for Lease
AIS	Automatic Identification System
ASCOBANS	Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas
AyM	Awel y Môr
BEIS	Department for Business, Energy and Industrial Strategy[1]
BSI	British Standards Institution
CBRA	Cable Burial Risk Assessment
CEA	Cumulative Effects Assessment
Cefas	Centre for Environment, Fisheries and Aquaculture
CGNS	Celtic and Greater North Seas
CI	Confidence Interval
CIEEM	Chartered Institute of Ecology and Environmental Management
CIS	Celtic and Irish Sea
CL	Confidence Limit
CPOD	Cetacean Porpoise Detector
CSIP	Cetacean Strandings Investigation Programme
CV	Coefficient of Variation
CWT	Cornwall Wildlife Trust
DAERA	Department of Agriculture, Environment and Rural Affairs
DCO	Development Consent Order
DECC	Department of Energy and Climate Change[1]
Defra	Department for Environment, Food and Rural Affairs
DEPONS	Disturbance Effects of Noise on the Harbour Porpoise Population in the North Sea
DESNZ	Department for Energy Security and Net Zero
DML	Deemed Marine Licence
E	East
EDR	Effective Deterrence Radius

[1] The Department of Energy and Climate Change (DECC) was merged with the Department for Business, Energy and Industrial Strategy (BEIS) in 2016. As of February 2023, BEIS is known as the Department for Energy Security and Net Zero (DESNZ).

EIA	Environmental Impact Assessment
EMEC	European Marine Energy Centre
EMF	Electromagnetic Field
EMODnet	European Marine Observation and Data Network
EPP	Evidence Plan Process
EPS	European Protected Species
ES	Environmental Statement
ETG	Expert Topic Groups
EU	European Union
FCS	Favourable Conservation Status
GBS	Gravity Based Structures
HF	High Frequency
HRA	Habitat Regulations Assessment
HWDT	Hebridean Whale and Dolphin Trust
IAMMWG	Inter-Agency Marine Mammal Working Group
ICES	International Council for the Exploration of the Sea
IEC	International Electrotechnical Commission
INSPIRE	Impulsive Noise Propagation and Impact Estimator
IoM	Isle of Man
IPC	Infrastructure Planning Commission (now PINS and SoS)
IPMP	In Principle Monitoring Plan
IS	Irish Sea
IUCN	International Union for Conservation of Nature
JCDP	Joint Cetacean Data Programme
JCP	Joint Cetacean Protocol
JNCC	Joint Nature Conservation Committee
LAT	Lowest Astronomical Tide
LF	Low Frequency
MARPOL	International Convention for the Prevention of Pollution from Ships
MF	Medium Frequency
ML	Marine Licence
MMMP	Marine Mammal Mitigation Protocol
MMO	Marine Management Organisation
MMObs	Marine Mammal Observers
MNR	Marine Nature Reserve
MPA	Marine Protected Area

MPCP	Marine Pollution Contingency Plan
MPS	Marine Policy Statement
MRE	Marine Renewable Energy
MU	Management Units
N	North
NCMPA	Nature Conservation Marine Protected Area
NI	Northern Ireland
NMFS	National Marine and Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPS	National Policy Statement
NRW	Natural Resources Wales
NSIP	Nationally Significant Infrastructure Project
NW	North-West
OESEA	Offshore Energy Strategic Environmental Assessment
OSP	Offshore Substation Platform
OSPAR	Oslo and Paris Convention for the Protection of the Marine Environment
OWF	Offshore Windfarm
PCW	Phocid Carnivores in Water
PDE	Project Design Envelope
PEIR	Preliminary Environmental Information Report
PEMP	Project Environment Management Plan
PINS	Planning Inspectorate
PTS	Permanent Threshold Shift
RIAA	Report to Inform Appropriate Assessment
RMS	Root Mean Square
RMU	Regional Management Unit
RoC	Review of Consents
RoI	Republic of Ireland
RSPB	Royal Society for the Protection of Birds
S	South
SAC	Special Area of Conservation
SBP	Sub-bottom Profiler
SCANS	Small Cetaceans in the European Atlantic and North Sea
SCOS	Special Committee on Seals
SEL	Sound Exposure Level

SEL_{cum}	Sound Exposure Level from cumulative exposure
SEL_{ss}	Sound Exposure Level from single strike
SMASS	Scottish Marine Animal Stranding Scheme
SMRU	Sea Mammal Research Unit
SNCBs	Statutory Nature Conservation Bodies
SoS	Secretary of State
SPL	Sound Pressure Level
SPL_{peak}	peak Sound Pressure Level
Spp.	Species plural
SSC	Suspended sediment concentrations
SW	South-West
TTS	Temporary Threshold Shift
UK	United Kingdom
USBL	Ultra-Short Base Line
UXO	Unexploded Ordnance
VHF	Very High Frequency
WTG	Wind Turbine Generator

Glossary of Unit Terms

µPa	micro pascal
dB	decibel
dB re 1 µPa	Underwater dB are referenced to a pressure of 1 micro Pascal (µPa), which is abbreviated as dB re 1 µPa
Hz	Herz
kHz	Kilohertz
kJ	kilojoule
km	kilometre
km/h	kilometre per hour
km^2	kilometre square kilometred
kV	kilovolt
m	metre
m/s	metres per second
m^2	metre square metred
m^3	metre cubedcubic metre
MW	Megawatt

Glossary of Terminology

Agreement for Lease (AfL)	Agreements under which seabed rights are awarded following the completion of The Crown Estate tender process.
Applicant	Morecambe Offshore Windfarm Ltd
Application	This refers to the Applicant's application for a Development Consent Order (DCO). An application consists of a series of documents and plans which are published on the Planning Inspectorate's (PINS) website.
Cetaceans	Commonly known as whales, dolphins or porpoises
European sites	Designated nature conservation sites, which include the National Site Network (designated within the United Kingdom (UK)) and Natura 2000 sites (designated in any European Union (EU) country). This includes candidate Special Areas of Conservation (cSAC), Sites of Community Importance, Special Areas of Conservation (SAC) and Special Protection Areas (SPA).
Expert Topic Group (ETG)	A voluntary consultation process with specialist stakeholders to agree the approach, and information to support, the Environmental Impact Assessment (EIA) and Habitats Regulations Assessment (HRA) for certain topics. The Evidence Plan Process (EPP) provides a mechanism to agree the information required to be submitted to PINS as part of the DCO application. This function of the EPP helps Applicants to provide sufficient information in their application, so that the Examining Authority can recommend to the Secretary of State whether or not to accept the application for examination and whether an appropriate assessment is required.
Generation Assets (the Project)	Generation assets associated with the Morecambe Offshore Windfarm. This is infrastructure in connection with electricity production, namely the fixed foundation wind turbine generators (WTGs), inter-array cables, offshore substation platform(s) (OSP(s)) and possible platform link cables to connect OSP(s).
Inter-array cables	Cables which link the WTGs to each other and the OSP(s).
Landfall	Where the offshore export cables would come ashore.
Management Unit	Management units provide an indication of the spatial scales at which impacts of plans and projects alone, cumulatively and in-combination, need to be assessed for the key cetacean species in UK waters, with consistency across the UK.
Mean High Water Spring	Mean High Water Spring (MHWS) refers to the average height of high tides during spring tides over a set period.

Morgan and Morecambe Offshore Wind Farms: Transmission Assets	The transmission assets for the Morgan Offshore Wind Project and the Morecambe Offshore Windfarm. This includes the OSP(s)[2], interconnector cables, Morgan offshore booster station, offshore export cables, landfall site, onshore export cables, onshore substations, 400kV cables and associated grid connection infrastructure such as circuit breaker infrastructure. Also referred to in this document as the Transmission Assets, for ease of reading.
Nacelle	The part of the turbine that houses all of the generating components
Offshore Substation Platform (OSP)	A fixed structure located within the windfarm site, containing electrical equipment to aggregate the power from the WTGs and convert it into a more suitable form for export to shore.
Permanent Threshold Shift (PTS)	A permanent total or partial loss of hearing sensitivity caused by acoustic trauma. PTS results in irreversible damage to the sensory hair cells of the ear, and thus a permanent reduction of hearing acuity.
Pinnipeds	Commonly known as seals.
Platform link cable	An electrical cable which links one or more OSP.
Safety Zone	An area around a structure or vessel which should be avoided, as set out in Section 95 of the Energy Act 2004 and the Electricity (Offshore Generating Stations) (Safety Zones) (Application Procedures and Control of Access) Regulations 2007.
Scour protection	Protective materials to avoid sediment being eroded away from the base of the foundations due to the flow of water.
Sequential piling	A scenario where one pile is installed after another pile in the same 24 hour period (e.g. three monopiles in the same 24 hour period or four pin-piles in the same 24 hour period).
Sound Exposure Level (SEL)	The constant sound level acting for one second, which has the same amount of acoustic energy, as indicated by the square of the sound pressure, as the original sound. It is the time-integrated, sound-pressure-squared level. SEL is typically used to compare transient sound events having different time durations, pressure levels, and temporal characteristics.
Sound Pressure Level (SPL)	The sound pressure level or SPL is an expression of the sound pressure using the decibel (dB) scale, and the standard reference pressures of 1 μPa for water and 20 μPa for air.
Study area	This is an area which is defined for each EIA topic, which includes the windfarm site, as well as potential spatial and temporal considerations of the impacts on relevant receptors. The study area for each EIA topic is intended to cover the area within which an effect can be reasonably expected.

[2] At the time of writing the Environmental Statement (ES), a decision had been taken that the offshore substation platform (OSP) would remain solely within the Generation Assets application and would not be included within the Development Consent Order application for the Transmission Assets. This decision post-dated the Preliminary Environmental Information report (PEIR) that was prepared for the Transmission Assets for the purposes of this ES as the Cumulative Effects Assessment (CEA) carried out in respect of the Generation/Transmission Assets is based on the Information available from the Transmission Assets PEIR.

	Marine mammal study areas have been defined, based on the relevant Management Units and current knowledge and understanding of the biology of each species.
Technical stakeholders	Technical stakeholders are considered to be organisations with detailed knowledge or experience of the area within which the Project is located and/or receptors which are considered in the EIA and HRA. Examples of technical stakeholders include the Marine Management Organisation (MMO), local authorities, Natural England (NE) and the Royal Society for the Protection of Birds (RSPB).
Wind turbine generator (WTG)	A fixed structure located within the windfarm site that converts the kinetic energy of wind into electrical energy.
Windfarm site	The area within which the WTGs, inter-array cables, OSP(s) and platform link cables would be present.

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11 The future of renewable energy

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11 Marine Mammals

11.1 Introduction

11.1 This chapter of the Environmental Statement (ES) describes the potential effects of the Morecambe Offshore Windfarm Generation Assets (the Project) on marine mammals. The chapter provides an overview of the existing environment, followed by an assessment of the potential effects and associated mitigation, where required, for the construction, operation and maintenance and decommissioning phases.

11.2 The Project includes the generation assets to be located within the windfarm site (wind turbine generators (WTGs), inter-array cables, offshore substation platform(s) (OSP(s)) and possible platform link cables to connect OSP(s)). The Environmental Impact Assessment (EIA) of the transmission assets, including offshore export cables to landfall and onshore infrastructure, is part of a separate Development Consent Order (DCO) Application, as outlined in **Chapter 1 Introduction** (Document Reference 5.1.1).

11.3 This assessment has been 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 EIA and Cumulative Effects Assessment (CEA), are presented in **Chapter 6 EIA Methodology** (Document Reference 5.1.6) and **Section 11.1** of this chapter.

11.4 This assessment has been informed by the following chapters:

- **Chapter 8 Marine Sediment and Water Quality** (Document Reference 5.1.8) - assessments inform this chapter due to indirect effects on marine mammals
- **Chapter 9 Benthic Ecology** (Document Reference 5.1.9) - assessments inform this chapter due to indirect effects on prey species
- **Chapter 10 Fish and Shellfish Ecology** (Document Reference 5.1.10) - assessments inform this chapter due to indirect effects on prey species
- **Chapter 13 Commercial Fisheries** (Document Reference 5.1.13) - assessments inform this chapter due to indirect effects on prey species
- **Chapter 14 Shipping and Navigation** (Document Reference 5.1.14) - assessments inform this chapter due to collision risk effects

11.5 Inter-relationships with these chapters are further described in **Section 11.9**.

11.6 Additional key information to support the marine mammal assessment includes:

- **Appendix 11.1 Underwater Noise Assessment** (Document Reference 5.2.11.1)
- **Appendix 11.2 Marine Mammal Information and Survey Data** (Document Reference 5.2.11.2)
- **Appendix 11.3 Marine Mammal Unexploded Ordnance (UXO) Assessment** (Document Reference 5.2.11.3)
- **Appendix 11.4 Marine Mammal CEA Project Sceening** (Document Reference 5.2.11.4)
- **Appendix 11.5 Marine Mammal Consultation Responses** (Document Reference 5.2.11.5)
- **Appendix 12.2 Aerial Surveys Two Year Report March 2021 to February 2023** (Document Reference 5.2.12.2)

11.2 Consultation

11.7 Consultation regarding marine mammals has been undertaken in line with the general process described in **Chapter 6 EIA Methodology**. The key elements undertaken to inform this ES have included Scoping (Scoping Opinion from the Planning Inspectorate (PINS) received on 2nd August 2022; PINS, 2022), comments received on the Preliminary Environmental Information Report (PEIR) which was published in April 2023 for statutory consultation, and the Evidence Plan Process (EPP) via the Marine Mammal Ecology Expert Topic Group (ETG) meetings.

11.8 The feedback received throughout the EPP, the Scoping Opinion and PEIR comments have been considered in preparing this ES. The key comments pertinent to this chapter are shown in **Appendix 11.5**, alongside details of how the Project team has had regard to the comments received and how these have been addressed within this chapter.

11.9 Full details on the consultation undertaken throughout the EIA process are presented in the Consultation Report (Document Reference 4.1), which is submitted as part of the DCO Application.

11.3 Scope

11.3.1 Study area

11.10 The Project windfarm site is located in the Eastern Irish Sea and encompasses a seabed area of 87km^2. Water depths within the windfarm site range from 18m to 40m (relative to Lowest Astronomical Tide (LAT)). It is located approximately 30km from the nearest point on the coast of Lancashire.

11.11 The study area for the marine mammal assessment has been defined on the basis that marine mammals are highly mobile and transitory in nature. Therefore, it is necessary to examine species occurrence not only within the windfarm site, but also over the wider area.

11.12 For the marine mammal species detailed in the assessment, the following study areas have been defined, based on the relevant Management Units (MUs) (Inter-Agency Marine Mammal Working Group (IAMMWG, 2023) and current knowledge and understanding of the biology of each species (see **Appendix 11.2** for further information and maps of the MUs):

- Harbour porpoise *Phocoena phocoena*: Celtic and Irish Sea (CIS) MU
- Bottlenose dolphin *Tursiops truncatus*: Irish Sea (IS) MU
- Common dolphin *Delphinus delphis*: Celtic and Greater North Seas (CGNS) MU
- Risso's dolphin *Grampus griseus*: CGNS MU
- White-beaked dolphin *Lagenorhynchus albirostris*: CGNS MU
- Minke whale *Balaenoptera acutorostrata*: CGNS MU

11.13 Based on the movements of grey seal *Halichoerus grypus* and potential connectivity with the Project, the relevant MUs (plus IoM) include:

- North-West (NW) England MU (within which the Project is located)
- South-West (SW) Scotland MU
- Wales MU
- Northern Ireland (NI) MU
- Isle of Man (IoM)
- Republic of Ireland (RoI) East (E) and South-East MUs.

11.14 For harbour seal *Phoca vitulina* the relevant MUs include:

- NW England MU (within which the Project is located)
- NI MU

11.15 The study area for the CEA is defined in **Appendix 11.4**. The study area for designated sites is defined in the Report to Inform Appropriate Assessment (RIAA) (Document Reference 4.9).

11.16 The status and activity of marine mammals known to occur within or adjacent to the Project windfarm site were considered in the context of regional population dynamics at the scale of the wider CIS. This depended on the data available for each species and the extent of the relevant reference population.

11.17 There is the potential for seals from haul-out sites to move along the coast and offshore to forage in and around the windfarm site. Key haul-out sites for grey seal in the vicinity of the Project include:

- South Walney; located approximately 30km north-east of the Project's northern boundary
- The Dee Estuary on the Welsh-English border (Hilbre Island); located approximately 45km south-east of the Project's southern boundary
- Puffin Island; located at the eastern edge of the Menai Strait, approximately 55km south-southwest of the Project's southern boundary
- The Skerries are an island group on the North coast of Angelsey; located approximately 72km SW of the Project's western boundary
- Calf of Man, south of the IoM; located approximately 80km NW of the Project's western boundary

11.3.2 Realistic worst-case scenario

11.18 The final design of the Project would be confirmed through detailed engineering design studies that would be undertaken post-consent to enable the commencement of construction. To provide a precautionary but robust impact assessment at this stage of the development process, realistic worst-case scenarios have been defined. The realistic worst-case scenarios for each individual impact were derived from the Project Design Envelope (PDE), to ensure that all other design scenarios would have the same, or less, impact. Further details are provided in **Chapter 6 EIA Methodology**. This approach is common practice for developments of this nature, as set out in PINS Advice Note Nine: Rochdale Envelope (PINS, 2018).

11.19 The realistic worst-case scenarios for the marine mammal assessments are summarised in **Table 11.1**. These are based on the project parameters described in **Chapter 5 Project Description** (Document Reference 5.1.5), which provides further details regarding specific activities and their durations. The envelope has been refined as much as possible between PEIR and ES, presenting a project description with design flexibility only where it is needed.

Table 11.1 Realistic worst-case scenarios for marine mammals

Impact	Worst-case scenario	Notes and rationale
Construction phase		
Impact 1 & 2: Underwater noise during foundation installation (piling)	**Number of piles for WTG foundations:** ▪ Maximum of 35 WTGs ○ Up to 35 monopiles or ○ Up to 140 jacket pin-piles **Number of piles for OSP foundations:** ▪ Maximum of 2 OSPs ○ Up to 2 monopiles or ○ Up to 8 jacket pin-piles **Total number of piles for WTG and OSP foundations:** ▪ Maximum of 37 foundations ○ Up to 37 monopiles or ○ Up to 148 jacket pin-piles	The worst-case scenario for number of piles assumes the maximum number of WTGs (35) and OSPs (2) and assumes 100% of foundations are piled. The worst-case scenario for number of piles assumes either one monopile per WTG and OSP, or four jacket pin-piles per WTG and OSP. The worst-case for sequential piling is three monopiles or four pin-piles installed sequentially in 24 hours. The worst-case underwater noise modelling locations are as described in **Appendix 11.1.** Hammer (impact) piled foundations represent the worst-case scenario for underwater noise. Alternative foundation types are also considered, but do not represent the worst-case for underwater noise.
	Maximum hammer energy for monopiles: ▪ Up to 6,600kJ **Maximum hammer energy for jacket pin-piles:** ▪ Up to 2,500kJ	The worst-case scenario assumes the maximum hammer energy would be required for each piling event after the completion of the soft start and ramp up. However, in reality this is not expected to be required for all piles and would not be required for the entire duration while installing a pile.

Impact	Worst-case scenario	Notes and rationale
	Maximum pile diameter for monopiles: ▪ Up to 12m **Maximum pile diameter for jacket piles:** ▪ Up to 3m per leg	The worst-case scenario for piles assumes the maximum pile diameters for the largest WTGs and OSP monopile and jacket pin-pile foundations.
	Duration of WTG/OSP foundation installation: ▪ Approximately 9 -12 months	Piling would not take place over the entire 9-12 month period that is expected to be required for the installation of WTG and OSP(s).
	Maximum piling time for WTG foundations: ▪ **Monopiles** (including soft-start and ramp-up): ○ 3 hours 48 minutes per WTG ○ Up to 133 hours for 35 WTGs or ▪ **Jacket pin piles** (including soft-start and ramp-up): ○ 3 hours 13 minutes per jacket pin pile ○ Up to 12 hours 53 minutes per foundation (4 pin piles per foundation) ○ Up to 452 hours for 35 WTGs	Maximum piling time includes soft-start and ramp-up. The maximum duration listed here reflects the worst-case scenario for underwater noise, which considers the highest strike rate. It is noted that the duration of piling could be up to 4 hours 30 minutes per pile (monopile and each pin pile) if a lower strike rate was used. However, this does not present the worst-case for underwater noise ranges. The minor difference between piling duration in the high strike rate scenario and the lower strike rate scenario is not considered to be material. As such, the high strike rate is carried throughout the assessment.
	Maximum piling time for OSP foundations: ▪ **Monopiles** (including soft-start and ramp-up): ○ 3 hours 48 minutes per OSP ○ Up to 7 hours 36 minutes for 2 OSPs or ▪ **Jacket pin piles** (including soft-start and ramp-up): ○ 3 hours 13 minutes per jacket pin pile	

Impact	Worst-case scenario	Notes and rationale
	○ Up to 12 hours 53 minutes per foundation (4 pin piles per foundation) ○ Up to 25 hours and 47 minutes for 2 OSPs	
	Maximum total piling time for WTGs and OSPs (including soft-start and ramp-up): ▪ Monopiles for WTGs and OSPs: ○ 190 hours ▪ Monopiles for WTGs and jacket pin-piles for OSPs: ○ 213 hours and 12 minutes ▪ Jacket pin-piles for WTGs and OSPs: ○ Up to 619 hours and 36 minutes	Worst-case scenario for total active piling time is assumed to be jacket piles for all WTGs and OSPs (including soft-start and ramp-up).
	Activation of Acoustic Deterrent Device (ADD): ▪ For example: 80 minutes per monopile or 58 minutes for four sequential jacket pin-piles.	This is only indicative, as this would be confirmed on the final design and stated in the Marine Mammal Mitigation Protocol (MMMP) post-consent.
	No concurrent piling for: ▪ Installation of WTG foundations (monopiles or jacket piles) ▪ Installation of OSP foundations (monopiles or jacket piles) ▪ Installation of WTG and OSP foundations (monopiles or jacket piles)	The Project does not include the option for concurrent piling of its foundations. [concurrent piling = two or more piles installed at the same time at different locations from different vessels].
	Potential for sequential piling: ▪ Monopiles = yes ○ Up to 3 monopiles could be installed sequentially in same 24-hour period	Assessments were based on a worst-case scenario of three monopiles installed sequentially in the same 24-hour period, or up to four jacket piles installed sequentially in the same 24-hour period.

Impact	Worst-case scenario	Notes and rationale
	▪ Jacket piles = yes ○ Up to 4 jacket pin-piles could be installed sequentially in same 24-hour period	[sequential piling = one pile is installed after another pile in the same 24-hour period]. Cumulative sound exposure levels (SEL_{cum}) have been modelled for each piling event under consideration: single monopiles, single pin-piles, three monopiles piled sequentially and four pin-piles piled sequentially. Three sequential monopiles provide the worst case in terms of SEL_{cum}.
	Underwater noise modelling was undertaken for worst-case scenarios for piling. See **Appendix 11.1** for parameters and scenarios.	
Impact 3: Underwater noise during other construction activities (such as seabed preparations, cable installation and rock placement) [3]	Seabed clearance methods could include: ▪ Pre-lay grapnel run, boulder grab, plough, sandwave levelling (pre-sweeping) and dredging	Dredging is considered to be the worst-case scenario, in terms of underwater noise levels.
	Cable & cable protection installation methods: ▪ Trenching (e.g. jetting or mechanical cutting) ▪ Dredging ▪ Ploughing ▪ Cable laying ▪ Rock placement	Underwater noise modelling undertaken for dredging, trenching, cable laying and rock placement is considered the worst-case scenario, in terms of underwater noise for construction activities other than piling (see **Appendix 11.1**).
	Windfarm site: 87km^2	Maximum windfarm site area.
	Duration of offshore construction: 2.5 years	Offshore construction works could require up to 2.5 years (excluding pre-construction activities such as geophysical surveys).

[3] UXO clearance will (if required) be assessed in a separate Marine Licence and is not included in the DCO Application. An indicative assessment based on current knowledge is available in **Appendix 11.3**.

Impact	Worst-case scenario	Notes and rationale
Impacts 4 & 6: Underwater noise, presence and movements of vessels	**Vessels:** ▪ 2,583 return trips per year vessels including deliveries, installation vessels and support vessels ▪ Maximum total number of construction vessels on site at any one time = up to 37 vessels	Construction port(s) would be confirmed prior to the start of construction. Not all construction vessels would be on site at same time. The number of vessels would vary depending on activities taking place within windfarm site. For example, piling vessels for OSPs would not be on site at the same time as piling vessels for WTGs as no concurrent piling would take place. Assessments are based on the worst-case scenario for the maximum number of vessels on site at any one time during the construction period. Assessments are based on the worst-case scenario for the maximum number of return vessel trips during the construction period.
Impact 5: Barrier effect from underwater noise	Maximum impact range for all potential noise sources from underwater noise assessments (worst-case parameters described above). Windfarm site located approximately 30km from the nearest point on the coast.	The maximum spatial area of potential impact, and duration of impacts, are considered to cause the worst-case barrier effect for underwater noise.
Impact 7: Changes to prey resources	Impacts to prey species and habitat as described in **Chapter 9 Benthic Ecology** and **Chapter 10 Fish and Shellfish Ecology**: Temporary habitat loss/physical disturbance; increased suspended sediment concentrations (SSCs) and sediment re-deposition; remobilisation of contaminated sediments; underwater noise and vibration; and changes in fishing activity.	
	Temporary habitat loss/seabed disturbance **WTG & OSP foundations:** ▪ 35 x WTGs with Gravity Based Structures (GBS) foundations (including jack-up footprint) = 303,625m^2	Given that the seabed preparation is the same per foundation for smaller and larger WTGs, the worst-case scenario assumes 35 x smaller WTGs with GBS foundations. GBS foundations are assumed to have a diameter of 65m + 10m disturbance either side.

Impact	Worst-case scenario	Notes and rationale
	▪ Two x OSPs with GBS foundations (including jack-up footprint) = 17,350m^2 ▪ Anchoring for 35 WTGs and two OSPs = 26,640m^2 **Inter-array and platform link cables:** ▪ Inter-array cables = 1,750,000m^2 ▪ Platform link cables = 250,000m^2 **Total area of seabed disturbance: 2,347,615m^2 (approximately 2.4km^2)**	The worst-case scenario is for two jack-up visits per WTG/OSP foundation in different positions over the construction period (each jack-up with 6 legs, each with a 250m^2 footprint). This equates to a total footprint of 1,500m^2 per jack-up vessel visit and 3,000m^2 over the construction period per WTG/OSP foundation. The worst-case scenario is for two anchor positions per foundation (including resetting), with up to 12 anchors per location. Each anchor width is estimated to be 6m, with an approximate seabed footprint of 30m^2 per anchor.
	Sediment displaced during seabed preparation: ▪ 35 x WTGs with GBS foundations = 455,438m^3 ▪ Two x OSPs with GBS foundations = 26,025m^3 ▪ Inter-array cables = 70,000m^3 ▪ Platform link cables = 10,000m^3 **Sediment displaced during cable installation:** ▪ Inter-array cables = 472,500m^3 ▪ Platform link cables = 67,500m^3 **Total volume of sediment disturbed: 1,101,463m^3 (approximately 1.1km^3)**	The seabed preparation area parameters are outlined in Impact 1 above. The seabed preparation area would be dredged to a depth of up to 1.5m. Drill arisings from drive-drill-drive installation methodology would result in a lower volume of sediment being disturbed (55,865m^3 – based on monopile foundations). The worst-case length of inter-array cables and platform link cables are 70km and 10km, respectively. The worst-case assumes that 10% of the length of inter-array and platform link cables would require sandwave clearance/levelling. A clearance width of 10m and height of 1m is used. The worst case assumes sediment would be released at the water surface. The worst-case for cable installation assumes that 50% of inter-array and platform link cables are buried

Impact	Worst-case scenario	Notes and rationale
		at 3m and 50% of the length is buried at 1.5m, by jetting in a box-shaped trench, with a 3m trench width. See **Chapter 9 Benthic Ecology** for more details.
	Remobilisation of contaminated sediments: as assessed **Chapter 8 Marine Sediment and Water Quality**.	
	Underwater noise and vibration: Underwater noise modelling in **Appendix 11.1**. Assessments for prey species in **Chapter 10 Fish and Shellfish Ecology**. Barrier effects to prey species from underwater noise: as assessed in **Chapter 10 Fish and Shellfish Ecology**.	As above for underwater noise parameters.
	Changes in fish activity: as assessed in **Chapter 13 Commercial Fisheries**.	
Impact 8: Changes to water quality	Changes to water quality: as assessed **Chapter 8 Marine Sediment and Water Quality**.	Worst-case scenario for any potential changes to water quality that could affect marine mammals directly.
Impact 9: Disturbance at seal haul-out sites	Distance of the windfarm site to seal haul-out sites: ▪ Dee Estuary/ Hilbre Island: approximately 45km ▪ South Walney: approximately 30km Windfarm site located approximately 30km from the nearest point on the coast. Number of vessel trips as outlined above.	Construction port(s) would be confirmed prior to the start of construction. However, the assessment considers the potential for in-transit vessels in proximity to the seal haul out sites in the study area. Movements of construction vessels could occur throughout the year.

Impact	Worst-case scenario	Notes and rationale
Operation and maintenance phase		
Impact 1: Underwater noise from operational turbines	WTG parameters (e.g. size and number) as outlined above and underwater noise parameters described in **Appendix 11.1.** Operational life of windfarm = 35 years	
Impact 2: Underwater noise from maintenance activities	**Estimated inter-array cable repair/replacement or reburial works:** ▪ Average length of inter-array/platform link cable repair/replacement every year = up to 200m ▪ Average length of inter-array/platform link cable reburial every year = up to 100m	Disturbance is shown on average per year; however, repair/replacement, cable lengths and reburial activities could vary across years during the operation and maintenance phase. Underwater noise modelling undertaken for dredging, trenching, cable laying and rock placement (see above and **Appendix 11.1**).
Impact 3 & 6: Underwater noise, presence and movements of vessels	**Vessels:** ▪ Types of vessels: cable laying and burial, rock placement, support vessels, crew transfer vessels, jack-up vessels ▪ Maximum number of vessels on site at any one time: ○ Three vessels during a standard year and 10 vessels on a 'heavy maintenance' year (every 5 years) ▪ Maximum annual number of vessel return trips to port: ○ 384 vessels during a standard year and 832 vessels on a 'heavy maintenance' year	Operation and maintenance port(s) have still to be determined. Assessments are based on the worst-case scenario for a maximum number of operation and maintenance vessels on site at any one-time and a maximum number of return vessel trips during the operation and maintenance period.

<table>
<tr><th>Impact</th><th>Worst-case scenario</th><th>Notes and rationale</th></tr>
<tr><td>Impact 4: Barrier effect from underwater noise</td><td>Maximum impact range for all potential noise sources from underwater noise assessments (as above) during operation and maintenance phase.

WTG spacing:
▪ Minimum in-row spacing: 1,060m
▪ Minimum inter row spacing: 1,410m</td><td>The maximum spatial area of potential impact, and duration of impacts, are considered to cause the worst-case barrier effect for underwater noise.</td></tr>
<tr><td>Impact 5: Barrier effects from physical presence of windfarm</td><td>Fixed foundations.

WTG spacing:
▪ Minimum in row spacing: 1,060m
▪ Minimum inter row spacing: 1,410m</td><td>The maximum spatial area of potential impact is considered to cause the worst-case barrier effect, due to the presence of windfarm infrastructure.</td></tr>
<tr><td rowspan="2">Impact 7: Changes to prey resources</td><td colspan="2">Impacts to prey species and habitat as described in **Chapter 9 Benthic Ecology** and **Chapter 10 Fish and Shellfish Ecology**: Permanent habitat loss; temporary habitat loss/physical disturbance of the seabed, increased SSCs and sediment deposition; underwater noise; Electromagnetic Fields (EMF); barrier effects; introduction of hard substrates; and changes in fishing activity.</td></tr>
<tr><td>**Worst-case for total habitat loss to the footprint of infrastructure:**
▪ 35 x GBS WTGs with scour protection = 248,080m^2
▪ Two GBS OSPs with scour protection = 14,176m^2
▪ Inter-array cables = 91,000m^2
▪ Platform link cables = 13,000m^2
▪ Cable protection at the entry to WTGs and OSPs = 45,500m^2
▪ Cable crossings (at inter-array and platform link cables): 66,750m^2
▪ Replacement scour protection = 13,950m^2</td><td>The worst-case scenario is based on the maximum area of infrastructure on the seabed.</td></tr>
</table>

Impact	Worst-case scenario	Notes and rationale
	▪ Replacement cable protection (including crossings and entries to WTGs/OSPs) = 21,625m^2 **Total worst-case habitat loss: 514,081m^2 (approximately 0.51km^2)**	
	Temporary habitat loss, physical disturbance of the seabed, increases in SSCs and sediment deposition due to maintenance activities could result from periodic jack-up vessel deployment, and cable repair, replacement and reburial activities. These activities are likely to be lower in magnitude than for construction.	
	Underwater noise parameters as outlined for operation noise-related impacts above and **Appendix 11.1** (operational WTGs, maintenance activities, vessels).	As above for underwater noise.
	EMF from offshore cables Up to 70km of inter-array and 10km platform link cables: ▪ Cable operating voltage of 220/275kV Alternating Current (AC) ▪ Burial range of 0.5m-3m where possible with a target burial depth of 1.5m	Cable burial would substantially reduce the levels of EMF in the surrounding area. Where cable burial is not possible, cable protection would be added that would reduce the levels of EMF.
	Barrier effects from underwater noise or EMF: As above	
	Introduction of hard substrate: As above for WTGs, OSPs, scour protection, inter-array and platform link cable protection, cable protection at the entry to WTGs and OSPs and cable crossings (approximately 0.51km^2)	As above for total habitat loss to the footprint of infrastructure.
Impact 8: Changes to water quality	Changes to water quality as assessed in **Chapter 8 Marine Sediment and Water Quality**.	
Impact 9: Disturbance at seal haul-out sites	Distance of the windfarm site and vessel routes to seal haul-out sites. ▪ Dee Estuary/ Hilbre Island: approximately 45km	Operation and maintenance port(s) to be confirmed post-consent. At this stage, it is assumed that the operation and maintenance port(s) would be within a 50km range of the windfarm site and considered in

Impact	Worst-case scenario	Notes and rationale
	▪ South Walney: approximately 30km The windfarm site is located approximately 30km from the nearest point on the coast. Number of vessel trips as outlined above.	transit in regard to the seal haul-out sites in the study area. Movements of vessels could occur throughout the year.
Decommissioning phase		
Impact 1 & 2: Underwater noise from foundation removal of WTGs and OSPs and cable removal (if required) and other offshore decommissioning activities Impact 3: Underwater noise, presence and movements of vessels Impact 4: Barrier effect from underwater noise Impact 5: Increased collision risk with vessels Impact 6: Changes to prey resources Impact 7: Changes to water quality Impact 8: Disturbance at seal haul-out sites	The decommissioning policy for the Project infrastructure is not yet defined, however, it is anticipated that structures above the seabed would be removed. The following infrastructure is likely be removed, reused, or recycled where practicable: ▪ WTGs and foundations ▪ OSPs including topsides and foundations. The following infrastructure is likely to be decommissioned and could be left in situ, depending on regulator advice and available information at the time of decommissioning: ▪ Inter array and platform link cables ▪ Scour protection ▪ Cable crossings and cable protection ▪ Part of the foundations (e.g. some foundation material below the seabed may be left in situ)	The detail and scope of the decommissioning works would be determined by the relevant legislation and guidance at the time. Decommissioning arrangements would be detailed in a Decommissioning Programme, which would be drawn up and agreed with the relevant authority at the time, prior to decommissioning. For the purposes of the worst-case scenario, it is anticipated that the impacts would be comparable to those identified for the construction phase.

11.3.3 Summary of mitigation embedded in the design

11.20 This section outlines the embedded mitigation relevant to the marine mammal assessment, which has been incorporated into the design of the Project (as summarised in **Table 11.2**).

11.21 Additionally, the Project would develop and implement a MMMP for piling activities outlining best proactive measures to reduce risk of underwater noise from UXO clearance and piling from causing auditory injury to marine mammals (as described in **Section 11.3.3.1**). A Draft MMMP detailing potential mitigation measures has been included with the Application (Document Reference 6.5).

11.22 Several techniques and engineering designs or modifications have been considered. These measures aim to either avoid certain impacts or minimise them as far as reasonably possible. Among these measures are adjustments to piling parameters, which involve factors such as regulating maximum hammer energy, determining the duration of soft-start and ramp-up, controlling the strike rate, and managing the number of strikes used in the process.

Table 11.2 Embedded mitigation measures related to marine mammals

Parameter	Mitigation measures embedded into the design of the Project
Underwater noise	
Piling schedule	No concurrent piling is to be undertaken.
Soft-start and ramp-up	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 soft-start and ramp-up allows mobile species to move away from the area before the maximum hammer energy with the greatest noise impact area is reached.
Water quality	
Pollution prevention	As outlined in **Chapter 8 Marine Sediment and Water Quality**, the Applicant is committed to the use of best practice techniques and due diligence regarding the potential for pollution throughout all construction, operation and maintenance, and decommissioning activities. An Outline Project Environment Management Plan (PEMP) (Document Reference 6.2) has been included with the Application. The PEMP, in line with international and national regulations, would set out all procedures and measures (including a Marine Pollution Contingency Plan (MPCP) and chemical risk assessment) to be followed during construction, operation and maintenance, and decommissioning phases to minimise the risk of, and effects in the event of an accidental spill. The final PEMP would be agreed with the Marine Management Organisation (MMO) prior to construction.

Parameter	Mitigation measures embedded into the design of the Project
EMF	
Cables and cable burial	Cables would be buried where possible. The cable burial range would be between 0.5m and 3.0m below the seabed (with a target depth of 1.5m where ground conditions allow (recognised industry good practice which would reduce effects of EMF)). A Cable Burial Risk Assessment (CBRA) would also be required to confirm the extent to which cable burial can be achieved. Where it is not reasonably practicable to achieve cable burial, additional cable protection (e.g., rock placement, concrete mattresses or grout bags) would be required. An Outline Scour Protection and Cable Protection Plan (Document Reference 6.8) has been included with the Application. Cables would be specified to reduce EMF emissions as per industry standards and best practice measures, such as, the relevant IEC (International Electrotechnical Commission) specifications.

11.3.3.1 Additional mitigation commitments

11.23 In addition to the embedded mitigation measures as outlined above, the Applicant has committed to the production of a MMMP for piling and to apply best practice measures to reduce collision risk (**Table 11.3**). A Draft MMMP detailing potential mitigation measures has been included with the Application.

11.24 Noting that there is currently insufficient detailed information available pertaining to the quantity and size of UXO present within the Project windfarm site that are likely to require clearance, UXO clearance is not included in the scope of the DCO Application. As agreed with Natural England and MMO during Marine Mammal Ecology ETG meetings, UXO clearance (if required) would be subject to separate application(s) post-consent. However, the Draft MMMP also identifies measures that would be implemented, or need to be considered, for UXO clearance, given the potential for underwater noise effects to marine mammals associated with UXO clearance activities. A commitment to an MMMP for UXO clearance is also outlined in the indicative UXO Assessment, which is provided with the Application in **Appendix 11.3.**

Table 11.3 Additional measures

Document	Measures
MMMP for piling activities	The MMMP for piling would be developed in the pre-construction period and would be based upon best available information, methodologies, industry best practice, latest scientific understanding, current guidance and detailed project design. The MMMP would be developed in consultation with the relevant Statutory Nature Conservation Bodies (SNCBs) and the MMO, detailing the proposed mitigation measures to reduce the risk of any physical or permanent auditory injury (Permanent Threshold Shift (PTS)) to marine mammals during all piling operations. This would include details of the embedded mitigation for the soft-start and hammer energy ramp-up, as well as details of the proposed mitigation zone and any additional mitigation measures required in order to minimise potential impacts of any physical injury or PTS. An example of potential additional mitigation would be the activation of an ADD prior to the soft-start for piling. The Draft MMMP has been included with the DCO Application.
PEMP Vessel Traffic Management Plan (Document Reference 6.9)	Best practice to reduce vessel collision risk: Where reasonably practicable, vessel movements would follow set routes (and hence areas where marine mammals are accustomed to vessels) to reduce collision risk. In line with efficient programming of tasks and utilisation of vessels, all vessel movements associated with the Project would be kept to a minimum. This, in turn, minimises the residual risk of collision. Additionally, vessel operators would use best practice to reduce any risk of collisions with marine mammals. Consideration would also be given to minimum operating distances from seal haul-out sites, outside main shipping channels, particularly during sensitive periods for breeding and moulting. The Outline PEMP and Outline Vessel Traffic Management Plan have been included with the DCO Application.

11.4 Impact assessment methodology

11.4.1 Policy, legislation and guidance

11.4.1.1 National Policy Statement

11.25 The assessment of potential effects on marine mammals has been made with specific reference to the relevant NPS. These are the principal decision-making documents for Nationally Significant Infrastructure Projects (NSIPs). Those relevant to the Project are:

- Overarching NPS for Energy (EN-1) (Department for Energy Security and Net Zero (DESNZ) 2023a)
- NPS for Renewable Energy Infrastructure (EN-3) (DESNZ) 2023b)

11.26 The specific assessment requirements for marine mammals, as detailed in the NPS, are summarised in **Table 11.4** together with an indication of the section of the ES chapter where each is addressed.

Table 11.4 NPS assessment requirements for marine mammals

NPS requirement	NPS reference	ES reference
NPS for Energy (EN-1)		
Where the development is subject to EIA the Applicant should ensure that the ES clearly sets out any effects on internationally, nationally, and locally designated sites of ecological or geological conservation importance (including those outside England), on protected species and on habitats and other species identified as being of principal importance for the conservation of biodiversity, including irreplaceable habitats.	Paragraph 5.4.17	Any internationally, nationally, and locally designated sites where marine mammals are a qualifying feature were identified in the Habitats Regulation Assessment (HRA) Screening Report (Document Reference 4.10). Any potential effects on these sites were assessed in the RIAA. The ES also assessed potential effects with the Isle of Man Marine Nature Reserves in **Section 11.8.1**.
The applicant should show how the project has taken advantage of opportunities to conserve and enhance biodiversity and geological conservation interests.	Paragraph 5.4.19	Measures to conserve the biodiversity of marine mammals by means of mitigation are presented in **Section 11.3.3** and in the Draft MMMP. The Applicant has also provided an Environmental Benefit and Net Gain Statement (Document Reference 4.4) as part of the DCO Application.
The design of energy NSIP proposals will need to consider the movement of mobile / migratory species such as birds, fish and marine and terrestrial mammals and their potential to interact with infrastructure. As energy infrastructure could occur anywhere within England and Wales, both inland and onshore and offshore, the potential to affect mobile and migratory species across the UK and more widely across Europe (transboundary effects) requires consideration, depending on the location of development.	Paragraph 5.4.22	Detailed consideration (**Section 11.1**) and assessment (**Section 11.1 – 11.8**) of all marine mammal species that have the potential to interact with the Project is provided throughout the ES.

NPS requirement	NPS reference	ES reference
Applicants should include appropriate avoidance, mitigation, compensation, and enhancement measures as an integral part of the proposed development. In particular, the applicant should demonstrate that: ▪ During construction, they will seek to ensure that activities will be confined to the minimum areas required for the works ▪ The timing of construction has been planned to avoid or limit disturbance ▪ During construction and operation best practice will be followed to ensure that risk of disturbance or damage to species or habitats is minimised, including as a consequence of transport access arrangements ▪ Habitats will, where practicable, be restored after construction works have finished Opportunities will be taken to enhance existing habitats rather than replace them, and where practicable, create new habitats of value within the site landscaping proposals. Where habitat creation is required as mitigation, compensation, or enhancement, the location and quality will be of key importance. In this regard habitat creation should be focused on areas where the most ecological and ecosystems benefits can be realised.	Paragraph 5.4.35	The proposed avoidance and mitigation measures relevant to marine mammals are specifically outlined in **Section 11.3.3** and in the Draft MMMP. The latter also points to further consideration that would be given post-consent to any potential for cumulative noise effects and any management measures required.
NPS for Renewable Energy Infrastructure (EN-3)		
The UK Government has obligations to protect the marine environment with a network of well managed Marine Protected Areas (MPAs), which also includes Highly Protected Marine Areas (HPMAs). MCZs together with HPMAs, SACs SPAs, and Ramsar sites and marine	Paragraph 2.8.51 and 2.8.52	The Project sits outside of any protected sites. Any SAC where marine mammals are a qualifying feature were identified in the HRA screening process. Any potential effects, alone or in-combination, on these sites have been assessed in the RIAA.

NPS requirement	NPS reference	ES reference
elements of SSSIs form an ecologically coherent network of MPAs. Government has set a target for MPA condition under the Environment Act 2021. Given the scale of offshore wind deployment required to meet 2030 and 2050 ambitions, applicants will need to give close consideration to impacts on MPAs, either alone or in combination, and employ the mitigation hierarchy, and if necessary, provide compensation (both individually and in combination with other plans or projects) which may be needed to approve their projects.		The ES also assessed potential effects with the Isle of Man Marine Nature Reserves in **Section 11.8.1**.
Applicants must undertake a detailed assessment of the offshore ecological, biodiversity and physical impacts of their proposed development, for all phases of the lifespan of that development, in accordance with the appropriate policy for offshore wind farm EIAs, HRAs and MCZ assessments (See Sections 4.3 and 5.4 of EN-1).	Paragraph 2.8.101	The ES provides a detailed assessments for all phases of the lifespan of the Project, the construction phase (**Section 11.6.3**), the operation and maintenance phase (**Section 11.6.4**) and the decommissioning phase (**Section 11.6.5**). Equally, the RIAA has considered these phases of the Project in the assessment. The Marine Conservation Zone (MCZ) assessment (Document Reference 4.13) has also considered these phases but it is not relevant to marine mammals.
Applicants should assess the potential of their proposed development to have net positive effects on marine ecology and biodiversity, as well as negative effects.	Paragraph 2.8.103	All potential effects from the Project on marine mammals, have been assessed in **Section 11.1.**
Applicants should consult at an early stage of pre-application with relevant statutory consultees and energy not-for profit organisations/non-governmental organisations as appropriate, on the assessment methodologies, baseline data collection, and potential avoidance, mitigation and compensation options should be undertaken.	Paragraph 2.8.104	Consultation on assessment methodologies and baseline data collection as part of the EPP has been detailed in **Appendix 11.5** and the Consultation Report.

NPS requirement	NPS reference	ES reference
In developing proposals applicants must refer to the most recent best practice advice originally provided by Natural England under the Offshore Wind Enabling Action Programme, and/or their relevant SNCB.	Paragraph 2.8.105	Best practice guidance by Natural England and other SNCB (e.g., JNCC, Department for Environment, Food and Rural Affairs (Defra)) have been applied where appropriate throughout the ES (see **Section 11.4.1.3**).
Any relevant data that has been collected as part of post-construction ecological monitoring from existing, operational offshore wind farms should be referred to where appropriate.	Paragraph 2.8.106	Where available, relevant ecological data from existing OWFs were incorporated in the ES (**Section 11.1**), and the baseline information in **Appendix 11.2**.
Construction activities, including installing wind turbine foundations by pile driving, geophysical surveys, and clearing the site and cable route of unexploded ordnance (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 licence to allow the activity to take place.	Paragraph 2.8.127 to 2.8.129	**Section 11.1** provides an assessment of the underwater noise levels and maximum impacts ranges that could cause injury or disturbance to marine mammals from piling and other noise sources. The assessment in **Section 11.7** addresses the cumulative effects of underwater noise from other plans and projects. An indicative assessment for UXO is detailed in **Appendix 11.3**. A wildlife licence would be applied as required under the Habitats Regulations prior to applicable work.
The development of offshore wind farms can also impact fish species (see paragraphs 2.8.235 – 2.8.239), which can have indirect impacts on marine mammals if those fish are prey species.	Paragraph 2.8.130	**Section 11.1** provides an assessment of any indirect effects on marine mammals arising due to impacts on prey species and the risk of collision with construction and maintenance vessels.

NPS requirement	NPS reference	ES reference
Impacts 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, PTS and 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 11.1** and **Appendix 11.2** provide a description of the existing and future environment, including likely feeding areas and prey, seal haul-out sites, migration routes and protected areas. **Section 11.1** details the assessment for PTS, TTS and disturbance from underwater noise, including during construction from pile driving and soft-start noise levels. **Section 11.6.4.1** provides the assessment of operational noise. **Section 11.7** provides the assessment of cumulative effects. **Sections 11.6.3.6** and **11.6.4.6** detail the assessment of collision risk with vessels during construction, operation and maintenance, respectively. **Sections 11.6.3.5**, **11.6.4.4** and **11.6.4.5** detail the assessment of potential barrier effects from underwater noise or physical presence of the Project infrastructure.
The scope, effort and methods required for marine mammal surveys should be discussed with the relevant SNCB.	Paragraph 2.8.132	Monthly aerial marine mammal and seabird surveys were conducted at the Project over a period of two years (2021-2023). The requirements of the surveys were discussed with the relevant SNCBs. Survey details are provided in **Section 11.4.2.1** and **Appendix 12.2**.

NPS requirement	NPS reference	ES reference
The applicant should discuss any proposed noisy activities with the relevant statutory body and must reference the joint JNCC and SNCB underwater noise guidance (JNCC *et al*., 2020) and any successor of this guidance, in relation to noisy activities (alone and in-combination with other plans or projects) within Special Area of Conservation (SACs), SPAs, and Ramsar sites, in addition to the JNCC mitigation guidelines (https://jncc.gov.uk/our-work/marine-mammals-and-noise-mitigation/) for piling, explosive use, and geophysical surveys. Natural Resources Wales (NRW) has a position statement (reference PS 17) on assessing noisy activities which should also be referenced where relevant. Where assessment shows that noise from construction and UXO clearance may reach noise levels likely to lead to noise thresholds being exceeded (as detailed in the JNCC guidance) or an offence as described in paragraph 2.8.119 above, the applicant must look at possible alternatives or appropriate mitigation.	Paragraph 2.8.133 -2.8.134	The Applicant has discussed noisy activities through the EPP (Marine Mammal Ecology ETG), as outlined in **Section 11.2** and **Appendix 11.5** Reference has been made to the JNCC underwater noise guidance (JNCC *et al*., 2020) in relation to noisy activities (alone and in-combination with other plans or projects) for the assessment of effects on European Sites in the RIAA. The proposed mitigation measures are outlined in **Section 11.3.3** and the proposed monitoring is outlined in **Section 11.12**. Any required UXO clearance activities would be subject to a separate Marine Licence application, however, an indicative UXO Assessment has been provided for information in **Appendix 11.3.** The Draft MMMP included as part of the DCO Application includes potential mitigation protocols for UXO clearance.
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.	Paragraph 2.8.135	The Project is not situated in any SAC designated for marine mammals; thus, a SIP is not required. The potential for additive underwater noise effects however is acknowledged. Management methods would be consulted on post-consent during the finalisation of the MMMP. The RIAA has been included with the DCO Application, which assesses the effects on the integrity of European designated sites.

NPS requirement	NPS reference	ES reference
Mitigation 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 ADDs. 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	The proposed mitigation measures are outlined in **Section 11.3.3** and the proposed monitoring is outlined in **Section 11.12.**
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.	Paragraph 2.8.238	Mitigation to reduce the impacts from underwater noise are provided in the Draft MMMP, which is submitted with this DCO Application. As outlined in **Section 11.3.3** and the Draft MMMP, the required mitigation measures would be further developed in the pre-construction period. This would be based upon the best information and methodologies that are available at that time, in consultation with the relevant SNCBs and the MMO.
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 (https://jncc.gov.uk/our-work/marine-mammals-and-noise-mitigation/)	Paragraph 2.8.239	The relevant JNCC mitigation guidelines are considered, as outlined in **Section 11.4.1.3** and **Section 11.12.**

NPS requirement	NPS reference	ES reference
Secretary of State decision making The Secretary of State (SoS) should be satisfied that the preferred methods of construction, in particular the construction method needed for the proposed foundations and the preferred foundation type, where known at the time of application, are designed to reasonably minimise significant impacts on marine mammals. Unless suitable noise mitigation measures can be imposed by requirements to any development consent the SoS may refuse the application.	Paragraph 2.8.312 – 2.8.313	**Section 11.3** outlines the selection of the types of foundations, construction methods and mitigation measures that are designed to reasonably minimise significant impacts on marine mammals.
The conservation status of cetaceans and seals are of relevance and the SoS should be satisfied that cumulative and in-combination impacts on marine mammals have been considered.	Paragraph 2.8.314	The conservation statuses of relevant marine mammal species are included in **Section 11.4.1.5**. The cumulative and in-combination effects on marine mammals have been assessed in **Section 11.7** of the ES and in the RIAA respectively. Population modelling has been presented in **Section 11.6.3.2** and **11.7.3.2** at a six-year period after the start of construction to reflect the potential impacts on the conservation status.

11.4.1.2 Additional relevant policy and legislation

11.27 In addition to the NPS, there are a several of pieces of legislation and policy that are applicable to the assessment of marine mammals, which are detailed in **Appendix 11.2** and **Chapter 3 Policy and Legislation** (Document Reference 5.1.3).

11.4.1.3 Guidance documents for marine mammals

11.28 The principal guidance documents that were used to inform the marine mammals assessment include, but are not limited to, the following:

- The Protection of Marine European Protected Species 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*., 2010a)
- Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater, Coastal and Marine (Chartered Institute of Ecology and Environmental Management (CIEEM), 2019)
- 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 Limited (SMRU Limited) on behalf of The Crown Estate, 2010)
- Guidelines for Data Acquisition to Support Marine Environmental Assessments of Offshore Renewable Energy Projects (Centre for the Environment and Fisheries and Aquaculture Science (Cefas, 2011)
- 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 NE, 2020)
- A review of noise abatement systems for 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, 2010b[4])

[4] DRAFT guidelines for minimising the risk of injury to marine mammals from unexploded ordnance clearance in the marine environment (JNCC, 2023a) were issued for consultation in 2023. It is anticipated that the publication of the guidelines will occur after submission of this DCO application.

- Marine Environment: Unexploded Ordnance Clearance Joint Interim Position Statement (UK Government, 2022)
- Statutory Nature Conservation Agency Protocol for Minimising the Risk of Injury to Marine Mammals from Piling Noise (JNCC, 2010c)
- Best Practice Advice for Evidence and Data Standards Phase I-IV by Natural England and the Department for the Environment, Food and Rural Affairs (Defra) (Parker *et al*., 2022)

11.4.1.4 Protected species and marine wildlife licence guidance

11.29 All cetacean species are listed as European Protected Species (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 the Habitat and Species Regulations, it is an offence to:

- Deliberately capture, injure or kill any cetacean species
- Deliberately disturb them
- Damage or destroy a breeding site or resting place

11.30 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 the Conservation of Seals Act 1970.

11.31 Further information about relevant legislation is provided in **Appendix 11.2**.

11.32 A Marine Wildlife Licence application would be submitted post-consent, where required, under the Habitats and Species Regulations. At that time, the PDE would have been further refined through detailed design and procurement activities and further detail would be available on the techniques selected for construction, as well as the mitigation measures that would be implemented following the development of MMMPs for piling and UXO clearance (if required).

11.4.1.5 Conservation status of marine mammals

11.33 The conservation status assessment for marine mammal species in the UK and adjacent waters are part of the 2019 UK Reporting under Article 17 of the European Union (EU) Habitats Directive. **Table 11.5** provides the current status of those species assessed in the ES.

Table 11.5 Conservation status of marine mammal species occurring in UK and adjacent waters (JNCC, 2019), relevant to the Project

Species	Conservation status assessment
Harbour porpoise *Phocoena phocoena*	Unknown
Bottlenose dolphin *Tursiops truncatus*	Unknown
Common dolphin *Delphinus delphis*	Unknown
Risso's dolphin *Grampus griseus*	Unknown
White-beaked dolphin *Lagenorhynchus albirostris*	Unknown
Minke whale *Balaenoptera acutorostrata*	Unknown
Grey seal *Halichoerus grypus*	Favourable
Harbour seal *Phoca vitulina*	Unfavourable-inadequate

11.34 The International Union for Conservation of Nature (IUCN)'s Red List of Threatened Species provides assessments of the conservation status of animals evaluated at a global scale using the IUCN Red List Categories and Criteria, with the aim of determining their relative risk of extinction. Assessments are updated periodically to reflect new information. Where sufficient information exists, the majority of marine mammal species occurring in UK waters fall into the lowest category of 'least concern' (**Table 11.6**).

Table 11.6 Global IUCN red list of threatened species assessments for marine mammal species relevant to the Project

Species	IUCN red list status	Year assessed
Harbour porpoise	Least Concern	2020
Bottlenose dolphin	Least Concern	2018
Common dolphin	Least Concern	2020
Risso's dolphin	Least Concern	2018
White-beaked dolphin	Least Concern	2018
Minke whale	Least Concern	2018
Grey seal	Least Concern	2016
Harbour seal	Least Concern	2016

11.4.2 Data and information sources

11.4.2.1 Site-specific surveys

11.35 To provide site-specific information on which to base the marine mammal impact assessment, site-specific aerial surveys were conducted over 24 months between March 2021 and February 2023.

11.36 HiDef Aerial Surveying Limited ('HiDef') collected high resolution aerial digital still imagery for marine megafauna (combined with ornithology surveys). The survey area covered the windfarm 125km^2 Agreement for Lease area, plus a custom buffer of 4km to the south and west, and 10km to the east and north (noting the buffer extended to 10km to the east and north due to proximity to Liverpool Bay Special Protection Area (SPA) for birds). Further detail of the survey method is provided in **Appendix 12.2**.

11.37 The aerial surveys were conducted monthly and the 24 months of data has been analysed (further details of the data are provided in **Appendix 11.2**).

11.38 Following PEIR, the windfarm site development area was reduced to 87km^2 with this revised windfarm site now forming the Application boundary (**Figure 11.1**). With the reduction in windfarm site, the survey custom buffer now extends 9km from the windfarm site to the west, 4km to the south and 10km to the north and east (see Plate 3.1 in **Appendix 12.2**).

11.4.2.2 Other available sources

11.39 Other data sources that have been used to inform the assessment are listed in **Table 11.7**.

11.40 Given the interconnected nature of the Project and the Morgan and Morecambe Offshore Wind Farms: Transmission Assets, the environmental information for the Transmission Assets PEIR has also been used to inform this chapter (Morgan Offshore Wind Limited and Morecambe Offshore Windfarm Ltd, 2023a).

Table 11.7 Existing data sources used in this chapter

Data source	Spatial coverage	Date	Data contents
Small Cetaceans in the European Atlantic and North Sea (SCANS-III) data (Hammond *et al.*, 2021).	North Sea and European Atlantic waters	Summer 2016	Provides information including abundance and density estimates of cetaceans in European Atlantic waters in summer 2016, including the proposed windfarm site.
SCANS-IV data (Gilles *et al.*, 2023).	North Sea and European Atlantic waters	Summer 2022	Provides information including abundance and density estimates of cetaceans in European Atlantic waters in summer 2022, including the proposed windfarm site.
MUs for cetaceans in UK waters (IAMMWG, 2023).	UK waters	2023	Provides information on cetacean MUs for the proposed windfarm site.
Offshore Energy Strategic Environmental Assessments (OESEA) (including relevant appendices and technical reports) (OESEA 3 (Department of Energy and Climate Change (DECC), 2016); OESEA 4 (Department for Business, Energy and Industrial Strategy (BEIS), 2022)).	UK waters	2016 2022	Provides information on marine mammals in UK waters.
The identification of discrete and persistent areas of relatively high harbour porpoise density in the wider UK marine area (Heinänen and Skov, 2015).	UK waters	1994-2011	Data was used to determine UK harbour porpoise SAC sites. Provides information on harbour porpoise in UK waters.
Revised Phase III data analysis of Joint Cetacean Protocol (JCP) data resources (Paxton *et al.*, 2016).	UK waters	1994-2011	Provides information on cetaceans in UK waters.
The Joint Cetacean Data Programme (JCDP) online database	UK waters	2023	Provides information on cetaceans in UK waters.

Data source	Spatial coverage	Date	Data contents
Distribution and abundance maps for cetacean species around Europe (Waggitt *et al*., 2019).	North-East Atlantic	1980-2018	Provides information on cetacean species in North-East Atlantic and UK waters.
Habitat-based predictions of at-sea distribution for grey and harbour seals in the British Isles (Carter *et al*., 2020 and 2022).	British Isles	1991-2019	Provides information on abundance and absolute density estimates (i.e. number of seals) for seal species.
Seal telemetry data (e.g. Russell and McConnell, 2014; Russell, 2016).	British Isles	1988-2010; 2015	Provides information on relative density (i.e. percentage of at-sea population) for seal species.
Special Committee on Seals (SCOS) annual reporting of scientific advice on matters related to the management of seal populations (SCOS, 2022).	UK and Ireland	2021 & 2022	Provides information on movements and distribution of seal species.
Survey data from other nearby sites, including aerial surveys undertaken by other projects in the region.	UK and Ireland	2022	PEIR information and survey data for Morgan and Mona OWF, and ES data for Awel y Môr (AyM) OWF.
Calf of Man Survey Reports	IoM	2009 - 2021	Provides information on annual grey seal pup counts
Manx Environmental Assessments (Howe, 2018)	IoM & Manx waters	2018	Provides information on abundance on cetacean and pinnipeds in Manx waters

11.4.3 Assessment methodology

11.41 **Chapter 6 EIA Methodology** provides a summary of the general impact assessment methodology applied to the Project. The following sections outline the methodology used to assess the potential impacts on marine mammals.

11.42 The following key terms have been used in this assessment:

- **Impact** – used to describe a change via the Project (e.g., increased underwater noise levels etc.)
- **Receptor** – used to define the environment being exposed to the Impact (e.g., marine mammals, prey species)
- **Effect** – the consequence of an impact combining with a Receptor, defined in terms of Significance (exact significance dependent on the magnitude of the impact and the sensitivity of the receptor)
- **Adverse effect** – an alteration of the existing environment with negative implications for the affected receptor
- **Beneficial effect** – an alteration of the existing environment with positive implications for the affected receptor

11.43 The approach to determining the significance of effect involved identifying, qualifying and, where possible, quantifying, the sensitivity and value of all ecological receptors which have been scoped into this assessment, and the magnitude of impacts.

11.44 The marine mammal receptors scoped into this assessment are summarised in **Section 11.6.1**.

11.4.3.1 Definitions of sensitivity, value and magnitude

11.45 For each impact, the assessment identifies the receptor's sensitivity to that impact and implements a systematic approach to understanding the impact pathways and the level of effect on the receptors. The definitions of receptor sensitivity and impact magnitude for the marine mammal assessments are provided in **Table 11.8** and **Table 11.10**, respectively.

11.46 The sensitivity of a marine mammal receptor is determined through its ability to accommodate change and on its ability to recover if it is negatively affected (**Table 11.8**). The sensitivity level of marine mammals to each impact is justified within the 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 would recover
- Value – A measure of the receptor importance and rarity (as reflected in the species conservation status (**Section 11.4.1.5**) and legislative importance (**Section 11.4.1** and **Appendix 11.2**))

11.47 **Table 11.8** defines the general levels of sensitivity. Furthermore, the sensitivity to potential effects of lethality, physical injury, auditory injury or hearing impairment, as well as behavioural disturbance or auditory masking are considered for each species, using available evidence including published data sources. Specific sensitivities of marine mammal receptors to underwater noise are set out in **Section 11.6.2**.

Table 11.8 Definitions 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.

11.48 The 'value' of the receptor also 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 (e.g., an Annex II species of the Habitats Directive (see **Section 11.4.1.2**)) but have a low or negligible physical/ecological sensitivity to an effect. Similarly, low value does not equate to low sensitivity and is judged on a receptor-by-receptor basis.

11.49 **Table 11.9** provides definitions for the value afforded to a receptor based on its legislative importance. The value is considered, where relevant, in the assessments.

Table 11.9 Definitions of value for marine mammals

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 that are a 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 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. 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.

11.50 Most marine mammal species are protected by national and international legislation (details in **Appendix 11.2**). All cetaceans in UK waters are EPS and, therefore, are internationally important. Harbour porpoise, bottlenose dolphin, grey seal and harbour seals are also afforded legislative protection through the designation of protected sites. As such, all species of marine mammal are considered to be of high value.

11.51 The magnitude of the potential impacts is based on the intensity or degree of impact to the baseline conditions and is categorised into four levels of magnitude: high, medium, low or negligible, as defined in **Table 11.10**.

11.52 Determining the magnitude of an impact considers several factors, including:

- Type of activity: would the impacts be permanent, long-term, or temporary
- Duration and frequency of the activity
- Extent of the activity
- Timing and location of the activity

11.53 The thresholds for defining the magnitude that could occur from a particular impact have been based on current scientific understanding of marine mammal population biology and JNCC *et al*. (2010a) draft guidance on disturbance to EPS species.

11.54 There were no agreed thresholds to determine magnitude for marine mammals at the time of writing. The JNCC *et al*. (2010a) 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 11.10**).

11.55 The JNCC *et al*. (2010a) draft guidance provides some indication on how many animals may be ‘removed’ from a population without causing detrimental effects to the population at Conservation Status.

11.56 The number of animals that can be ‘removed’ from a population, through injury or disturbance, varies between species, but is largely dependent on the growth rate of the population. The removal of just one individual from a small population with a slow growth rate could be detrimental to the population, whereas the removal of several to hundreds of individuals would not be detrimental to a population that is highly abundant.

11.57 The JNCC *et al*. (2010a) draft guidance also provides limited consideration of temporary impacts, with guidance reflecting consideration of displacement.

11.58 Temporary impacts are considered to be of medium magnitude at greater than 5% of the reference population. JNCC *et al*. (2010a) 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% of the reference population to a temporary impact in this assessment, consideration is given to uncertainty of the individual consequences of temporary disturbance.

11.59 Permanent impacts with 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 (ASCOBANS, 2015; Defra, 2003), 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 less than 1% of the population (ASCOBANS, 2015; Defra, 2003).

Table 11.10 Definition of impact 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 more than 1% of the reference population are anticipated to be exposed to the impact. OR Long-term impact for 10 years or more, but not permanent (e.g., limited to operational phase of the Project). Assessment indicates that more than 5% of the reference population are anticipated to be exposed to the impact. OR Temporary impact (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 more than 10% of the reference population are anticipated to be exposed to the impact.
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 impact. OR Long-term impact for 10 years or more, but not permanent (e.g., limited to operational phase of the Project). Assessment indicates that between 1% and 5% of the reference population are anticipated to be exposed to the impact. OR Temporary impact (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 are anticipated to be exposed to the impact.
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 impact. OR Long-term impact for 10 years or more, but not permanent (e.g., limited to operational phase of the Project). Assessment indicates that between 0.01% and 1% of the reference population are anticipated to be exposed to the impact. OR Intermittent and temporary impact (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 are anticipated to be exposed to the impact.

Magnitude	Definition
Negligible	Permanent irreversible change to exposed receptors or feature(s) of the habitat of particular importance to the receptor. Assessment indicates that less than 0.001% of the reference population anticipated to be exposed to impact. OR Long-term impact for 10 years or more (but not permanent, e.g., limited to lifetime of the Project). Assessment indicates that less than 0.01% of the reference population are anticipated to be exposed to the impact. OR Intermittent and temporary impact (e.g., 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 less than 1% of the reference population are anticipated to be exposed to the impact.

11.4.3.2 Significance of effect

11.60 The potential significance of effect for a given impact is a function of the sensitivity of the receptor and the magnitude of the impact (see **Chapter 6 EIA Methodology** for further details). A matrix is used (**Table 11.11**) as a framework to determine the significance of an effect. Definitions of each level of significance are provided in **Table 11.12**. Impacts and effects may be deemed as being either positive (beneficial) or negative (adverse).

11.61 It is important that the matrix (and indeed the definitions of sensitivity and magnitude) is seen as a framework, to aid understanding of how a judgement has been reached from the narrative of each effect assessment and it is not a prescriptive formulaic method.

11.62 Potential effects are described, followed by a statement of whether the effect is significant in terms of the EIA regulations. Potential effects identified within the assessment as major or moderate are regarded as significant in terms of the EIA regulations. Whilst minor effects (or below) are not significant in EIA terms in their own right, it is important to distinguish these, as they may contribute to significant effects cumulatively or through interactions.

11.63 Following initial assessment, if the effect does not require additional mitigation (or none is possible), the residual effect would remain the same. If, however, additional mitigation is proposed, an assessment of the post-mitigation residual effect is provided.

Table 11.11 Significance of effect matrix

		Adverse 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*	*Moderate*	*Major*
	Low	*Moderate*	*Minor*	*Minor*	*Negligible*	*Negligible*	*Minor*	*Minor*	*Moderate*
	Negligible	*Minor*	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Minor*

Table 11.12 Definition of significance of effect

Significance	Definition
Major	Very large or large change in receptor condition, both adverse or beneficial, which is 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 is likely to be important considerations at a local level.
Minor	Small change in receptor condition, which may be raised as local issue.
Negligible	No discernible change in receptor condition.
No change	No impact, therefore, no change in receptor condition.

11.4.4 Cumulative effect assessment methodology

11.64 The CEA considers other plans, projects and activities that may impact cumulatively with the Project. As part of this process, the assessment considers which of the residual impacts assessed for the Project on its own have the potential to contribute to a cumulative effect. **Chapter 6 EIA Methodology** provides further details of the general framework and approach to the CEA.

11.65 The types of plans and projects to be taken into consideration are:

- Other offshore windfarms (including construction, operation and maintenance, and decommissioning)
- Marine Renewable Energy (MRE) developments (wave and tidal)
- Aggregate extraction and dredging
- Licenced disposal sites
- Planned construction of sub-sea cables and pipelines

- Potential port/harbour developments
- Oil and gas development, operation and decommissioning
- UXO clearance
- Geophysical and seismic surveys

11.66 Commercial fishing activity and shipping (noise and vessel collision) are not considered in the CEA. Further information and justification for this decision is provided in the CEA project screening, which is set out in **Appendix 11.4**.

11.67 The CEA is a two-part process where firstly, an initial long list of potential projects and activities is identified. The potential to interact with the Project is determined based on the mechanism of interaction and the spatial extent of the reference population for each marine mammal species. The long list of projects activities is then refined based on the potential for cumulative effects and the level of information available to enable further assessment.

11.68 The plans and projects screened into the CEA are:

- Located in the marine mammal MU population reference area (defined for individual species in the assessment sections)
- Offshore projects and activities, if there is the potential for cumulative effects during the construction, operation and maintenance, or decommissioning of the Project
- Offshore windfarms (OWFs), if the construction and/or piling period of the OWFs could overlap with the proposed construction and/or piling period of the Project, based on best available information on when the OWFs are likely to be constructed and indicative piling schedules

11.69 The CEA considers projects, plans and activities which have sufficient information publicly available to undertake the assessment. Insufficient information would preclude a meaningful quantitative assessment, and it is not appropriate to make assumptions about the detail of future projects in such circumstances. Accordingly, projects which do not have sufficient publicly available information have not been cumulatively assessed. **Appendix 11.4** sets out the screening for projects, plans and activities considered in the CEA.

11.70 As described in **Chapter 1 Introduction**, the Transmission Assets associated with the Project are undergoing a separate consent process as part of the Transmission Assets project. To enable impacts from the Project and the Transmission Assets to be considered together, a 'combined' assessment is made within the CEA to identify any key interactions and additive effects (**Section 11.7.3.1**).

11.4.5 Transboundary assessment methodology

11.71 **Chapter 6 EIA Methodology** provides details of the general framework and approach to the assessment of transboundary effects.

11.72 The transboundary assessment considers the potential for transboundary effects to occur on marine mammal species. The highly mobile nature of marine mammals included within the assessments means that there is the potential for transboundary impacts, since species might arise from areas beyond UK waters.

11.73 For marine mammals, the potential for transboundary effects has been addressed by considering the reference populations (MUs) and potential linkages to other countries (for example, as identified through seal telemetry studies), as described in **Section 11.8**.

11.74 The assessment of effects on transboundary European Sites is presented in the RIAA. Potential impacts on the designated sites for the IoM are presented separately in **Section 11.8**, as the IoM territory is not subject to the regulations laid out in the Habitats Directive. Consequently, the protected sites within the IoM are outside the scope of the RIAA.

11.4.6 Assumptions and limitations

11.75 Due to the large amount of available data and information that has been reviewed for marine mammals within the region, including the site-specific surveys, there is a good understanding of the existing environment.

11.76 However, there are some limitations to the data collected by marine mammal surveys. Primarily limitations are due to the highly mobile nature of marine mammals and, therefore, the potential variability in usage of the windfarm 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 aerial surveys are conducted every month during a two-year survey period, with both years’ worth of data analysed (**Appendix 12.2**). Therefore, taking into account the site-specific survey, and given the number of surveys and data collected from other surveys for different months, seasons and years, there is good coverage to provide information on the species likely to be present at the windfarm site and surrounding areas.

11.77 There are acknowledged limitations in the detectability of marine mammals from aerial surveys, including the inability to detect submerged individuals and those not available to count. To address these limitations, a correction factor is used.

11.78 For harbour porpoise, these correction factors are based on Teilmann *et al*. (2013), with different correction factors applied for different months, times of day, and for whether individuals would be at the surface or within the top 2m of the water column. This methodology determines the absolute density estimates from the site-specific aerial surveys (details in Section 3 of **Appendix 12.2**).

11.79 For grey and harbour seal, a correction factor (derived by SCOS-BP 21/02 in SCOS, 2021) is applied to the haul-out counts from SCOS (2022), to take account of the number of seals that were not available to count during the surveys (Section 5.7 and 5.8 of **Appendix 12.2**).

11.80 Limitations of the use of distribution maps developed by Waggitt *et al.* (2019) emphasise that their use should only illustrate the general, broad-scale distributions of species. Using these densities for fine-scale distributions should be avoided due to the following caveats:

- Small and isolated sub-populations have very little influence on models, such as white-beaked dolphins in SW England and Risso's dolphins in North Wales/IoM
- Substantial changes in harbour porpoise movements from north to south in the Norh Sea took place across the study period
- Seasonal movements were detected by the modelling, but have not produced changes in seasonal changes in densities
- The densities for bottlenose dolphins represent the offshore ecotype only, exluding regionally important inshore populations (e.g Cardigan Bay)

11.81 To allow a more accurate comparison of the species densities across the different data sets, the average for seasonal and annual periods across the area of the SCANS block where the Project is located have been calculated; see **Section 11.1**. As a precautionary approach, density estimates for each marine mammal species used in the assessments are based on the highest density for the area, based on available data sources.

11.82 Further assumptions and limitations with regards to population modelling and the application of dose-response curves in assessments are detailed in **Appendix 11.2**.

11.5 Existing environment

11.83 As outlined in **Section 11.3.1**, the key marine mammal species relevant to the Project study area are:

- Harbour porpoise
- Bottlenose dolphin
- Common dolphin
- Risso's dolphin
- White-beaked dolphin
- Minke whale
- Grey seal
- Harbour seal

11.84 **Appendix 11.2** provides further information that is relevant for the assessments for each of the species, including details from the site-specific surveys, density estimates, abundance estimates, distribution, diet, and seal haul-out sites.

11.5.1 Harbour porpoise

11.85 The most abundant cetacean in UK waters, including the IS area is the harbour porpoise (Gilles *et al*., 2023; BEIS, 2022a, b; Hammond *et al*., 2021; Waggitt *et al*., 2019).

11.86 Modelling by Heinänen and Skov (2015) identified considerable variation in harbour porpoise densities between the summer and winter periods in offshore waters, and a more persistent pattern of distribution in coastal areas for the CIS MU. This report identified high density areas of harbour porpoise off the west coast of Wales and to the north of the IoM during winter. The modelling did not predict areas of high harbour porpoise density in or around the Project during summer or winter (see **Appendix 11.2**).

11.87 Distribution and abundance maps have been developed by Evans & Waggitt (2023) for five cetacean species commonly distributed in the IS. Distribution maps for harbour porpoise show a clear pattern of high density in the IS, particularly in NW and SW Wales, between July and September (see **Appendix 11.2**). Examination of this data, and all 2.5km grids that overlap with the SCANS-IV block CS-E (in which the Project is located), indicates an average annual density estimate of:

- 0.182 individuals per km^2 over the area of the SCANS block CS-E

11.88 Results from the SCANS-IV survey (undertaken in summer 2022; Gilles *et al*., 2023) for survey block CS-E (see **Appendix 11.2**), provide the following abundance and density estimates:

- Abundance estimate = 6,325 harbour porpoise (95% Confidence Limits (CL) = 3,663 – 10,162)
- Density estimate = 0.5153 harbour porpoise/km^2 (Coefficient of Variation (CV) = 0.250)

11.89 Data from the two-year (March 2021 to February 2023) site-specific aerial surveys conducted for the Project have been used to generate initial abundance and density estimates for harbour porpoise across the full survey area (encompassing the windfarm site and buffers). Further information on the survey area and buffers applied is provided in **Section 11.4.2.1** and **Appendix 11.2**.

11.90 Harbour porpoise was the most commonly sighted marine mammal species during the site-specific surveys. They were consistently present throughout each month and widespread across the survey area. Overall, 925 individuals were recorded in the 24-month survey period (**Plate 11.1**).

11.91 There were some seasonal patterns in the harbour porpoise abundance results (see **Appendix 11.2**). In the first survey year, the number of harbour porpoise sightings declined with the onset of summer and began to increase starting January 2022. The highest abundance was recorded in March 2021 (n=85), May 2022 (n=179), and November 2022 (n=80), and the lowest abundance recorded was in July 2022, with just seven individuals.

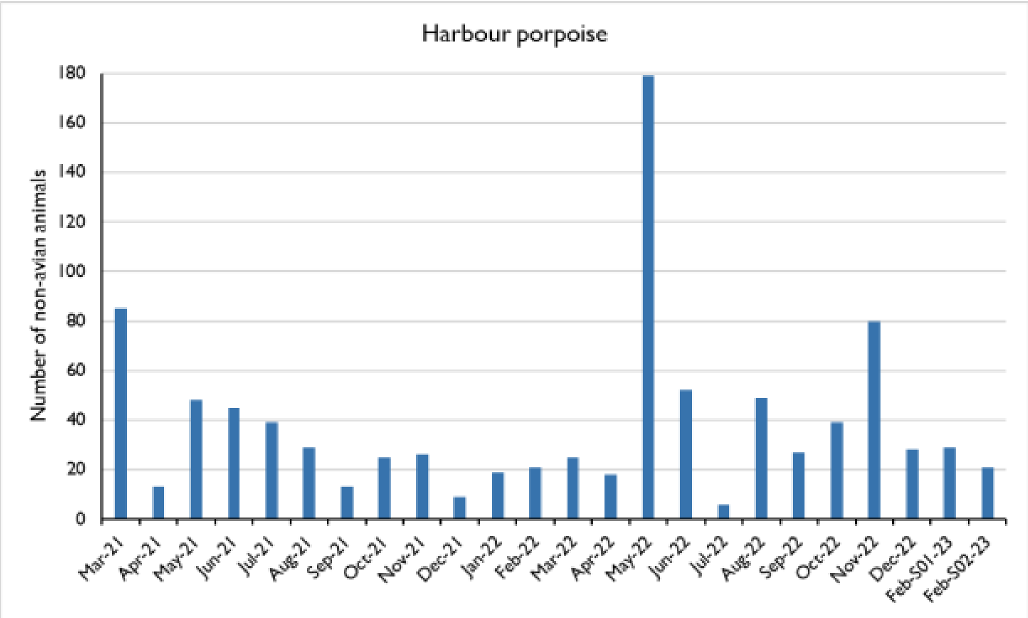

Plate 11.1 Abundance of harbour porpoise recorded between March 2021 and February 2023 in the survey area (see ***Appendix 12.1****).*

11.92 The average densities for the summer months (April to September), winter months (October to March) and annual density (March 2021 to February 2023) have been estimated, based on the monthly absolute and relative density estimates for the survey area over the two year survey period (**Table 11.13**). See **Appendix 11.2** for further information on monthly density estimates.

Table 11.13 Harbour porpoise summer, winter and annual density estimates for the Project survey area (including buffer area) from two years (March 2021 to February 2023) of site-specific surveys

Season	Absolute density estimates
Summer average (April-September)	1.621/km^2
Winter average (October-March)	1.528/km^2
Annual average (24 months)	1.574/km^2

11.93 The average summer density estimate has been used in the impact assessment, as this worst-case compared to that of SCANS-IV or Evans and Waggitt (2023) density estimates for the area. The average density estimate applied to the assessment was therefore:

- 1.621 harbour porpoise/km^2

11.94 As outlined in **Section 11.3.1** and **Appendix 11.2**, the Project is located in the CIS MU. The IAMMWG estimate of harbour porpoise abundance in the CIS MU is 62,517 (CV = 0.13; 95% Confidence Interval (CI) = 48,324 – 80,877; IAMMWG, 2023), which represents the reference population for harbour porpoise used in the assessment.

11.5.2 Bottlenose dolphin

11.95 In UK waters, bottlenose dolphin have frequently been reported off the east and south-west of Scotland, in the IS, and in the Western English Channel, with limited interchange between these inshore groups (BEIS, 2022b; Cheney *et al*., 2013; IAMMWG, 2023; Robinson *et al*., 2012).

11.96 As outlined in **Appendix 11.2**, there is the potential for individuals from the east and west of Scotland, Wales and Northern Spain (Galicia) to be present in the Project site. However, there is no evidence of connectivity with any other coastal population of bottlenose dolphin in the UK, Ireland, and Northern continental Europe (Nykänen *et al*., 2019).

11.97 During both years of site-specific surveys, from March 2021 to February 2023, only two bottlenose dolphin were recorded over the survey area (including buffers), both in February 2023 (see **Appendix 11.2**).

11.98 During Project geotechnical surveys conducted across the windfarm site between July and October 2023, five bottlenose dolphins were observed, of which one was a mother and another a calf (see **Appendix 11.2**).

11.99 The SCANS-III survey during summer 2016 (recorded no bottlenose dolphin in survey block F, in which the Project is located (Hammond *et al*., 2021; see **Appendix 11.2**).

11.100 The distribution maps produced by Evans and Waggitt (2023) also indicate very low bottlenose dolphin densities in and around the Project location, with a low average annual density of 0.0007 individuals per km^2 estimated over the area of the SCANS block F.

11.101 Few bottlenose dolphins were recorded during SCANS-IV (Gilles *et al*., 2023), resulting in an estimated density of at 0.0104 animals/km^2 (CV = 0.700); with an abundance of 127 (95% CL = 3 – 353) individuals.

11.102 To present a precautionary approach, the impact assessments for bottlenose dolphin are based on the worst-case SCANS-IV density:

- 0.0104 bottlenose dolphin/km^2

11.103 Of the seven defined MUs for bottlenose dolphin IAMMWG (2023) (see **Appendix 11.2**), the windfarm site is located in the IS MU, which has an abundance estimate of 293 (CV= 0.54; 95% CI = 108 – 793; IAMMWG, 2023). This estimate has been used as the reference population for bottlenose dolphin in the assessments. It should be noted that there is a migration rate of 25.7% of bottlenose dolphins between the coastal populations of Wales/West Scotland and East Scotland (Nykänen *et al*., 2019).

11.5.3 Common dolphin

11.104 Common dolphin were primarily distributed in the Celtic Sea and Western Approaches to the Channel, and off Southern and Western Ireland (Gilles *et al*., 2023; BEIS, 2022b; Hammond *et al*., 2021; Waggitt *et al*., 2019).

11.105 The distribution of common dolphins in the IS where the Project is located is sparse, as evident from only 32 recorded sightings of common dolphin in one month during the site-specific aerial surveys (from March 2021 to February 2023) within the survey area (see **Appendix 11.2**).

11.106 During Project geotechnical surveys conducted across the windfarm site from July to October 2023, common dolphins were observed in August and September 2023 (see **Appendix 11.2**).

11.107 Examination of long-term data provided by Evans and Waggitt (2023) (see **Appendix 11.2**) indicated a mean annual density estimate of 0.00008 individuals per km^2 for all 2.5km grids over the area of SCANS block CS-E.

11.108 No common dolphin were recorded in survey block F (in which the Project is located), or adjacent survey block E of the IS, during the SCANS-III survey (Hammond *et al*., 2021). Neither were they recorded in block CS-E (equivalent to block F) during SCANS-IV (Gilles *et al*., 2023).

11.109 In order to find a density to best represent the wider area for common dolphins, data from Evans and Waggitt (2023) and Waggitt *et al*. (2019) were applied to the area of SCANS-IV block CS-E, of which the latter, worst-case density was taken forward for assessment:

- Mean summer density: 0.028 common dolphin/km^2

11.110 There is a single MU for common dolphins in UK waters, the CGNS MU (see **Appendix 11.2**). The CGNS MU for common dolphin has an abundance estimate of 102,656 (CV=0.29; 95% CI=58,932 – 178,822; IAMMWG, 2023) and represents the reference population in the assessments.

11.5.4 Risso's dolphin

11.111 The Risso's dolphin was less common in the IS, but regularly sighted in the Manx territorial waters (Howe, 2018), and in the Southern IS, particularly off the NW coast of Wales, and off the SW coast of Ireland (BEIS, 2022b; Evans and Waggitt, 2023). This species was more common in the nearshore waters around Shetland, Orkney and the Outer Hebrides (BEIS, 2022b).

11.112 Distribution maps by Evans and Waggitt (2023) indicated that there were low densities in and around the Project (see **Appendix 11.2**). Examination of this data, and all 2.5km grids that overlap with the windfarm site, indicated an average annual density estimate of 0.0002 individuals per km^2 over the area of the SCANS block CS-E.

11.113 Neither SCANS-III nor SCANS-IV survey recorded Risso's dolphin within the relevant survey blocks F and CS-E (in which the Project is located), respectively (Hammond *et al*., 2021, Gilles *et al*., 2023; see **Appendix 11.2**).

11.114 No Risso's dolphin were recorded across the survey area during the Project site-specific aerial surveys that were undertaken from March 2021 to February 2023 (see **Appendix 11.2**).

11.115 In order to find a density to best represent the wider area for Risso's dolphin, data from Evans and Waggitt (2023) and Waggitt *et al*. (2019) were applied to the area of SCANS-IV block CS-E, of which the latter, worst-case density was taken forward for assessment:

- 0.0006 Risso's dolphin/km^2

11.116 The CGNS MU (see **Appendix 11.2**) represents a single MU for Risso's dolphins in UK waters, with an estimated abundance of 12,262 (CV=0.46; 95% CI=5,227-

28,764; IAMMWG, 2023) which was used as reference population in the assessment.

11.5.5 White-beaked dolphin

11.117 White-beaked dolphin were the second most commonly occurring cetacean in UK shelf waters and were regularly encountered in coastal and offshore waters (BEIS, 2022b).

11.118 However, the evidence presented here shows that their appearance in the IS was very rare; no sightings were recorded in either SCANS-III block F (Hammond *et al*., 2021), nor SCANS-IV block CS-E (Gilles *et al*., 2023).

11.119 No white-beaked dolphin were recorded across the survey area during the Project site-specific aerial surveys undertaken from March 2021 to February 2023 (see **Appendix 11.2**).

11.120 The latest 30-year dataset provided by Evans and Waggitt (2023) also showed that too few white-beaked dolphins were recorded to model a density estimate.

11.121 In order to find a density to best represent the wider area for white-beaked dolphin, data from Waggitt *et al*. (2019) were applied to the area of SCANS-IV block CS-E, for worst-case density to be taken forward for assessment:

- 0.007 white-beaked dolphin/km^2

11.122 There was a single MU identified for white-beaked dolphin in UK waters, the CGNS MU (see **Appendix 11.2**), with an abundance estimate of 43,951 (CV=0.22; 95% CI= 28,439 – 67,924; IAMMWG, 2023), which was taken as the reference population in the assessment.

11.5.6 Minke whale

11.123 Within UK waters, minke whale were the most common among the baleen whales and present throughout much of the Celtic Sea and western IS during summer (BEIS, 2022b). They were also regular visitors to the IoM territorial waters, particularly during the summer (Felce, 2014; Evans & Waggitt, 2023).

11.124 No minke whale were recorded across the survey area during the Project site-specific aerial surveys undertaken from March 2021 to February 2023 (see **Appendix 11.2**).

11.125 No minke whale were recorded within survey block F, in which the Project is located, during the SCANS-III survey (Hammond *et al*., 2021).

11.126 Distribution maps by Waggitt *et al.* (2019) and Evans and Waggitt (2023) both indicated relatively low minke whale densities in and around the Project site, compared to other areas in the IS, with a strong seasonal increase during the summer (see **Appendix 11.2**). Examination of the data revealed an average annual density estimate of 0.003 individuals per km^2 (Waggitt *et al.,* 2019) and 0.0006 individuals per km^2 (Evans and Waggitt, 2023) over the area of the SCANS block CS-E.

11.127 However, the most recent SCANS-IV survey provided the worst-case densities, despite the limited number of sightings recorded during the 2022 surveys in block CS-E (in which the Project is located) and have been used in the assessments:

- 0.0088 minke whale/km^2

11.128 There was a single MU that has been identified for minke whale, the CGNS MU (see **Appendix 11.2**), with an abundance estimate of 20,118 animals (CV = 0.18; 95% CI = 14,061 – 28,786; IAMMWG, 2023), which was used as the reference population in the assessment.

11.5.7 Grey seal

11.129 Considerable movement of grey seals occurred (as observed from telemetry data; see **Appendix 11.2**) among the different areas and regional sub-units of the IS, and potential connectivity across the North and South IS was identified between NW England, Wales, the east coast of Ireland, NI and the IoM (Carter *et al*., 2020, 2022).

11.130 During their annual moult (between December and April) and during their breeding season (between August and December), grey seals in the UK spend longer hauled out, compared with other times of the year. The pupping season varies between regions: in north and west Scotland it occurs mainly between September and late November, whereas in SW England, the majority of pups were born between August and October (SCOS, 2022).

11.131 Telemetry studies have shown that grey seals typically forage in the open sea and return to land regularly to haul-out, although, they may frequently travel up to 100km between haul-out sites (SCOS, 2022). Foraging trips generally occur within 100km of their haul-out sites, although, grey seal can travel to maximum foraging ranges of 448km (Carter *et al*., 2022).

11.132 The Project is located in the NW England MU (see **Appendix 11.2**). The two largest haul-out sites in the NW England MU are at West Hoyle Bank (often referred to as Hilbre Island) in the Dee estuary (approximately 45km from the Project), and at South Walney in Cumbria (approximately 30km from the Project), which was identified as the only known grey seal breeding site on the mainland in the NW England MU (SCOS, 2021).

11.133 Other haul-out sites located outside of the NW England MU, including Puffin Island (approximately 55km from the Project), the Calf of Man (approximately 80km from the Project), and the Skerries (approximately 75km from the Project) have been identified. These sites are not in close proximity to larger ports or harbours which could be used for the Project.

11.134 A relatively low number of grey seals were recorded across the survey area during the Project site-specific aerial surveys carried out between March 2021 and February 2023, with a total of 42 individuals recorded during 19 of the 24 surveys. In addition, a total of 59 individuals of unidentified seal species were recorded, which were likely to be grey seal (see **Appendix 11.2**).

11.135 From those sightings, apportioned densities were generated (**Appendix 11.2 Section 3.4**) as seasonal and annual averages. For grey seal, the annual average was 0.0284 animals/km^2.

11.136 Carter *et al*. (2022) provided habitat-based predictions of at-sea distribution for seals around the British Isles. The predicted distribution maps provided estimates per species, on a 5km by 5km grid of relative at-sea density for seals hauling-out in the British Isles.

11.137 The grey seal density estimates for the Project were calculated from the seal at-sea usage maps (Carter *et al*., 2022), based on the grids that overlap with the windfarm site (see **Appendix 11.2**). The mean at-sea density estimate used in the assessments was:

- 0.100 individuals per km^2 for the windfarm site and 4km buffer

11.138 To take into account the wide-ranging movement of grey seal (as indicated by tagging studies), the reference population extent for grey seal incorporated the NW England MU, SW Scotland MU, Wales MU and NI MU (SCOS, 2022; Carter *et al*., 2022), the E and SE RoI MUs (Morris and Duck, 2019), and the IoM resident population estimate (Howe, 2018) (see **Appendix 11.2**).

11.139 SCOS (2022) carried out surveys in August 2022 to estimate the current status of British grey seals. In order to take account of the grey seals that were not available for counting during these surveys, a population scalar was added to provide a more accurate population estimate. The population scalar was based on the proportion of seals estimated to be available to count during the August surveys (0.2515 taken from SCOS, 2021 (BP 21/02)). This resulted in the following adjusted population estimates for the relevant MUs for grey seal:

- NW England MU = 1,193 grey seal (SCOS, 2022)
- Wales MU = 3,579 grey seal (SCOS, 2022)
- SW Scotland = 2,056 grey seals (SCOS, 2022)
- NI MU = 2,182 grey seal (SCOS, 2022)
- IoM resident population estimate = 400 grey seal (Howe, 2018)
- E RoI MU = 1,662 grey seal (Morris and Duck, 2019)

- SE RoI MU = 2,211 grey seal (Morris and Duck, 2019)

11.140 Based on the above, the wider reference population used for the assessment was 13,283 grey seal.

11.141 Assessments set out in this chapter have been undertaken in the context of the combined NW England MU and IoM population estimates (1,593 grey seal), as well as the wider reference population (13,283 grey seal). As a worst-case, it was assumed that all seals were from the nearest MUs (i.e., the combined NW England MU and IoM populations), although a more realistic assessment has also been presented based on the wider reference population, which considered the movement of seals.

11.5.8 Harbour seal

11.142 Only one harbour seal was recorded (in July 2021) during the two years of site-specific aerial surveys (see **Appendix 11.2**). No relevant densities were derived from this single sighting.

11.143 The harbour seal density estimates for the Project were calculated using the latest seal at sea maps, produced by Carter *et al*. (2022), based on the 5km by 5km grids that overlap with the windfarm site (see **Appendix 11.2**). The upper at-sea density estimates were used in the assessment, as the worst-case:

- 0.00011 harbour seal per km^2 for the windfarm site

11.144 SCOS (2022) carried out surveys in August 2022 to estimate the current status of British harbour seals (SCOS, 2022). The reference population extent for harbour seal incorporated the NW England MU (SCOS, 2022) and the NI MU (SCOS, 2022; Carter *et al*., 2022). To account for the harbour seals that were not available for counting during these surveys, a population scalar was added to provide a more accurate population estimate. The population scaler was based on the proportion of seals estimated to be available to count during the August surveys (0.72 taken from Lonergan *et al*., 2013). This resulted in the below adjusted population estimates for the relevant MUs for harbour seal:

- NW England MU = 7 harbour seal (SCOS, 2022)
- NI MU = 1,136 harbour seal (SCOS, 2022)

11.145 Seal telemetry studies have shown that harbour seals are most likely to be from neighbouring MUs (detailed in **Appendix 11.2**) and unlikely to be an isolated population. Further, no significant harbour seal breeding or haul out sites were identified in the NW England MU (SCOS, 2022). Thus, as worst-case and precautionary approach the reference population for the assessment was seven harbour seal, assuming that all seals were from the NW England MU in which the project is located.

11.146 A more realistic wider reference population of 1,142 harbour seal was also represented by the inclusion of the nearest MUs, the NW England MU and NI MU.

11.5.9 Summary of marine mammal densities and reference populations used in the impact assessment

11.147 **Table 11.14** and **Table 11.15** provide a summary of the reference populations and the density estimates for marine mammal species used in the impact assessments described in the chapter.

11.148 To determine the magnitude of an impact, the number of individuals that could be impacted by the Project were put into the context of the relevant reference population (see **Table 11.10** for definitions of magnitude).

Table 11.14 Summary of marine mammal reference populations used in the assessments

Species	Reference population extent	Population	Source
Harbour porpoise	CIS MU	62,517	IAMMWG (2023)
Bottlenose dolphin	IS MU	293	IAMMWG (2023)
Common dolphin	CGNS MU	102,656	IAMMWG (2023)
Risso's dolphin	CGNS MU	12,262	IAMMWG (2023)
White-beaked dolphin	CGNS MU	43,951	IAMMWG (2023)
Minke whale	CGNS MU	20,118	IAMMWG (2023)
Grey seal	Combined population = NW England MU and IoM population estimate	**1,593** (1,193 + 400)	SCOS (2022) Howe (2018)
	Wider reference population = NW England MU; SW Scotland; IoM population estimate; Wales MU; NI MU; E RoI; SE RoI	**13,283** (1,193 + 2,056 + 400 + 3,579 + 2,182 + 1,662 + 2,211)	SCOS (2022) Howe (2018) Morris and Duck (2019)
Harbour seal	Reference population = NW England MU	7	SCOS (2022)
	Wider reference population = NW England MU; NI MU	1,143 (7 + 1,136)	SCOS (2022)

Table 11.15 Summary of marine mammal density estimates used in the impact assessments

Species	Summer density estimate (individuals per km^2)	Source
Harbour porpoise	1.621	Site-specific surveys
Bottlenose dolphin	0.0104	SCANS-IV (Gilles *et al.*, 2023); block CS-E
Common dolphin	0.028	Waggitt *et al*. (2019); calculated over area of SCANS block CS-E
Risso's dolphin	0.0006	Waggitt *et al*. (2019); calculated over area of SCANS block CS-E
White-beaked dolphin	0.007	Waggitt *et al*. (2019); calculated over area of SCANS block CS-E
Minke whale	0.0088	SCANS-IV (Gilles *et al*., 2023); block CS-E
Grey seal	0.100	Carter *et al*. (2022)
Harbour seal	0.00011	Carter *et al*. (2022)

11.5.10 Designated and protected sites

11.149 Designated sites within the CIS MU where harbour porpoise are present as a qualifying feature, were identified due to their potential connectivity to the Project as follows:

- North Anglesey Marine SAC
- North Channel SAC
- West Wales Marine SAC
- Rockabill to Dalkey Island SAC
- Bristol Channel Approaches SAC
- Roaringwater Bay and Islands SAC
- Blasket Islands SAC
- Nord Bretagne DH
- Tregor Goëlo
- Baie de Morlaix
- Abers - Côte des légendes
- Ouessant-Molène

- Chaussée de Sein
- Mers Celtiques - Talus du golfe de Gascogne
- Récifs du talus du golfe de Gascogne

11.150 The closest harbour porpoise SAC is the North Anglesey Marine (Gogledd Môn Forol) SAC, which is 45km from the windfarm site at the nearest point.

11.151 It is unlikely that any harbour porpoise present within the windfarm site were associated with the SACs on the west coast of Ireland and north coast of France. However, connectivity between the windfarm site and all SACs with harbour porpoise as a qualifying feature in the CIS MU has been assessed in the RIAA.

11.152 For bottlenose dolphin, connectivity between the windfarm site and all SACs with bottlenose dolphin as a qualifying feature in the IS MU was assessed in the RIAA and comprise of:

- Pen Llŷn a’r Sarnau SAC
- Cardigan Bay SAC

11.153 The closest bottlenose dolphin SAC is the Pen Llŷn a`r Sarnau SAC, which is approximately 130km from the windfarm site at the nearest point.

11.154 For grey seal and harbour seal, tagging studies and information on species movements determined the potential for connectivity between the windfarm site and all SACs with grey and/or harbour seal as a qualifying feature in the CIS area and West Scotland area. This potential for connectivity was assessed in the RIAA.

11.155 The closest grey seal SAC is the Pen Llŷn a`r Sarnau SAC, which lies approximately 130km from the windfarm site at the nearest point. The closest harbour seal SAC is the Strangford Lough SAC, which is approximately 135km from the windfarm site at the nearest point.

11.156 There are also three Nature Conservation Marine Protected Areas (NCMPA) designated on the West coast of the CGNS MU. Minke whale NCMPAs are the Sea of the Hebrides, approximately 300km away, and the Southern Trench NCMPA, approximately 945km away. The North-East Lewis NCMPA for Risso’s dolphin is approximately 620km away.

11.157 The distance between the Project and the NCMPAs are significantly larger than the potential impact ranges from the Project. It is unlikely that there was any association between Risso’s dolphin or minke whale within the Project area and the distant NCMPAs. Temporary short-term and/or minor changes in the protected features, due to human activity, were considered not to compromise the conservation objectives or favourable condition of the species within these sites (NatureScot, 2020abc).

11.158 Further assessments on the impacts on the NCMPAs have also not been conducted in the ES. Assessments for these species were conducted based on the CGNS MU, which encompasses the geographical locations of the NCMPAs. Therefore, while Risso's dolphins or minke whales may be present within the Project area, their presence is unlikely to be directly linked with the NCMPAs.

11.159 The NCMPAs did not have site specific populations for minke whale or Risso's dolphin. Assessments for minke whale and Risso's dolphin were based on the CGNS MU, in which the NCMPAs were located, and were, therefore relevant to the NCMPAs.

11.160 There are several Marine Nature Reserves (MNRs) in Manx waters (IoM) that have been taken into account. Further information and a list of the IoM MNRs, along with their designated marine mammal species are provided in **Appendix 11.2** (Section 2.6).

11.161 The marine mammal species listed in the IoM MNRs were all included in the impact assessments and transboundary effects are further described in **Section 11.8.1**. The MNRs did not have site-specific populations for marine mammals. Assessments were therefore based on the relevant MUs for each species in which the MNRs were located and were, therefore, relevant to the IoM MNRs.

11.5.11 Marine turtles

11.162 Leatherback turtles undertake extensive trans-oceanic migrations to waters surrounding the UK, within the Atlantic NW Regional Management Unit (RMU) (Wallace *et al*., 2023). Most sightings have occurred during June-October, with a peak in August; whilst strandings peaked slightly later in September and October (Botterell *et al*., 2020). Leatherback turtles are known to have a wide-ranging migration in response to food distribution, including jellyfish and other gelatinous zooplankton. Their presence in UK waters was often due to displacement from their normal range by adverse currents (BEIS, 2022c; Robinson *et al*., 2022, Jones *et al*., 2012).

11.163 The records suggest that leatherback turtles enter British and Irish waters from the south and west. However, these waters are likely to represent the most northern limit of leatherback turtle migration, as evidenced by a notable decrease in annual records (stranding, sightings, captures) and a limited number of sightings across the UK in recent years (Botterell *et al*., 2020).

11.164 In 2021, there were no leatherback turtle sightings in the waters of Morecambe Bay and only two sightings in the IS, at the IoM and Solway Firth. There was only one live Kemp's Ridley turtle stranded in the Dee estuary in 2021 (Penrose *et al*., 2022).

11.165 With only 11 live sightings of leatherback turtles across the UK and Ireland in 2021 (Penrose *et al*., 2022), and the low number of marine turtles (two leatherback turtles, one Kemp's ridley turtle, two dead loggerhead turtles) recorded in Morecambe Bay and the wider IS, it has been concluded that significant effects would be unlikely to occur at a population level. Therefore, marine turtles have not been assessed further in the ES.

11.5.12 Climate change and future trends

11.166 The existing baseline conditions for marine mammals are considered to be relatively stable, for most species. The baseline environment of the IS has been influenced by the fishing industry (by various methods) for hundreds of years, by oil and gas activities since 1974, and by the construction and operation of OWFs for over ten years (e.g. Barrow in 2005, Walney in 2010, West of Dudden Sands in 2012). The baseline will continue to evolve as a result of global trends, which also include the predicted effects of climate change.

11.167 The potential impacts of climate change on marine mammals can be direct, such as the effects of rising sea levels on seal haul-out sites, or species tracking a specific range of water temperatures in which they can physically survive (Learmonth *et al*., 2006; MacLeod *et al*., 2005; Evans and Waggitt, 2020). Species of marine mammal with a narrow range of temperature tolerance, such as species of the Phocidae (earless seals), have been shown to be more susceptible to the effects of climate change (Orgeret *et al*., 2021).

11.168 Indirect effects of climate change include changes in prey resources, in turn affecting distribution, abundance and migration patterns, community structure, and susceptibility to disease and contaminants. Ultimately, these can impact the reproductive success and survival of marine mammals and, therefore, have consequences for populations (Learmonth *et al*., 2006; Evans and Waggitt, 2020).

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

11.170 For harbour porpoise in the CIS, the SCANS-III 2016 abundance estimate was less than 50% of the SCANS-II 2005 estimate (although the lognormal 95% CIs did overlap slightly). Hammond *et al*. (2021) suggested that if the difference in abundance estimates in the CIS reflected a real difference in abundance, possible reasons could include the impact of bycatch or the movement of animals between areas. Changes in the distribution of harbour porpoise were likely the result of changes to the availability of their principal prey species, such as sandeel, within the IS (SCANS-II, 2008).

11.171 The effects 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 availability. 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).

11.172 The observed distribution of bottlenose dolphins in SCANS-IV in 2022 saw more sightings in the northern Celtic Sea, IS and the Hebrides compared to that observed in SCANS-III (Gilles *et al*., 2023; Hammond *et al*., 2021). The total abundance estimate in 2022 was 126,489 (CV = 0.23) (which included offshore Portuguese waters). In 2016, the estimate was 120,500 (CV = 0.17). The estimates appeared similar however, the survey blocks in Portuguese waters contributed around 10% to the overall estimate for 2022. However, the estimates for 2016 and 2022 were both considerably greater than results from 2005/07 of 56,077 (CV = 0.27) (Gilles *et al*., 2023; Hammond *et al*., 2021; WGMME, 2016). The difference in abundance estimates between 2005/07 and 2016 may have reflected bottlenose dolphins responding to spatial variation in prey availability across the wider range (Hammond *et al*., 2021).

11.173 In SCANS-III, there was an increase in predicted densities of bottlenose dolphin off the SW coast of Britain and NW coast of Spain since 2005, indicating that the species may have been increasing its range northwards, in response to warming seas and prey availability.

11.174 Studies have found colder-water adapted species, such as white-beaked dolphin, have been seen less frequently in British waters, potentially due to climate change effects (IAMMWG, 2023; Williamson *et al*., 2021; Evans & Waggitt, 2020). However, the observed distribution of white-beaked dolphin in 2022 (SCANS-IV) was similar to that observed in SCANS-III in 2016, SCANS-II in 2005 and in SCANS-I in 1994 (Gilles *et al*., 2023; Hammond *et al*., 2002, 2013, 2021). The estimate of abundance of white-beaked dolphin in 2022 of 67,138 (CV = 0.33) was higher than previous estimates, with SCANS-III being 36,287 (CV = 0.29) in 2016, SCANS-II was 37,689 (CV = 0.36) in 2005 and SCANS was 23,716 9CV = 0.30) in 1994.

11.175 Around NW Scotland in the period 1992 to 2003, the relative frequency of strandings of white-beaked dolphin (a colder water species) declined, while strandings of common dolphin (a warmer water species) increased. Similarly, sightings surveys in the area also showed that the relative occurrence and abundance of white-beaked dolphins had declined, and common dolphins increased, in comparison to previous studies. These observations were consistent with changes in the local cetacean community, being driven by increases in local water temperature (MacLeod *et al*., 2005).

11.176 The common dolphin population range may have been expanding further north as the occurrence of common dolphin increased in the Celtic Sea, SW of the UK and in western parts of the English Channel (Gilles *et al*., 2023; Williamson *et al*., 2022; Macleod *et al*., 2008). A 15-year time-series of sightings data by the Hebridean Whale and Dolphin Trust (HWDT) has shown a marked increase in the occurrence of common dolphins in the Sea of the Hebrides and The Minch over the period 2003-2017 (HWDT, 2018).

11.177 SCANS-III found no evidence of a trend in abundance of minke whale in the IS since the mid-1990s (Hammond *et al*., 2021). Although predicted densities off the south coast of Ireland decreased between 2005 and 2016, these densities displayed a shifting pattern northward, with a marked increase around the IoM. The distribution observed in the 2022 SCANS survey indicated many sightings of minke whale further south in the North Sea than previously seen, indicating an extension of range in the summer.

11.178 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 (Davis *et al.*, 2020). A decline in the reproductive success of humpback whales (*Megaptera novaeangliae*) could have been linked to climate change, as a result of females being unable to accumulate the energy reserves necessary to maintain pregnancy and/or meet the energetic demands of lactation in years of poorer prey availability (Kershaw *et al*., 2020).

11.179 There has been a continual increase in the total UK grey seal pup production and population estimates since regular surveys began in the 1960s. The overall UK pup production increased by <1.4% per year between 2019 and 2022. The majority of this growth has been seen within colonies in the North Sea, with a growth rate of around 7% per year (SCOS, 2022).

11.180 The grey seal was the only species of pinniped breeding in the Eastern IS and populations were mainly located around the coast of Wales and SW of England, with one noted colony on the IoM. Less intensive monitoring efforts have made calculation of accurate population trends difficult, but data suggested pup production and populations were increasing over time (SCOS, 2021). A severe storm event in 2017 reportedly killed 75% of the pups at major breeding sites in Wales and highlights a potentially increasing impact of climate change on this species (Evans and Waggitt, 2020).

11.181 Overall, the UK population of harbour seal has increased since the late 2000s and was close to the late 1990s level, prior to the 2002 Phocine Distemper Virus epizootic. However, the total UK population decreased by approximately 1% when comparing surveys between 2016 – 2021 with those from 2011-2015. There were significant differences in the population dynamics between regions (SCOS, 2022).

11.182 There were few harbour seal reported within the IS, except along the coast of NI, and in SW Scotland (Firth of Clyde), with no breeding sites known along the Welsh coast (SCOS, 2021). All counts of harbour seals in all areas surveyed in 2021 were substantially lower than previous counts in recent years (SCOS, 2022). Harbour seal densities were very low across the Eastern IS and the offshore development area, increasing slightly in the South, near to Liverpool Bay, and along the NI coast (Carter *et al*., 2020, 2022).

11.183 Potential impacts from climate change on seals include rising sea levels and increasing storms impacting haul-out locations (and therefore, breeding success), new infectious diseases (e.g. *Brucella* bacteria already present in the North Sea (Kroese *et al*., 2018)) and increased toxic algal blooms (Broadwater *et al*., 2018). Seals have a varied diet and can adapt depending on prey availability. However, shortages or changes in prey availability can affect fecundity, survival, lead to movements to new areas, or increased competition between grey and harbour seal.

11.184 For marine mammals, there have been some changes evident as a result of climate change, and it is reasonable to expect further such changes in the future and over the lifetime of the Project. However, the latest changes in population distribution and abundance have been taken into account in the impact assessment.

11.6 Assessment of effects

11.6.1 Receptors

11.185 As outlined in **Section 11.3.1** and **11.1,** the marine mammal receptors requiring assessment were identified as:

- Harbour porpoise
- Bottlenose dolphin
- Common dolphin
- Risso's dolphin
- White-beaked dolphin
- Minke whale
- Grey seal
- Harbour seal

11.186 Further details on each marine mammal receptor, relevant to the impact assessment is provided in **Section 11.1**, with further information provided in **Appendix 11.2**.

11.6.2 Sensitivity to underwater noise

11.187 All species of cetaceans rely on sonar for navigation, finding prey and communication, and are therefore highly sensitive to permanent hearing damage (Southall *et al*., 2007). As such, sensitivity to PTS from pile driving noise was assessed as high for all cetacean species (**Table 11.16**). However, when considering the effect 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.

11.188 Pinnipeds use sound in both air and water for social and reproductive interactions (Southall *et al*., 2007), but not for finding prey. Therefore, Thompson *et al*. (2012) suggested 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 seal and grey seal is expected to be lower than in cetacean species, such as harbour porpoise, with the individual showing some tolerance to avoid, adapt to or accommodate or recover from the effect (for example, Russell *et al*., 2016). As a precautionary approach, harbour seal and grey seal were also considered as having high sensitivity in this assessment (**Table 11.16**).

11.189 Any PTS would be permanent and marine mammals within the potential impact area were considered to have very limited capacity to avoid such effects and considered unable to recover from the effects (see **Table 11.8**).

11.190 All marine mammal species were assessed as having medium sensitivity to temporary changes in hearing sensitivity (TTS) (**Table 11.16**). 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 effect; see (**Table 11.8**).

11.191 Marine mammals may exhibit varying intensities of behavioural response at different noise levels. These responses 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, and temporary or permanent habitat abandonment. 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).

11.192 The response of individuals to a noise stimulus would vary, and not all individuals would respond. However, for the purpose of this assessment, it has been assumed that at the disturbance range, 100% of the individuals exposed to the noise stimulus would respond and be displaced from the area. This is a highly precautionary approach given that it is unlikely that all individuals would be displaced from the potential disturbance area.

11.193 The sensitivity of marine mammals to disturbance was considered to be medium for harbour porpoise and minke whale in this assessment, as a precautionary approach, and low for dolphin spp. and seals (**Table 11.16**).

11.194 Harbour porpoise have been shown to be more sensitive to construction activities and there is an increased potential for disturbance. Due to the broadband frequencies emitted during construction and the low frequency (LF) hearing spectrum of minke whales there is also an increased probability of disturbance. Marine mammals within the potential disturbance area are considered to have the 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 (**Table 11.8**).

Table 11.16 Summary of marine mammal sensitivity to underwater noise

Species	PTS	TTS	Disturbance
Harbour porpoise	High	Medium	Medium
Bottlenose dolphin	High	Medium	Low
Common dolphin	High	Medium	Low
Risso's dolphin	High	Medium	Low
White-beaked dolphin	High	Medium	Low
Minke whale	High	Medium	Medium
Grey seal	High	Medium	Low
Harbour seal	High	Medium	Low

11.6.3 Potential effects during construction

11.195 The potential effects during construction assessed for marine mammals were:

- Impact 1: Permanent and temporary auditory injury from underwater noise during piling
- Impact 2: Disturbance or behavioural effects from underwater noise during piling
- Impact 3: TTS and disturbance from underwater noise during other construction activities, including seabed preparation, cable installation and rock placement
- Impact 4: TTS and disturbance from underwater noise due to presence of vessels
- Impact 5: Barrier effects as a result of underwater noise during construction
- Impact 6: Increased collision risk with vessels during construction
- Impact 7: Changes to prey resources
- Impact 8: Changes to water quality
- Impact 9: Disturbance of seals at haul-out sites

11.196 The worst-case scenarios on which the assessments were based are outlined in **Table 11.1**.

11.6.3.1 Impact 1: Permanent and temporary auditory injury from underwater noise during piling

11.197 A range of WTG/OSP foundation options are being considered for the Project. Of these, monopiles and jackets (with pin-piles) may require pile driving (henceforth, the term 'piling' has been used to describe pile driving of monopiles and jackets with pin-piles towards the target embedment depth). As a worst-case scenario for underwater noise effects, it has been assumed that piling would be required at each WTG and OSP location.

11.198 Impact piling is a source of high-level underwater noise (vibro-piling has also been modelled as a continuous lower-level noise source but is not considered worst-case in terms of noise levels that could incur PTS or TTS). Underwater noise can cause both physiological (e.g., lethal, physical injury and auditory injury) and behavioural (e.g., disturbance and masking of communication) effects on marine mammals.

11.199 Should a marine mammal be very close to the noise 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 PTS or TTS. The potential for auditory injury is not only related to the level of the underwater sound and its frequency relative to the hearing bandwidth of the animal, but it is also influenced by the duration of exposure. The level of effect on an individual is a function of the sound exposure level (SEL) that an individual receives as a result of underwater noise.

11.200 The potential effect of underwater noise depends on several factors, which include, but are not limited to:

- The source levels of noise
- Frequency relative to the hearing bandwidth of the animal (dependent upon species)
- Propagation range, which is dependent upon
  - Frequency of noise (LF travels at greater distances; high frequency (HF) attenuates at shorter distances)
  - Reflection (sediment/sea floor composition)
  - Water depth, temperature and salinity
- Duration of exposure
- Ambient noise levels
- Distance between the animal and the source

Underwater noise modelling

11.201 Underwater noise modelling was carried out by SubAcoustech (**Appendix 11.1**) to predict the noise levels likely to arise during impact piling and other activities. The modelled impact ranges were used to determine the potential effects on marine mammals.

11.202 The underwater noise modelling was undertaken using the Impulsive Noise Propagation and Impact Estimator (INSPIRE) v5.1 subsea noise propagation model. The INSPIRE model is a semi-empirical noise propagation model, based on the use of a combination of numerical modelling and actual measured underwater noise data. It is designed to calculate the propagation of noise in shallow, mixed water, typical of both conditions around the UK (see **Appendix 11.1** for further details).

11.203 The modelling considered a wide array of input parameters, including variations in bathymetry and source frequency content, to ensure the results were of sufficient quality. It should also be noted that the results presented in this assessment are precautionary, as the worst-case parameters have been selected for:

- Piling hammer energies
- Soft-start, ramp-up profile and strike rate
- Duration of piling
- Receptor swim speeds

Underwater noise modelling methodology

Piling locations

11.204 Modelling was undertaken at three representative locations covering the extents of the Project windfarm site. This included the deeper location of the site which is typically the worst-case location (i.e., the deepest location where piling can take place tends to give the greatest noise propagation) (**Appendix 11.1**):

- NW location with a water depth of 28.5m
- E location with a water depth of 25.2m
- SW location with a water depth of 37.2m

11.205 The worst-case scenario was derived from the maximum impact range modelled for the three locations, and was used to inform the assessment of the maximum potential effect on receptor groups in order to provide a conservative assessment.

Hammer energy, soft-start and ramp-up

11.206 Two piling scenarios were considered in the modelling for both monopiles and pin-piles. The first scenario allowed for the longest duration with a lower strike rate, and the second was a high strike rate scenario with a lower starting energy but faster strike rate. Overall, the duration was not significantly shorter for the high strike rate scenario, but this scenario provided greater impact ranges and thus represented the worst-case scenario modelled. The piling duration (for one monopile) for the lower strike scenario was estimated to take 4 hours 30 minutes, whereas the duration for the higher strike rate monopile scenario was 3 hours and 48 minutes. The piling duration (for one pin pile) for the lower strike scenario was estimated to take 4 hours 30 minutes, whereas the duration for the pin pile higher strike rate scenario was 3 hours and 13 minutes.

11.207 The underwater noise modelling was based on the following worst-case hammer energies for monopiles and jacket pin piles:

- Monopile, with maximum diameter of up to 12m, maximum hammer energy of up to 6,600kJ and maximum starting energy of 550kJ
- Jacket pin pile, with diameter of up to 5m, maximum hammer energy of up to 2,500kJ and maximum starting hammer energy of 250kJ

11.208 To determine the potential for PTS or TTS from SEL_{cum}, the soft-start, ramp-up, hammer energy, total duration and strike rate were taken into account. **Table 11.17** summarises the soft-start, ramp-up and piling duration used to assess SEL_{cum} for monopiles and jacket pin-piles.

11.209 As a worst-case scenario, it was assumed that the maximum hammer energy would be required and applied for the remaining duration of the pile installation. However, in practice, the maximum hammer energy is only likely to be required for a proportion of the piling installation and for shorter periods of time. Therefore, the modelling and assessments are considered conservative and precautionary.

Table 11.17 Hammer energy, soft-start, ramp-up and piling duration for one monopile or up to four pin-piles for the worst-case maximum strike rate scenario

Parameter	Starting hammer energy		Ramp-up				Maximum hammer energy
Monopile							
Monopile hammer energy	550kJ	550kJ	1,375 kJ	2,750 kJ	4,125 kJ	5,225 kJ	6,600 kJ
Number of strikes	10	1,067	1,601	710	551	2,012	3,405
Strikes per minute	0.5	100	86	72	58	44	30
Duration (seconds)	1,200	642	1,116	588	570	2,742	6,810
Total duration	1 pile: 3 hours 48 minutes (9,356 total strikes) 3 piles: 11 hours 23 minutes (28,068 total strikes)						
Jacket pin-pile							
Pin-pile hammer energy	250 kJ	250kJ	625 kJ	1,250 kJ	1,875 kJ	2,375 kJ	2,500 kJ
Number of strikes	10	1,067	1601	710	551	500	3,405
Strikes per minute	0.5	100	86	72	58	44	30
Duration (seconds)	1,200	642	1,116	588	570	678	6,810
Total duration	1 pile: 3 hours 13 minutes (7,844 total strikes) 4 piles: 12 hours 54 minutes (31,376 total strikes)						

Sequential piling

11.210 Underwater noise modelling has also been undertaken to cover the possible option for more than one monopile or jacket pin pile to be installed, one after the other, in the same 24-hour period. The modelling was based on the worst-case of three monopiles or four jacket pin piles to be installed sequentially at all locations. The SW location at the Project resulted in the largest ranges due to the deeper water surrounding that location, representing the worst-case impact ranges (**Appendix 11.1**).

11.211 Due to the uncertainty of what a receptor would do between jacket pin-piling operations, it has been assumed that any additional piling would occur immediately after the previous installation, with no pause.

11.212 A fleeing receptor, such as marine mammals, would have travelled away from the noise source by the time the second sequential pile installation starts, and, as such, increases in noise level compared to a single installation are not as pronounced, when compared to simultaneous piling (see **Appendix 11.1** for further information).

Noise source levels

11.213 Underwater noise modelling requires knowledge of the source level, which is the theoretical noise level at 1m from the noise source. The INSPIRE noise propagation model assumes that the noise acts as a single point source. The source level is estimated based on the pile diameter and the hammer energy imparted on the pile by the hammer. This is then adjusted, depending on the water depth at the modelling location, to allow for the length of pile in contact with the water, which can affect the amount of noise that is transmitted from the pile into its surroundings (see **Appendix 11.1** for further information).

11.214 The unweighted peak sound pressure level (SPL_{peak}) and single strike sound exposure level (SEL_{ss}) source levels estimated for this assessment are summarised in **Table 11.18**. All decibel SPL values are referenced to 1µPa and all SEL values are referenced to 1µPa^{2}s.

Table 11.18 Unweighted source levels used in underwater noise modelling for monopiles and jacket pin-piles

Source level	Monopile (6,600kJ)	Pin pile (2,500kJ)
SPL_{peak} (dB re 1 µPa @ 1m)	243.1	241.5
SEL_{ss} (dB re 1 µPa^{2}s @ 1m)	224.3	222.4

Environmental conditions

11.215 The inclusion of measured data for similar offshore piling operations in UK waters allows the INSPIRE noise propagation model to intrinsically account for various environmental conditions. This includes the differences that can occur with the temperature and salinity of water, as well as the sediment type surrounding the windfarm site. Data from the British Geological Survey show that the seabed surrounding the Project is generally made up of sand. The in-situ geophysical surveys in 2021 and the benthic sediment samples taken during a site-specific survey in 2022 support the above findings (**Appendix 7.1 Offshore Geophysical Survey** (Document Reference 5.2.7.1) and **Appendix 9.1 Benthic Characterisation Survey** (Document Reference 5.2.9.1)).

11.216 **Appendix 11.1** notes that variations of sediment composition have not been found to lead to a significant effect on the transmission of noise levels from piling. For the modelling, digital bathymetry, from the European Marine Observation and Data Network (EMODnet), has also been used. Mean tidal depth has been used throughout (**Appendix 11.1**).

Thresholds and criteria

11.217 Sound measurements underwater are usually expressed using the decibel (dB) scale, which is a logarithmic measure of sound. The logarithmic scale is when for every 10dB increase, the sound is perceived to double in loudness (Salfordacoustics, 2023).

11.218 The SPL is normally used to characterise noise and vibration of a continuous nature. The variation in sound pressure can be measured over a specific time period, to determine the root mean square (RMS) level of the time varying acoustic pressure. Therefore, SPL (i.e. SPL_{RMS}) can be considered as a measure of the average unweighted level of the sound over the measurement period.

11.219 SPL_{peak} are often used to characterise sound transients from impulsive sources, such as percussive impact piling. A peak SPL is calculated using the maximum variation of the pressure, from positive to zero, within the wave. This represents the maximum change in positive pressure (differential pressure from positive to zero) as the transient pressure wave propagates.

11.220 The SEL sums up the acoustic energy over a measurement period, and effectively takes account of both the SPL of the sound source, and the duration the sound is present in the acoustic environment (further details are provided in **Appendix 11.1**).

11.221 SEL_{ss} is the potential sound exposure level from a single strike of the hammer, i.e., one hammer strike at the starting hammer energy or maximum hammer energy applied.

11.222 SEL_{cum} is the cumulative sound exposure level throughout the duration of piling, including the soft-start, ramp-up and time required to complete the installation of the pile (**Table 11.17**). To determine SEL_{cum} ranges for marine mammals, a fleeing animal model has been used. This assumes that the animal exposed to high noise levels would swim away from the noise source. For this, a constant swimming speed of 3.25m/s has been assumed for minke whale (Blix and Folkow, 1995), and as a precautionary approach for all other species, a constant swimming speed of 1.5m/s has been used, based on the average swimming speed for harbour porpoise mother and calf pairs (Otani *et al*., 2000). This is considered a worst-case scenario, as marine mammals are expected to be able to swim faster. Further details on how SEL_{cum} is modelled is provided in **Appendix 11.1**.

11.223 At the time of writing, the metrics and criteria that have been used to assess the potential effect of underwater noise on marine mammals are based on the most up to date publications, recommended guidance, and discussions during Marine Mammal Ecology ETG meetings (see consultation in **Appendix 11.5**).

11.224 Southall *et al*. (2019) presented unweighted peak criteria (SPL_{peak}) for single strike, weighted sound exposure criteria for single strike (SEL_{ss}) and cumulative (i.e., more than a single sound impulse) weighted sound exposure criteria (SEL_{cum}) for both PTS, where unrecoverable reduction in hearing sensitivity may occur and TTS, where a temporary reduction in hearing sensitivity may occur.

11.225 Southall *et al*. (2019) categorised marine mammal species into hearing groups and applied filters to the unweighted noise in order to approximate the hearing sensitivities of the species. This allowed the specific hearing abilities and sensitivities of each group to be approximated. This provides the weighted SEL criteria, which corrects the sound level based on the sensitivity of the receiver; for example, harbour porpoise are less sensitive to low frequency (LF) sound than minke whales. Marine mammal hearing group ranges are summarised in **Table 11.19**.

Table 11.19 Southall et al. (2019) marine mammal hearing ranges

Species hearing group	Generalised hearing range
Harbour porpoise Very high-frequency cetaceans (VHF)	275Hz to 160kHz
Bottlenose dolphin, common dolphin, Risso's dolphin, white-beaked dolphin High-frequency cetaceans (HF)	150Hz to 160kHz
Minke whale Low-frequency cetaceans (LF)	7Hz to 35kHz
Grey seal and harbour seal Phocid carnivores in water (PCW)	50Hz to 86kHz

11.226 Southall *et al*. (2019) also included criteria based on SPL_{peak}, which are unweighted and do not take species sensitivity into account. It is important to note that they are different criteria and, as such, should not be compared directly. Assessments have been based on the criteria with the greatest predicted impact ranges.

11.227 It should be noted that the Southall *et al*. (2019) Marine Mammal Noise Exposure Criteria are the same as the National Marine and Fisheries Service (NMFS) (2018) criteria, although Southall *et al*. (2019) renamed the following species groupings: Medium-Frequency (MF) cetaceans are now classed as HF cetaceans, and previous HF cetaceans are classified as VHF cetaceans.

11.228 The Southall *et al*. (2019) thresholds and criteria for PTS and TTS impacts to the species groups used in the assessments are summarised in **Table 11.20**.

Table 11.20 Southall et al. (2019) thresholds and criteria used in the underwater noise modelling and assessments

Species	Species group	Impact	Unweighted SPL_{peak} (dB re 1 μPa) impulsive	Weighted SEL_{ss} and SEL_{cum} (dB re 1 $\mu Pa^2 s$)	
				Impulsive	Non-impulsive
Harbour porpoise	VHF cetacean	PTS	202	155	173
		TTS	196	140	153
Dolphin species	HF cetacean	PTS	230	185	198
		TTS	224	170	178
Minke whale	LF cetacean	PTS	219	183	199
		TTS	213	168	179
Grey seal and harbour seal	PCW	PTS	218	185	201
		TTS	212	170	181

11.229 The PTS thresholds are extrapolated from TTS thresholds. These PTS thresholds are ultimately used to indicate the potential number of animals that could be at risk (e.g., experience permanent hearing sensitivity loss, even after the exposure to sound ceases, or in-between successive sound exposures), as opposed to the number of animals that could develop TTS (temporary hearing sensitivity loss that will recover completely once exposure to sound ceases, or in-between successive sounds exposures).

11.230 The likelihood of individual animals experiencing PTS and TTS is also dependent on the frequency band at which PTS and TTS is predicted to occur and whether that frequency band is in the critical hearing sensitivity band for that species. If PTS or TTS is predicted to occur at a frequency outside the critical hearing band, potential effects would be minimal.

11.231 Noise sources are categorised as either impulsive or non-impulsive (Southall *et al., 2019*):

- Impulsive (single or multiple pulse): High peak sound pressure, short duration, fast rise-time and broad frequency content at source. Explosives, impact piling and seismic airguns are considered impulsive noise sources
- Non-impulsive (or continuous non-pulsed sound): Vessel engines, sonars, vibro-piling, drilling and other low-level continuous noises are considered non-impulsive. However, a non-impulsive noise does not necessarily have to have a long duration

11.232 As sound pulses propagate through the environment and dissipate, they lose their most injurious characteristics (e.g., rapid pulse rise time and high peak sound pressure) and become more like a "non-pulse" at greater distances. Active research is currently underway into the identification of the distance at which the pulse can be considered effectively non-impulsive (see **Appendix 11.1**). Both impulsive and non-impulsive criteria from Southall *et al*. (2019) have been included in the underwater noise modelling, however, assessments presented in this chapter have been based on the criteria with the greatest predicted impact range.

Assumptions and considerations

11.233 It should be noted, and considered, that the underwater noise modelling and assessment was based on worst-case scenarios and precautionary approaches. This includes, but is not limited to:

- The maximum hammer energy to be applied and maximum piling duration for each scenario was assumed for all piling locations; however, it is unlikely that applying maximum hammer energy throughout the maximum duration would be required at the majority of piling locations
- The maximum predicted impact ranges were based on the location with the greatest potential noise propagation range and this was assumed as the worst-case for each piling location

11.234 The assumption that fleeing marine animals (such as harbour porpoise, dolphin species, grey seal and harbour seal) are swimming at a constant speed of 1.5m/s is based on the slow swimming speed of harbour porpoise mothers and their calves (Otani *et al.*, 2000). Normally, marine mammals are expected to swim faster, for example harbour porpoise have been recorded swimming at speeds of up to 4.3m/s (Otani *et al*., 2000). During playbacks of pile driving sounds (SPL of 154 dB re 1µPa) the swimming speed was measured as 1.97m/s (7.1km/h), whereas, during quiet baseline periods, the mean swimming speed was 1.2m/s (4.3km/h; Kastelein *et al*., 2018).

11.235 The assumption that animals are submerged 100% of the time does not account for any time that an individual may spend at the surface, where SELs are reduced. When cetaceans surface to breathe, or when seals have their head out of the water, the animal would not be exposed to such high levels.

11.236 Underwater noise modelling assumed that marine mammals would travel in the mid-water column, where SPL are greatest. However, in reality, animals would not be subjected to these high SPL at all times, since they are likely to move up and down through the water column. In order to breathe, the animals would have to regularly surface, where the sound pressure would drop to zero. A study by Teilmann *et al*. (2007) on diving behaviour of harbour porpoise in Danish waters suggested that animals spent 55% of their time in the upper 2m of the water column from April to August, and over the whole year, they spent 68% of their time in less than 5m depth. However, it should be noted that this study was conducted for “undisturbed” animals, which could show a different behaviour.

11.237 The swimming patterns of harbour porpoise undertaking direct travel are typically characterised by short submergence periods, compared to feeding animals (Watson and Gaskin, 1983). These short duration dives, with horizontal travel, suggest that travelling animals, such as harbour porpoise moving away from pile driving noise, would swim in the upper part of the water column. It would be anticipated that, during a fleeing response from a loud underwater noise (such as piling), that their swimming behaviour may change with a reduction in deep dives. For example, during pile driving playback sounds to examine TTS, harbour porpoise showed behaviour response during the exposure periods which included increased swimming speeds and jumping out of the water more (Kastelein *et al*., 2016).

11.238 Noise impact assessments assumed that all animals within the noise contour may be affected to the same degree for the maximum worst-case scenario. For example, all animals exposed to noise levels that induce behavioural avoidance would be displaced, or all animals exposed to noise levels that are predicted as inducing PTS or TTS would suffer permanent, or temporary, auditory injury, respectively. However, a study looking at the proportion of trials at different SELs that result in TTS in exposed bottlenose dolphins, suggested that, to induce TTS in 50% of animals, it would be necessary to extrapolate well beyond the range of measured SEL levels (Finneran *et al*., 2005). This suggests that, for a given species, the potential effects follow a dose-response curve, such that the probability of inducing TTS would decrease moving further away from the SEL threshold required to induce TTS. Further work by Thompson *et al*. (2013) has adopted this dose-response curve to produce a theoretical dose-response for PTS in harbour seal, by scaling up Finneran *et al*. (2005) dose-response curve for changes in levels of TTS at different SEL. This showed the probability of seals experiencing PTS increases from an SEL of 186, up to 240 dB re 1 μPa2s; the point at which all animals are predicted to have PTS.

11.239 Soft-start and ramp-up periods have been included as embedded mitigation (**Section 11.3.3**). The soft-start begins with a lower hammer energy, before ramping-up to the maximum hammer energy, with the assumption that marine mammals would move out of the area as the hammer energy is increased and before there is the increased risk of PTS from the maximum hammer energy.

11.240 However, research around the installation of jacket foundations in the Moray Firth found that received noise levels at any given distance were highest at low hammer energies (Thompson *et al*., 2020). Modelling highlighted that there was a strong negative relationship between noise from pin pile installations and pile penetration depth, whereas hammer energy only had a weak positive relationship between received noise and hammer energy. The study further found that strong responses of porpoises to ADDs resulted in far-field disturbance beyond that required to mitigate injury.

Results

11.241 **Table 11.21** presents the underwater noise modelling results for the predicted PTS impact ranges and areas from the maximum strike rate scenario at the windfarm site (worst-case SW location) in a 24-hour period from:

- A single strike from the maximum hammer energy
- Cumulative SEL for:
  - Monopile
  - Three sequential monopiles
  - Jacket pin piles
  - Four sequential jacket pin piles

11.242 **Table 11.22** presents the underwater noise modelling results for the predicted TTS impact ranges and areas from the maximum strike rate scenario at the windfarm site (worst-case location – SW) from:

- A single strike from the maximum hammer energy
- Cumulative SEL for:
  - Monopile
  - Three sequential monopiles
  - Jacket pin piles
  - Four sequential jacket pin piles in 24-hour period

11.243 The summary of impact ranges in **Table 11.21** and **Table 11.22** indicates that the impact ranges for cumulative noise exposure of three sequentially piled monopiles or four sequentially piled pin-piles are the same or slightly larger than those of a single piling event (<100m difference). To avoid repetition, the impact assessment was based on the worst-case ranges of the three sequential monopiles or four sequential pin-piles.

Table 11.21 Predicted PTS impact ranges (and areas) at the Project from a single strike and from cumulative exposure for maximum hammer energy

Species	Impact	Criteria and threshold (Southall *et al.*, 2019)	Monopile Maximum impact range (km) and area (km^2) Maximum hammer energy (6,600kJ)	Monopile (sequential piling) Maximum impact range (km) and area (km^2) Maximum hammer energy (6,600kJ)	Pin pile Maximum impact range (km) and area (km^2) Maximum hammer energy (2,500kJ)	Pin pile (sequential piling) Maximum impact range (km) and area (km^2) Maximum hammer energy (2,500kJ)
Harbour porpoise (VHF)	PTS from single strike (without mitigation)	SPL_{peak} Unweighted (202 dB re 1µPa) Impulsive	0.69km (1.5km^2)	N/A	0.54km (0.9km^2)	N/A
	PTS from cumulative SEL (including soft-start and ramp-up)	SEL_{cum} Weighted (155 dB re 1µPa^2s) Impulsive	8.1km (150km^2)	8.2km (150km^2)	5.1km (60km^2)	5.2km (61km^2)
Dolphin species (HF)	PTS from single strike (without mitigation)	SPL_{peak} Unweighted (230 dB re 1µPa) Impulsive	<0.05km (<0.01km^2)	N/A	<0.05km (<0.01km^2)	N/A
	PTS from cumulative SEL (including soft-start and ramp-up)	SEL_{cum} Weighted (185 dB re 1µPa^2s) Impulsive	<0.1km (<0.1km^2)	<0.1km (<0.1km^2)	<0.1km (<0.1km^2)	<0.1km (<0.1km^2)

Species	Impact	Criteria and threshold (Southall *et al*., 2019)	Monopile Maximum impact range (km) and area (km^2) Maximum hammer energy (6,600kJ)	Monopile (sequential piling) Maximum impact range (km) and area (km^2) Maximum hammer energy (6,600kJ)	Pin pile Maximum impact range (km) and area (km^2) Maximum hammer energy (2,500kJ)	Pin pile (sequential piling) Maximum impact range (km) and area (km^2) Maximum hammer energy (2,500kJ)
Minke whale (LF)	PTS from single strike (without mitigation)	SPL_{peak} Unweighted (219 dB re 1µPa) Impulsive	<0.05km ($0.01km^2$)	N/A	<0.05km (<$0.01km^2$)	N/A
	PTS from cumulative SEL (including soft-start and ramp-up)	SEL_{cum} Weighted (183 dB re $1µPa^2s$) Impulsive	13km ($330km^2$)	13km ($330km^2$)	8.9km ($150km^2$)	8.9km ($150km^2$)
Grey and harbour seal (PCW)	PTS from single strike (without mitigation)	SPL_{peak} Unweighted (218 dB re 1µPa) Impulsive	0.06km ($0.01km^2$)	N/A	<0.05km (<$0.01km^2$)	N/A
	PTS from cumulative SEL (including soft-start and ramp-up)	SEL_{cum} Weighted (185 dB re $1µPa^2s$) Impulsive	0.95km ($1.9km^2$)	0.98km ($2.0km^2$)	<0.1km (<$0.1km^2$)	<0.1km (<$0.1km^2$)

Table 11.22 Predicted TTS impact ranges (and areas) at the Project from a single strike and from cumulative exposure for maximum hammer energy

Species	Impact	Criteria and threshold (Southall *et al*., 2019)	Monopile Maximum impact range (km) and area (km^2) Maximum hammer energy (6,600kJ)	Monopile (sequential piling) Maximum impact range (km) and area (km^2) Maximum hammer energy (6,600kJ)	Pin pile Maximum impact range (km) and area (km^2) Maximum hammer energy (2,500kJ)	Pin pile (sequential piling) Maximum impact range (km) and area (km^2) Maximum hammer energy (2,500kJ)
Harbour porpoise (VHF)	TTS from single strike (without mitigation)	SPL_{peak} Unweighted (196 dB re 1µPa) Impulsive	1.6km ($8.3km^2$)	N/A	1.3km ($5.3km^2$)	N/A
	TTS from cumulative SEL (including soft-start and ramp-up)	SEL_{ss} Weighted (140 dB re $1µPa^2s$) Impulsive	26km ($1400km^2$)	27km ($1500km^2$)	22km ($1000km^2$)	22km ($1000km^2$)
Dolphin species (HF)	TTS from single strike (without mitigation)	SPL_{peak} Unweighted (224 dB re 1µPa) Impulsive	<0.05km (<$0.01km^2$)	N/A	<0.05km (<$0.01km^2$)	N/A
	TTS from cumulative SEL (including soft-start and ramp-up)	SEL_{cum} Weighted (170 dB re $1µPa^2s$) Impulsive	<0.1km (<$0.1km^2$)	<0.1km (<$0.1km^2$)	<0.1km (<$0.1km^2$)	<0.1km (<$0.1km^2$)

Species	Impact	Criteria and threshold (Southall *et al*., 2019)	Monopile Maximum impact range (km) and area (km^2) Maximum hammer energy (6,600kJ)	Monopile (sequential piling) Maximum impact range (km) and area (km^2) Maximum hammer energy (6,600kJ)	Pin pile Maximum impact range (km) and area (km^2) Maximum hammer energy (2,500kJ)	Pin pile (sequential piling) Maximum impact range (km) and area (km^2) Maximum hammer energy (2,500kJ)
Minke whale (LF)	TTS from single strike (without mitigation)	SPL_{peak} Unweighted (213 dB re 1µPa) Impulsive	0.13km (0.05km^2)	N/A	0.1km (0.03km^2)	N/A
	TTS from cumulative SEL (including soft-start and ramp-up)	SEL_{cum} Weighted (168 dB re 1µPa^2s) Impulsive	34km (2,100km^2)	34km (2,100km^2)	29km (1,500km^2)	29km (1,500km^2)
Grey and harbour seal (PCW)	TTS from single strike (without mitigation)	SPL_{peak} Unweighted (212 dB re 1µPa) Impulsive	0.15km (0.07km^2)	N/A	0.11km (0.04km^2)	N/A
	TTS from cumulative SEL (including soft-start and ramp-up)	SEL_{cum} Weighted (170 dB re 1µPa^2s) Impulsive	15km (500km^2)	15km (510km^2)	12km (330km^2)	12km (340km^2)

Sensitivity

11.244 All marine mammal species were assessed as having high sensitivity to PTS from underwater noise during piling (**Table 11.16**).

11.245 All marine mammal species were assessed as having medium sensitivity to TTS from underwater noise during piling (**Table 11.16**).

Magnitude

PTS

PTS from single strike at maximum hammer energy

11.246 The maximum predicted impact range for instantaneous PTS, from a single strike of monopile or pin pile, with maximum hammer energy without any mitigation, was up to 0.69km for harbour porpoise for a piling hammer with a maximum hammer energy of 6,600kJ (**Table 11.21**).

11.247 An assessment of the maximum number of marine mammals for each species that could be at risk of instantaneous PTS from a single strike of monopile or jacket pin pile is presented in **Table 11.23**. This assessment assumed the maximum hammer energy without any mitigation, based on the worst-case SW location.

11.248 The magnitude of the potential impact without any mitigation was assessed as **low** (between 0.001% to 0.01% of the reference population exposed to permanent effect) for harbour porpoise. The magnitude of the potential impact without any mitigation was assessed to be **negligible** for bottlenose dolphin, common dolphin, Risso's dolphin, white-beaked dolphin, minke whale, grey seal and harbour seal, with 0.001% or less of the reference populations anticipated to be exposed to any permanent effect (**Table 11.23**).

Table 11.23 Maximum number of individuals (and % of reference population) that could be at risk of PTS from single strike of monopile or jacket pin-pile at maximum hammer energy without mitigation, based on worst-case location at the windfarm site

Species	Criteria and threshold (Southall *et al*., 2019)	Monopile with maximum hammer energy of 6,600kJ		Pin-pile with maximum hammer energy of 2,500kJ	
		Maximum number of individuals (% of reference population)	Magnitude (permanent effect)	Maximum number of individuals (% of reference population)	Magnitude (permanent effect)
Harbour porpoise	SPL_{peak} Unweighted (202 dB re 1µPa) Impulsive	2.4 (0.004% of CIS MU)	Low	1.5 (0.002% of CIS MU)	Low
Bottlenose dolphin	SPL_{peak} Unweighted (230 dB re 1µPa) Impulsive	0.0001 (0.00004% of IS MU)	Negligible	0.0001 (0.00004% of IS MU)	Negligible
Common dolphin	SPL_{peak} Unweighted (230 dB re 1µPa) Impulsive	0.0003 (0.0000003% of CGNS MU)	Negligible	0.0003 (0.0000003% of CGNS MU)	Negligible
Risso's dolphin	SPL_{peak} Unweighted (230 dB re 1µPa) Impulsive	0.000006 (0.00000005% of CGNS MU)	Negligible	0.000006 (0.00000005% of CGNS MU)	Negligible
White-beaked dolphin	SPL_{peak} Unweighted (230 dB re 1µPa) Impulsive	0.00007 (0.0000002% of CGNS MU)	Negligible	0.00007 (0.0000002% of CGNS MU)	Negligible

Species	Criteria and threshold (Southall *et al.*, 2019)	Monopile with maximum hammer energy of 6,600kJ		Pin-pile with maximum hammer energy of 2,500kJ	
		Maximum number of individuals (% of reference population)	Magnitude (permanent effect)	Maximum number of individuals (% of reference population)	Magnitude (permanent effect)
Minke whale	SEL_{ss} Weighted (219 dB re $1\mu Pa^2s$) Impulsive	0.00009 (0.0000004% of CGNS MU)	Negligible	0.00009 (0.0000004% of CGNS MU)	Negligible
Grey seal	SPL_{peak} Unweighted (218 dB re 1µPa) Impulsive	0.001 (0.0001% of combined MUs; or 0.00001% of wider ref pop)	Negligible (Negligible)*	0.001 (0.0001% of combined MUs; or 0.00001% of wider ref pop)	Negligible (Negligible)*
Harbour seal	SPL_{peak} Unweighted (218 dB re 1µPa) Impulsive	0.000001 (0.00002% of NW England MU; or 0.0000001% of wider ref pop)	Negligible (Negligible)*	0.000001 (0.00002% of NW England MU; or 0.0000001% of wider ref pop)	Negligible (Negligible)*

* Magnitude in brackets is for the wider reference population for grey seals (incl. Wales, SW Scotland, NI and RoI) and harbour seal (incl. NI)

PTS from cumulative exposure for sequential pile installation

11.249 As previously discussed, the impact ranges for a single monopile/pin pile or three sequential monopiles or four sequential pin piles is the same (or slightly higher for sequential piling) (see **Table 11.21**), thus the worst-case ranges modelled for sequential piling were assessed.

11.250 The maximum predicted impact range for PTS from cumulative exposure (SEL_{cum}) during a monopile or a pin pile installation with maximum hammer energy, in the absence of any additional mitigation, was up to 8.2km for harbour porpoise and 13km for minke whale (for three sequential monopiles installed with a maximum hammer energy of 6,600kJ) (**Table 11.21**).

11.251 The maximum predicted impact range for PTS from cumulative exposure (SEL_{cum}) during sequential piling of four jacket pin piles, with maximum hammer energy of 2,500kJ, was up to 5.1km for harbour porpoise and 8.9km for minke whale, without any additional mitigation (**Table 11.21**).

11.252 The SEL_{cum} is a measure of the total received noise over the whole piling operation and the SEL_{cum} range indicates the distance from the piling location. 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 could receive a noise exposure in excess of the criteria threshold. 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 11.1** for further details).

11.253 An assessment of the maximum number of individuals for each species that could be at risk of PTS from cumulative exposure during installation of a single monopile or single jacket pin pile is presented in **Table 11.24**. This assessment assumed a maximum hammer energy, the absence of any additional mitigation and was based on the worst-case SW location for the maximum impact range.

11.254 The magnitude of the potential impact for a monopile, with a maximum hammer energy of 6,600kJ, in the absence of any additional mitigation, was assessed as **medium** for harbour porpoise and minke whale; **medium** (**low**) for grey seal; **low** (**negligible**) for harbour seal; and **negligible** for all other species (**Table 11.24**).

11.255 The magnitude of the potential impact of PTS from sequential piling of four jacket pin piles, with a maximum hammer energy of 2,500kJ, without any additional mitigation, was assessed as **medium** for harbour porpoise; **low** for minke whale; and **negligible** for all other species (**Table 11.24**).

11.256 It is important to note that the assessment for PTS from cumulative exposure is highly precautionary, as outlined in **Section 11.4.6**. There was also a lot of variation in the potential impact ranges for SEL_{cum} at each location and between locations. The assessments were based on the modelled impact set out in **Table 11.21**. It is unlikely that the maximum hammer energy would be required at all piling locations for the entire duration of the piling activity.

Table 11.24 Maximum number of individuals (and % of reference population) that could be at risk of PTS from cumulative exposure (SEL_{cum}) during installation of three sequential monopiles or four sequential pin-piles without additional mitigation, based on worst-case location

Species	Criteria and threshold (Southall *et al.*, 2019)	Monopile with maximum hammer energy of 6,600kJ†		Pin-pile with maximum hammer energy of 2,500kJ†	
		Maximum number of individuals (% of reference population)	Magnitude (permanent effect)	Maximum number of individuals (% of reference population)	Magnitude (permanent effect)
Harbour porpoise	SEL_{cum} Weighted (155 dB re 1µPa^{2}s) Impulsive	243 (0.4% of CIS MU)	Medium	98.9 (0.2% of CIS MU)	Medium
Bottlenose dolphin	SEL_{cum} Weighted (185 dB re 1µPa^{2}s) Impulsive	0.001 (0.0004% of IS MU)	Negligible	0.001 (0.0004% of IS MU)	Negligible
Common dolphin	SEL_{cum} Weighted (185 dB re 1µPa^{2}s) Impulsive	0.003 (0.000003% of CGNS MU)	Negligible	0.003 (0.000003% of CGNS MU)	Negligible
Risso's dolphin	SEL_{cum} Weighted (185 dB re 1µPa^{2}s) Impulsive	0.0006 (0.0000005% of CGNS MU)	Negligible	0.0006 (0.0000005% of CGNS MU)	Negligible
White-beaked dolphin	SEL_{cum} Weighted (185 dB re 1µPa^{2}s) Impulsive	0.001 (0.000002% of CGNS MU)	Negligible	0.0007 (0.000002% of CGNS MU)	Negligible
Minke whale	SEL_{cum} Weighted (183 dB re 1µPa^{2}s) Impulsive	2.9 (0.01% of CGNS MU)	Medium	1.3 (0.007% of CGNS MU)	Low

Species	Criteria and threshold (Southall *et al.*, 2019)	Monopile with maximum hammer energy of 6,600kJ†		Pin-pile with maximum hammer energy of 2,500kJ†	
		Maximum number of individuals (% of reference population)	Magnitude (permanent effect)	Maximum number of individuals (% of reference population)	Magnitude (permanent effect)
Grey seal	SEL_{cum} Weighted (185 dB re 1µPa^{2}s) Impulsive	0.2 (0.01% of combined MUs; or 0.002% of wider ref pop)	Medium (low)*	0.01 (0.0006% of combined MUs; or 0.00008%of wider ref pop)	Negligible (Negligible)*
Harbour seal	SEL_{cum} Weighted (185 dB re 1µPa^{2}s) Impulsive	0.0002 (0.003% of NW MU; or 0.00002% of wider ref pop)	Low (negligible)*	0.00001 (0.0002% of NW England MU; or 0.000001% of wider ref pop)	Negligible (Negligible)*

RoI† SEL_{cum} relates to three sequential monopiles or four sequential pin piles within 24 hours as worst-case

* Magnitude in brackets is for the wider reference population for grey seals (incl. Wales, SW Scotland, NI and RoI) and harbour seal (incl. NI)

TTS

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

11.258 The underwater noise modelling results for the maximum predicted ranges (and areas) for TTS in marine mammals are presented in **Table 11.22**.

TTS from single strike at maximum hammer energy

11.259 The maximum predicted impact range for TTS from a single strike of a monopile, with maximum hammer energy, without any mitigation, was up to 1.6km for harbour porpoise (**Table 11.22**).

11.260 An assessment of the maximum number of marine mammals for each species that could be at risk of TTS from a single strike of a monopile or jacket pin pile is presented in **Table 11.25**. This assessment assumed the maximum hammer energy without any mitigation, based on the worst-case location.

11.261 The magnitude of the potential impact, without any mitigation, was assessed as **negligible** for all marine mammal species, with 1% or less of the relevant reference populations anticipated to be exposed to any temporary effect (**Table 11.25**).

Table 11.25 Maximum number of individuals (and % of reference population) that could be at risk of TTS from single strike of monopile or pin-pile at maximum hammer energy without mitigation, based on worst-case location

Species	Criteria and threshold (Southall *et al*., 2019)	Monopile with maximum hammer energy of 6,600kJ		Pin-pile with maximum hammer energy of 2,500kJ	
		Maximum number of individuals (% of reference population)	Magnitude (permanent effect)	Maximum number of individuals (% of reference population)	Magnitude (permanent effect)
Harbour porpoise	SPL_{peak} Unweighted (196 dB re 1µPa) Impulsive	13.5 (0.02% of CIS MU)	Negligible	8.6 (0.01% of CIS MU)	Negligible
Bottlenose dolphin	SPL_{peak} Unweighted (224 dB re 1µPa) Impulsive	0.0001 (0.00004% of IS MU)	Negligible	0.0001 (0.00004% of IS MU)	Negligible
Common dolphin	SPL_{peak} Unweighted (224 dB re 1µPa) Impulsive	0.0003 (0.0000003% of CGNS MU)	Negligible	0.0003 (0.0000003% of CGNS MU)	Negligible
Risso's dolphin	SPL_{peak} Unweighted (224 dB re 1µPa) Impulsive	0.000006 (0.00000005% of CGNS MU)	Negligible	0.000006 (0.00000005% of CGNS MU)	Negligible
White-beaked dolphin	SPL_{peak} Unweighted (224 dB re 1µPa) Impulsive	0.00007 (0.0000002% of CGNS MU)	Negligible	0.00007 (0.0000002% of CGNS MU)	Negligible

Species	Criteria and threshold (Southall *et al*., 2019)	Monopile with maximum hammer energy of 6,600kJ		Pin-pile with maximum hammer energy of 2,500kJ	
		Maximum number of individuals (% of reference population)	Magnitude (permanent effect)	Maximum number of individuals (% of reference population)	Magnitude (permanent effect)
Minke whale	SPL_{peak} Unweighted (213 dB re 1µPa) Impulsive	0.0004 (0.000002% of CGNS MU)	Negligible	0.0003 (0.000001% of CGNS MU)	Negligible
Grey seal	SPL_{peak} Unweighted (212 dB re 1µPa) Impulsive	0.007 (0.0004% of combined MUs; or 0.00005% of wider ref pop)	Negligible (negligible)*	0.004 (0.0003% of combined MUs; or 0.00003% of wider ref pop)	Negligible (negligible)*
Harbour seal	SPL_{peak} Unweighted (212 dB re 1µPa) Impulsive	0.00001 (0.0001% of NW MU; or 0.0000005% of wider ref pop)	Negligible (negligible)*	0.000004 (0.00006% of NW MU; or 0.0000003% of wider ref pop)	Negligible (negligible)*

* Magnitude in brackets is for the wider reference population for grey seals (incl. Wales, SW Scotland, NI and RoI) and harbour seal (incl. NI)

TTS from cumulative exposure for sequential pile installation

11.262 The maximum predicted impact range for TTS from cumulative exposure (SEL_{cum}) during installation of a monopile, with maximum hammer energy of 6,600kJ, was up to 27km for harbour porpoise and 34km for minke whale, based on the worst-case location and in the absence of any additional mitigation (**Table 11.22**).

11.263 The maximum predicted impact range for TTS from cumulative exposure (SEL_{cum}), during sequential piling of four pin piles, was up to 22km for harbour porpoise and 29km for minke whale, for maximum hammer energy of 2,500kJ and without any additional mitigation (**Table 11.22**).

11.264 The maximum number of marine mammals for each species that could be at risk of TTS from cumulative exposure during installation of three sequential monopiles or four sequential jacket pin-piles is presented in **Table 11.26**. This assessment assumed a maximum hammer energy, without any additional mitigation and was based on the worst-case location for the maximum impact range.

11.265 The magnitude of the potential impact, in the absence of any additional mitigation, for monopiles and jacket pin piles, was assessed as **low** for harbour porpoise and **low** (**negligible**) for grey seal; and **negligible** for all other species (**Table 11.26**).

Table 11.26 Maximum number of individuals (and % of reference population) that could be at risk of TTS from cumulative exposure (SEL_{cum}) during installation of three sequential monopiles or four sequential pin-piles without additional mitigation, based on worst-case location

Species	Criteria and threshold (Southall *et al*., 2019)	Monopile with maximum hammer energy of 6,600kJ†		Pin-pile with maximum hammer energy of 2,500kJ†	
		Maximum number of individuals (% of reference population)	Magnitude (permanent effect)	Maximum number of individuals (% of reference population)	Magnitude (permanent effect)
Harbour porpoise	SEL_{cum} Weighted (140 dB re 1 µPa^{2}s) Impulsive	2,432 (3.9% of CIS MU)	Low	1,621.0 (2.6% of CIS MU)	Low
Minke whale	SEL_{cum} Weighted (168 dB re 1 µPa^{2}s) Impulsive	18.5 (0.1% of CGNS MU)	Negligible	13.2 (0.07% of CGNS MU)	Negligible
Grey seal	SEL_{cum} Weighted (170 dB re 1 µPa^{2}s) Impulsive	51 (3.2% of combined MUs; or 0.4% of wider ref pop)	Low (negligible)*	34 (2.1% of combined MUs; or 0.3% of wider ref pop)	Low (negligible)*
Harbour seal	SEL_{cum} Weighted (170 dB re 1 µPa^{2}s) Impulsive	0.06 (0.8% of NW MU; or 0.004% of wider ref pop)	Negligible (negligible)*	0.04 (0.5% of NW MU; or 0.003% of wider ref pop)	Negligible (negligible)*
Dolphin species	SEL_{cum} Weighted (170 dB re 1 µPa^{2}s) Impulsive	Same impact ranges as PTS (see **Table 11.24**)	Negligible	Same impact ranges as PTS (see **Table 11.24)**	Negligible

† SEL_{cum} relates to three sequential monopiles or four sequential pin piles within 24 hours as the worst-case

* Magnitude in brackets is for the wider reference population for grey seals (incl. Wales, SW Scotland, NI and RoI) and harbour seal (incl. NI)

Significance of effect

11.266 For PTS from a single strike of the maximum hammer energy for monopiles or jacket pin piles, the significance of effect for any permanent changes in hearing sensitivity (PTS) has taken into account the high marine mammal sensitivity and the potential magnitude of the impact. The latter was based on the number of individuals as a percentage of the reference population, as set out in **Table 11.23** and **Table 11.24**.

11.267 The PTS from a single strike of the maximum hammer energy for monopiles or jacket pin piles, in the absence of any additional mitigation, has been assessed as **moderate adverse** (significant in EIA terms) for harbour porpoise and **minor adverse** (not significant in EIA terms) for all other species (**Table 11.27**).

11.268 For PTS from cumulative exposure, in the absence of any additional mitigation, the significance of effect has been assessed as **major adverse** (significant in EIA terms) for harbour porpoise and grey seal for the sequential piling of monopiles and pin-piles; **major adverse** for minke whale for three sequential monopiles and **moderate adverse** (significant in EIA terms) for four sequential pin-piles. Harbour seal was assessed as **moderate adverse** (significant in EIA terms) for monopiles, but **minor adverse** (not significant in EIA terms) for pin piles. For all dolphin species, the significance of effect from the sequential piling of monopiles and pin-piles, have been assessed as **minor adverse** (not significant in EIA terms) (**Table 11.27**).

11.269 For TTS, from a single strike of the maximum hammer energy for monopiles or jacket pin piles, the significance of effect for any temporary changes in hearing sensitivity has taken into account the medium marine mammal sensitivity and the potential magnitude of the impact as set out in **Table 11.25** and **Table 11.26**.

11.270 From a single strike of the maximum hammer energy for monopiles or jacket pin piles, in the absence of any additional mitigation, TSS effects have been assessed as **minor adverse** (not significant in EIA terms) for all species (**Table 11.27**).

11.271 For TTS from cumulative exposure, the significance of effect has also been assessed as **minor adverse** (not significant in EIA terms) for all species (**Table 11.27**).

Mitigation

11.272 The development and implementation of a MMMP for piling (as described in **Section 11.3.3** would reduce the risk of PTS from the first strike of the soft-start, from a single strike of the maximum hammer energy and from the cumulative exposure of each monopile and each jacket pin-pile foundation.

11.273 The MMMP for piling would be developed post-consent, in consultation with the MMO and other relevant organisations, and would be based on the latest information, scientific understanding and guidance, and detailed Project design. The final MMMP for piling would be based on the Draft MMMP which has been included with the DCO Application. The Draft MMMP includes further details of the embedded mitigations and the potential additional mitigation measures to be adopted by the Project.

11.274 Potential additional mitigation to reduce the risk of PTS would include establishing a monitoring zone and ADD activation prior to the soft-start commencing.

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

11.276 It is important to note that Brandt *et al*. (2018) found that, at seven German offshore wind farms, 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). This vessel disturbance of marine mammals from the area around the construction site, prior to piling, would also reduce the risk of PTS.

11.277 The mitigation measures set out in the MMMP to reduce the risk of PTS would also reduce the number of marine mammals at risk of TTS.

Residual significance of effect

11.278 Taking into account the additional mitigation, the residual significance of effect of the potential risk of PTS to marine mammals due to underwater noise during piling, would be **minor adverse** (not significant in EIA terms) for all species (**Table 11.27**).

11.279 The additional mitigation adopted to reduce the risk of PTS would also reduce the risk of TTS. The residual effect of the potential risk of TTS to marine mammals due to underwater noise during piling, would also be **minor adverse** (not significant in EIA terms) for all species (**Table 11.27**).

Table 11.27 Assessment of significance of effect for PTS and TTS in marine mammals from underwater noise during piling

Species/ receptor	Potential impact		Sensitivity	Magnitude	Significance of effect	Additional mitigation measures proposed	Residual effect
Harbour porpoise	Single strike of maximum hammer energy – monopile or pin-pile	PTS	High	Low	Significant (Moderate adverse)	MMMP (**Section 11.3.3**)	Not Significant (Minor adverse)
		TTS	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Cumulative exposure from single or sequential piling at max hammer energy	PTS	High	Medium	Significant (Major adverse)		Not Significant (Minor adverse)
		TTS	Medium	Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Bottlenose dolphin	Single strike of maximum hammer energy – monopile or pin-pile	PTS	High	Negligible	Not Significant (Minor adverse)	MMMP (**Section 11.3.3**)	Not Significant (Minor adverse)
		TTS	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Cumulative exposure from single or sequential piling at max hammer energy	PTS	High	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
		TTS	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)

Species/ receptor	Potential impact		Sensitivity	Magnitude	Significance of effect	Additional mitigation measures proposed	Residual effect
Common dolphin	Single strike of maximum hammer energy – monopile or pin-pile	PTS	High	Negligible	Not Significant (Minor adverse)	MMMP (**Section 11.3.3**)	Not Significant (Minor adverse)
		TTS	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Cumulative exposure from single or sequential piling at max hammer energy	PTS	High	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
		TTS	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Risso's dolphin	Single strike of maximum hammer energy – monopile or pin-pile	PTS	High	Negligible	Not Significant (Minor adverse)	MMMP (**Section 11.3.3**)	Not Significant (Minor adverse)
		TTS	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Cumulative exposure from single or sequential piling at max hammer energy	PTS	High	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
		TTS	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)

Species/ receptor	Potential impact		Sensitivity	Magnitude	Significance of effect	Additional mitigation measures proposed	Residual effect
White-beaked dolphin	Single strike of maximum hammer energy – monopile or pin-pile	PTS	High	Negligible	Not Significant (Minor adverse)	MMMP (**Section 11.3.3**)	Not Significant (Minor adverse)
		TTS	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Cumulative exposure from single or sequential piling at max hammer energy	PTS	High	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
		TTS	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Minke whale	Single strike of maximum hammer energy – monopile or pin-pile	PTS	High	Negligible	Not Significant (Minor adverse)	MMMP (**Section 11.3.3**)	Not Significant (Minor adverse)
		TTS	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Cumulative exposure from single or sequential piling at max hammer energy	PTS	High	Monopile: medium; Pin-pile: low	Significant (Major adverse for monopile; and moderate adverse for pin-pile)		Not Significant (Minor adverse)
		TTS	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)

Species/ receptor	Potential impact		Sensitivity	Magnitude	Significance of effect	Additional mitigation measures proposed	Residual effect
Grey seal	Single strike of maximum hammer energy – monopile or pin-pile	PTS	High	Negligible (negligible)*	Not Significant (Minor adverse)	MMMP (**Section 11.3.3**)	Not Significant (Minor adverse)
		TTS	Medium	Negligible (negligible)*	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Cumulative exposure from single or sequential piling at max hammer energy	PTS	High	Monopile: medium (low)* Pin-pile: negligible (negligible)*	Significant (Major to moderate adverse for monopile); Not significant (minor adverse for pin-pile)		Not Significant (Minor adverse)
		TTS	Medium	Low (negligible)*	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Harbour seal	Single strike of maximum hammer energy – monopile or pin-pile	PTS	High	Negligible (negligible)*	Not Significant (Minor adverse)	MMMP (**Section 11.3.3**)	Not Significant (Minor adverse)
		TTS	Medium	Negligible (negligible)*	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Cumulative exposure from single or sequential piling at max hammer energy	PTS	High	Monopile: low (negligible)* Pin-pile: negligible (negligible)*	Significant (moderate adverse for monopile); Not Significant (Minor adverse for pin-pile)		Not Significant (Minor adverse)
		TTS	Medium	Negligible (negligible)*	Not Significant (Minor adverse)		Not Significant (Minor adverse)

* Magnitude in brackets is for the wider reference population for grey seals (incl. Wales, SW Scotland, NI and RoI) and harbour seal (incl. NI)

11.6.3.2 Impact 2 Disturbance from underwater noise during piling

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

11.281 A review of current information in relation to the potential disturbance and impact ranges of marine mammals from underwater noise during piling has been included to provide an understanding of the associated potential effects and support the marine mammal assessment (**Appendix 11.2**).

11.282 Southall *et al.* (2007) stated that in the absence of data on the behavioural responses or possible fleeing from impulsive noise, the TTS onset threshold could be used as a proxy for a behavioural threshold. Therefore, the potential TTS impact ranges and areas presented in **Table 11.22**, along with the estimated number of marine mammals and percentage of reference populations presented in **Table 11.25** and **Table 11.26**, provide an indication of a possible fleeing response.

11.283 To assess the potential for disturbance, it is necessary to consider the likelihood that exposure of the animal(s) elicits a response which is likely to generate a significant population-level effect. Assessment of population-level effects from a temporary disturbance is made complicated by the highly variable nature of the introduced disturbance (e.g., the complex nature of sound and its propagation in the marine environment), and the variability of behavioural response in different species and individuals.

11.284 The JNCC *et al*. (2010) guidance proposes that "any action that is likely to increase the risk of long-term decline of the population(s) of (a) species could be regarded as disturbance under the Regulations." The JNCC *et al*. (2010) guidance indicates that a score of 5 or more on the Southall *et al*. (2007) behavioural response severity scale could be significant (see **Appendix 11.2**, Table 6.1). The more severe the response on the scale, the less time animals will likely tolerate the disturbance, before there could be significant negative effects on life functions, which would constitute a disturbance.

11.285 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).

11.286 It should be noted that a behavioural response does not mean that the individuals would avoid the area. Additionally, the modelled maximum predicted ranges for behavioural response from piling are based on the maximum hammer energy at the worst-case location for noise propagation. In reality, the duration of any piling at maximum energy would be less (if this energy is reached at all) and noise propagation would vary considerably with location (i.e., be less than the worst case modelled).

Sensitivity

11.287 Harbour porpoise and minke whale are assessed as having medium sensitivity to disturbance and all other marine mammal species are assessed as having low sensitivity to disturbance from underwater noise (**Table 11.16**).

Magnitude

11.288 Potential disturbance of marine mammals from underwater noise during piling has been assessed based on:

- Effective Deterrence Radius (EDR) approach for harbour porpoise
- Disturbance assessment based on known impact ranges for dolphin species, minke whale, and seals
- Dose-response curve
- Disturbance during ADD activation
- Modelled Population Level Consequences (iPCoD)

11.289 The worst-case numbers of animals disturbed, as derived from EDRs, known disturbance impact ranges or dose-response curves, have been applied to the population modelling available for harbour porpoise, bottlenose dolphin, minke whale, grey seal and harbour seal. The overall magnitude of disturbance has then been based on the population modelling (where available) to assess the significance of effect for disturbance from piling.

11.290 Further information on the estimated number of animals that could be disturbed are summarised in see **Appendix 11.2** (Table 7.5).

Disturbance/displacement based on known disturbance ranges for marine mammal

Harbour porpoise

11.291 The SNCBs recommend using a 26km EDR for monopiles (2,124km^2) and 15km EDR for pin-piles (707km^2), both without noise abatement, to assess potential disturbance areas for harbour porpoise within designated SACs in England, Wales, and NI (JNCC, 2023a). While the Project is not situated in close proximity to any harbour porpoise SACs, this precautionary approach has been applied for assessing disturbance from piling at the Project.

11.292 Not all harbour porpoise within these potential EDR disturbance areas would be disturbed. However, a worst-case scenario of 100% disturbance of harbour porpoise in the areas has been assumed in the assessment.

11.293 The estimated number of harbour porpoise, and corresponding percentage of the CIS MU reference population, that could be disturbed as a result of underwater noise during piling at the Project, is presented in **Table 11.28**.

11.294 The magnitude of the potential impact is assessed as **medium** for the 26km EDR, with >5% of CIS MU anticipated to be temporarily disturbed, and **low** for the 15km EDR (**Table 11.28**).

Table 11.28 Maximum number of harbour porpoise (and % of reference population) that could be at disturbed during piling at the Project based on EDRs

Species	26km EDR (2,124km^2) for monopile		15km EDR (707km^2) for pin-pile	
	Maximum number of individuals (% of reference population)	Magnitude (temporary effect)	Maximum number of individuals (% of reference population)	Magnitude (temporary effect)
Harbour porpoise	3,443 (5.5% of CIS MU)	Medium	1,146 (1.8% of CIS MU)	Low

Dolphin species

11.295 Based on the literature described in **Appendix 11.2**, there was no agreed disturbance range for dolphin species for piling noise impacts. The estimated number of bottlenose dolphin, common dolphin, Risso's dolphin and white-beaked dolphin, and the corresponding percentage of the MU reference population, that could be disturbed as a result of underwater noise during Project piling, has been estimated by using the worst-case TTS impact ranges in **Table 11.29**.

11.296 The magnitude of the potential impact was assessed as **negligible** for all dolphin species across the relevant MUs, anticipated to be temporarily disturbed (**Table 11.29**).

Table 11.29 Maximum number of dolphin spp. (and % of reference population) that could be at disturbed during piling at the Project based on a TTS range of 0.1km

Species	0.1km TTS range (0.1km^2) for monopile	
	Maximum number of individuals (% of reference population)	Magnitude (temporary effect)
Bottlenose dolphin	0.001 (0.0004% of IS MU)	Negligible
Common dolphin	0.003 (0.000003% of CGNS MU)	Negligible
Risso's dolphin	0.0006 (0.0000005% of CGNS MU)	Negligible
White-beaked dolphin	0.001 (0.000002% of CGNS MU)	Negligible

Minke whale

11.297 Based on the literature review in **Section 6.1.3** of **Appendix 11.2**, a precautionary disturbance range of 30km has been applied to minke whale. The estimated number of minke whale, and corresponding percentage of the CGNS MU reference population, that could be disturbed as a result of underwater noise during piling at the Project is presented in **Table 11.30**.

11.298 The magnitude of the potential impact was assessed as **negligible** with <1% of the CGNS MU anticipated to be temporarily disturbed (**Table 11.30**).

Table 11.30 Maximum number of minke whale (and % of reference population) that could be at disturbed during piling at the Project based on a disturbance range of 30km

Species	30km disturbance range (2827.43km^2) for monopile	
	Maximum number of individuals (% of reference population)	Magnitude (temporary effect)
Minke whale	24.9 (0.12% of CGNS MU)	Negligible

Seal species

11.299 Based on the literature review in **Section 6.1.4** of **Appendix 11.2**, a precautionary disturbance range of 25km has been applied to both seal species. The estimated number of grey and harbour seal, and the corresponding percentage of the reference population, that could be disturbed as a result of underwater noise during piling at the Project, is presented in **Table 11.31.**

11.300 The magnitude of the potential impact was assessed as **high** for the reference population of grey seal with >10% of the combined MU population (NW MU and IoM population) anticipated to be temporarily disturbed. For the wider population of grey seal and the harbour seal NW MU, the magnitude was assessed as **low**, with >1% of the relevant population disturbed. For the wider harbour seal reference population, the magnitude was assessed as **negligible** (**Table 11.31**).

Table 11.31 Maximum number of grey and harbour seal (and % of reference population) that could be at disturbed during piling at the Project based on a disturbance range of 25km

Species	**25km disturbance range (1963.5 km^2) for monopile**	
	Maximum number of individuals (% of reference population)	**Magnitude (temporary effect)**
Grey seal	196.4 (12.3% of the combined MU; or 1.5% of the wider ref population)	High (low)*
Harbour seal	0.22 (3.1% of the NW MU; or 0.015% of wider ref population)	Low (negligible)*

*Magnitude in brackets is for the wider reference population for grey seals (incl. Wales, SW Scotland, NI and RoI) and harbour seal (incl. NI)

Dose-response curve assessment

11.301 The application of a dose-response curve allows for an evidence-based estimate of the number of animals disturbed, 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).

11.302 For the purposes of this assessment, the dose was the received single-strike SEL (SEL_{ss}). The use of SEL_{ss} in a dose-response analysis, where possible, is considered best practice in the latest guidance provided by Southall *et al*. (2021). It accounts for the actual behavioural response (i.e., not all individuals would respond to the same level of noise) and is therefore a more realistic approach to assessing the potential for disturbance.

11.303 The dose-response methodology has been adopted in this assessment for species where there are appropriate dose-response experiments published in scientific literature, namely for harbour porpoise, harbour seal and grey seal (further information, including dose-response curves used, is provided in **Appendix 11.2**, Section 6).

11.304 The assessment was based on SEL_{ss} for the worst-case scenario of a monopile struck with a maximum hammer energy of 6,600kJ. To estimate the number of animals disturbed by piling, SEL_{ss} contours at 5dB increments (generated by the noise modelling, see **Appendix 11.2**) were overlain on the relevant species density surfaces, 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.

11.305 The dose-response relationship used for harbour porpoise was developed by Graham *et al*. (2017), using data collected on harbour porpoise during Phase 1 of piling at the Beatrice OWF (see **Appendix 11.2**). Following the development of this dose-response relationship, further study revealed that the responses of harbour porpoises to piling noise diminished over the construction period (Graham *et al*., 2019). Therefore, the use of the dose-response relationship based on an initial piling event for all piling events in this assessment, can be considered conservative.

11.306 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 functional hearing groups, audiograms and behaviour, it would not be appropriate to extrapolate the findings of Graham *et al*. (2017) to other cetacean species. However, given the limited data and studies on dolphin behavioural response to piling and construction work in general, the application of the harbour porpoise dose-response data has been undertaken as a highly conservative worst-case method to quantify potential disturbance for dolphin spp.

11.307 For both harbour seal and grey seal, a dose-response relationship has been used that is derived from harbour seal telemetry data collected during several months of piling at the Lincs OWF (Whyte *et al*., 2020; see **Appendix 11.2**). Whyte *et al.* (2020) tested the effects of pile driving noise (characterised as SEL_{ss} (dB re 1 µPa s)) on harbour porpoise disturbance in 5dB increments between 115dB to 180dB SEL_{ss} (dB re 1 µPa s). From this data, a dose-response curve was derived and has been applied to SEL contours from 120dB to 200dB SEL re 1 µPa s. The Whyte *et al.* (2020) dose-response curve for harbour seal has also been used for grey seal, as both species have similar hearing audiograms.

11.308 For harbour porpoise, the site-specific density of 1.621 animals/km^2 was applied for the survey area (i.e., the windfarm site plus custom 4-10km buffer). A secondary density taken from SCANS-IV was applied to all noise contours beyond the survey area to provide a more accurate representation for densities across the noise contours. The 1.621 animals/km^2 density (summer average) represents the highest site-specific density seasonally during survey.

11.309 For bottlenose dolphin SCANS-IV densities were applied to the assessment and for all other dolphin species Waggitt *et al*. (2019) density estimates were used. For both seal species, the Carter *et al*. (2022) density estimates were used.

11.310 The estimated numbers of harbour porpoise, dolphin spp., grey seal, and harbour seal, and the corresponding percentage of the relevant MU population that could be disturbed as a result of underwater noise during piling, based on the worst-case foundation and location, are presented in **Table 11.32**.

11.311 For harbour porpoise, the potential magnitude of the impact was assessed as **low** (3.02% of the CIS MU); for bottlenose dolphin it was **high** with 19.2% of the IS MU disturbed; and for all other species the magnitude was **negligible**, with less than 0.5% of the relevant MU reference population predicted to be disturbed (**Table 11.32**).

11.312 It should be noted that, this dose-response analysis was carried out in relation to pile driving noise only, and, therefore, did 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 11.32 Number of individuals (and % of Reference Population) that could be disturbed during piling based on the dose-response approach

Species	Number of individuals disturbed (% of reference population)	Magnitude (temporary effect)
Harbour porpoise	1,857.9 harbour porpoise (2.97% of the CIS MU)	Low
Bottlenose dolphin	56.3 bottlenose dolphin (19.2% of the IS MU)	High
Common dolphin	127.6 common dolphin (0.12% of the CGNS MU)	Negligible
Risso's dolphin	2.4 Risso's dolphin (0.02% of the CGNS MU)	Negligible
White-beaked dolphin	17.9 white-beaked dolphin (0.04% of the CGNS MU)	Negligible
Grey seal	0.151 grey seal (0.009% of the combined MU; 0.00001% of the wider reference population)	Negligible
Harbour seal	0.001 harbour seal (0.0084% of the NW MU; or <0.00001% of the wider reference population)	Negligible

Disturbance during ADD activation

11.313 As outlined in **Section 11.3.3**, additional mitigation to reduce the risk of PTS could include activation of ADDs prior to the soft-start commencing.

11.314 Assessment of the potential disturbance during any ADD activation is indicative only at this time as the final requirements for mitigation would be determined in the MMMP prior to construction and would be based upon best available information and methodologies at that time, in consultation with the relevant SNCBs and the MMO.

11.315 Based on the worst-case maximum predicted PTS impact ranges for cumulative exposure (SEL_{cum}) during installation of monopile or pin piles, including soft-start and ramp-up (see **Table 11.17** and **Table 11.21**), ADD activation would be a necessary mitigation to deter animals out of the ranges. Considering known swimming speeds for minke whale (Blix & Folkow, 1995) and harbour porpoise (Otani *et al*., 2000) from scientific literature, it was established how far animals would have to swim to flee beyond the modelled PTS (SEL_{cum}) impact ranges.

11.316 **Table 11.33** provides a summary of the ADD activation durations required to reach the modelled piling PTS SEL_{cum} impact ranges. This identified that a minimum 90 minute ADD activation would be necessary to deter harbour porpoise from the impact area during monopile installation. This activation time would also be sufficient to cover the impact ranges for minke whale, dolphins and seals.

11.317 However, based on scientific evidence and experiences from other OWF constructions (see **Appendix 11.3,** Section 5.2.1.1 for more details), an upper boundary has been identified for when ADD activation time appears to become ineffective, thereby becoming an unnecessary additional noise source to the marine environment. This upper limit was identified as approximately 80 minutes, during which harbour porpoise, dolphins and seals would swim at least 7.2km away and minke whale would move 15.6km away (**Table 11.33**). Considering these distances, all marine mammal species would be sufficiently deterred, apart from harbour porpoise which would not reach the maximum PTS SEL_{cum} of 8.1km. However, it can be assumed that harbour porpoise would also be deterred after 80 minutes as the precautionary swimming speed applied is based on a slow swimming mother and calf pair (Otani *et al*., 2000). If a harbour porpoise increased its swimming speed to 2.4m/s (60% faster), it could cover the distance of the maximum PTS SEL_{cum} of 8.1km. Additionally, the current monopile impact ranges are based on the worst-case maximum hammer energy of 6,600kJ (= 120% of the maximum hammer energy). The final Project design would define which hammer energies are likely to be used, and for what duration, and may be below the maximum hammer energy assessed. Thus, the impact ranges could be smaller, and the 80-minute ADD duration may be sufficient time for harbour porpoise to vacate the area around a pile.

11.318 For pin piles, the maximum predicted PTS SEL_{cum} impact ranges for sequential installation of four jacket pin piles is 5.1km for harbour porpoise and 8.9km for minke whale. **Table 11.33** shows that only 57 minutes of ADD activation would be necessary for both harbour porpoise and minke whale to be able to swim to the maximum impact ranges that assume the maximum hammer energy of 2,500kJ.

Table 11.33 Effect ranges of ADD activation for monopile and pin pile for PTS SEL_{cum} impact ranges

	Minke whale (LF)*	Dolphins (HF)**	Harbour porpoise (VHF)**	Seals (PCW)**
Monopile				
Maximum PTS SEL_{cum} impact range (km)	**13**	**<0.1**	**8.1**	**0.95**
ADD effect range (km) (ADD on for 90 min)	17.6	8.1	8.1	8.1
ADD effect range (km) (ADD on for 80 min)	15.6	7.2	7.2	7.2
Pin pile				
Maximum PTS SEL_{cum} impact range (km)	**8.9**	**<0.1**	**5.1**	**<0.1**
ADD effect range (km) (ADD on for 57 min)	11.1	5.1	5.1	5.1

*based on a swimming speed of 3.25m/s (Blix & Folkow, 1995) for LF

**based on a precautionary swimming speed of 1.5m/s (Otani *et al*., 2000) for HF, VHF, PCW

11.319 Based on the above presented information, the assessments for disturbance effects during ADD activation were based on an 80-minute ADD activation for monopiles and a 57-minute ADD activation for pin piles.

11.320 The magnitude of the potential impact was assessed as **low** for grey seal, with 1% or more of the combined MU reference population anticipated to be temporarily disturbed and was **negligible** when considered for the wider reference population. All other marine mammal receptors were assessed as **negligible** with 1% or less of the relevant reference populations anticipated to be temporarily disturbed (**Table 11.34**).

Table 11.34 Maximum number of individuals (and % of reference population) that could be at disturbed during 80 minute ADD activation prior to piling

Species	Maximum number of individuals (% of reference population)	Magnitude (temporary effect)
Harbour porpoise	264.0 (0.42% of CIS MU)	Negligible
Bottlenose dolphin	1.7 (0.58% of IS MU)	Negligible
Common dolphin	4.6 (0.004% of CGNS MU)	Negligible
Risso's dolphin	0.1 (0.001% of CGNS MU)	Negligible
White-beaked dolphin	1.1 (0.003% of CGNS MU)	Negligible
Minke whale	6.7 (0.04% of CGNS MU)	Negligible
Grey seal	16.3 (1.02% of combined MUs; or 0.12% of wider ref pop)	Low (negligible)*
Harbour seal	0.02 (0.3% of the NW MU; or 0.001% of wider ref pop)	Negligible (negligible)*

* Magnitude in brackets is for the wider reference population for grey seals (incl. Wales, SW Scotland, NI and RoI) and harbour seal (incl. NI)

Duration of piling and ADD activation

11.321 The Project foundation installation campaign for WTGs and OSP(s) is expected to be carried out over a period of 9-12 months (**Table 11.1**). This would include transit of the foundation components in batches to the site, and foundation installation, including any piling.

11.322 Piling would not be constant during the piling phases and construction periods. There would be gaps between the installation of individual piles and, if installed in groups, there would be time periods when piling is not taking place, accounting for vessel transit to and from the site. There are also likely to be potential breaks due to weather or other technical issues.

11.323 **Table 11.35** summarises the worst-case scenarios for the duration of piling (including ADD activation), based on:

- Maximum number of WTGs and OSP(s)
- Maximum number of piles
- Piling duration to install each pile, including soft-start, ramp-up and ADD activation

Table 11.35 Maximum duration of piling, based on worst-case scenarios for the impact range, 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 ADD activation
Up to 35 WTGs	35 monopiles	3 hours and 48 minutes including soft-start and ramp-up	Up to 133 hours for 35 monopiles	80 minutes ADD activation prior to each monopile installation = 46 hours and 42 minutes for 35 monopiles	Up to 179 hours and 42 minutes
	140 pin-piles for jackets (4 pin piles per foundation)	3 hours 13 minutes including soft-start and ramp-up	Up to 450 hours and 48 minutes for 140 pin-piles	58 minutes ADD activation prior to each pin-pile installation = 135 hours and 18 minutes for 140 pin-piles	Up to 586 hours and 6 minutes
Two OSPs	2 monopiles	3 hours and 48 minutes including soft-start and ramp-up	Up to 7 hours and 36 minutes for 2 monopiles	80 minutes ADD activation prior to each monopile installation = 2 hours and 42 minutes for 2 monopiles	Up to 10 hours and 18 minutes
	8 pin-piles (4 pin piles per foundation)	3 hours and 13 minutes including soft-start and ramp-up	25 hours and 48 minutes for 8 pin-piles	58 minutes ADD activation prior to each pin-pile installation = 7 hours 42 minutes for 8 pin-piles	Up to 33 hours and 30 minutes
Piling of up to 37 monopiles for 35 WTGs and two OSPs (including soft-start, ramp-up and ADD activation) = 190 hours					
Piling of up to 35 monopiles for 35 WTGs and 8 pin-piles for two OSPs (including soft-start, ramp-up and ADD activation) = 213 hours and 12 minutes					
Piling of up to 148 pin-piles for 35 WTGs and two OSPs (including soft-start, ramp-up and ADD activation) = 619 hours and 36 minutes					

11.324 The duration of piling identified in **Table 11.35** to inform the assessment was based on a very precautionary approach. The duration can be considered to be overestimated, as demonstrated through experience at other OWFs.

11.325 For example, within the ES for the Beatrice OWF it was estimated that each pin-pile would require five hours of active piling time. However, during construction, the total piling duration ranged from 19 minutes to 2 hours and 45 minutes, with an average duration of 1 hour and 15 minutes per pin-pile (Beatrice OWF Limited, 2018).

11.326 A study on the effects of OWF construction on harbour porpoise within the German North Sea, between 2009 and 2013 (Brandt *et al.*, 2016), indicated that the duration of effect 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 shipping activity during preparation works. The study concluded that, although there were adverse, short-term effects of construction on acoustic porpoise detections (1-2 days in duration), there was no indication that harbour porpoises within the German Bight were negatively affected by windfarm 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.

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

11.328 Nabe-Nielsen *et al*. (2018) developed the Disturbance Effects of Noise on the Harbour Porpoise Population in the North Sea (DEPONS) 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 effect of OWF construction noise on the North Sea harbour porpoise population, based on the acoustic monitoring of harbour porpoise during construction of the Dutch Gemini OWF. Local population densities around the Gemini windfarm recovered 2–6 hours after piling, with similar recovery rates being obtained in the model. The model indicated that, assuming noise influenced porpoise movements as observed at the Gemini windfarm, the North Sea harbour porpoise population was not affected by construction of 65 windfarms, as required to meet the EU renewable energy target (Nabe-Nielsen *et al*., 2018).

11.329 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 windfarm. 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 windfarms. Indicating that in these scenarios, the population effect 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 effect would differ, depending on the distance of the individual from the piling activity and the noise level to which the animal is exposed.

Modelled population level consequences due to disturbance

11.330 Population modelling has been conducted for harbour porpoise, bottlenose dolphin, minke whale, harbour seal and grey seal. The iPCoD framework (Harwood *et al.,* 2013, King *et al.*, 2015) was used to predict the potential medium and long term population consequences of the predicted amount of disturbance resulting from piling at the Project. The model only has capacity to run simulations for species that have sufficient data on population-specific demographic rates; and have undergone the expert elicitation process (Harwood *et al*., 2013). This is essential in capturing how disturbance modifies the demographic rates and underpins the functioning of the model.

11.331 The iPCoD modelling methods, including key assumptions and chosen model inputs, are detailed in **Appendix 11.2**. The worst-case piling schedule used for the modelling is set out in **Table 11.36**.

11.332 If, as a result of PTS, a population shows a continued decline of >1% per year (versus a modelled unimpacted reference population) over a set period of time (e.g., the first 6 years, based on the former Favourable Conservation Status (FCS) reporting period), then there is a high likelihood that a significant effect cannot be ruled out (NRW, 2023).

11.333 For context, for each species assessed, the estimated number of animals disturbed or potentially exposed to PTS for each monopile event are set out in **Table 11.37**. The number of disturbed animals has been determined based on the worst-case assessment. This is considered to be the effective disturbance ranges found in the literature for harbour porpoise, minke whale, grey and harbour seal, and the dose-response assessment for bottlenose dolphin.

11.334 The results of the iPCoD modelling for each species considered, along with the associated impact magnitudes, are set out in the following sections.

Table 11.36 Piling scenario used for iPCoD modelling for the Project

Parameter	Value
Number of WTGs	35
Number of OSPs	2
Number of piles	Monopiles: 35 (WTG) and 2 (OSP)
Number of piling days	37 (assumed 1 pile per day)
Piling window	Q2 and Q3 2027 (WTG/OSP monopiles)
Piling schedule	Q2 and Q3 2027: 37 monopile days (distributed randomly)

Table 11.37 Estimated number of animals with the potential to be exposed to PTS or to be disturbed during each piling event

Species	PTS	Disturbance
Harbour porpoise	243	3,443
Bottlenose dolphin	0.001	56.3
Minke whale	2.9	24.9
Grey seal	0.2	196.4
Harbour Seal	0.0002	0.22

Harbour porpoise

11.335 Assuming a worst-case of 3,443 harbour porpoises disturbed and 243 estimated animals with PTS on every piling day (**Table 11.37**), the iPCoD model estimated there to be only the slightest discernible impact to the harbour porpoise population (**Plate 11.2** and **Table 11.38**). It should be noted that the number of disturbed harbour porpoise were precautionary as they were based on the high site-specific density which has been applied across the entire 26km EDR range.

11.336 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 has been completed). By the end of 2029 (2 years after piling ends) the median population size for the impacted population was predicted to be 99.89% of the un-impacted population size. Beyond 2029, the impacted population was expected to maintain the same stable trajectory as the un-impacted population (as far as 2052 which was the end point of the modelling).

11.337 For harbour porpoise, the potential magnitude of the impact was assessed as **negligible** due to there being less than a 1% population level impact over both the first six years and 25-year modelled periods.

Table 11.38 Results of the iPCoD modelling for the Project, giving the mean population size of the harbour porpoise population (CIS MU) for years up to 2052 for both impacted and un-impacted populations, in addition to the mean and median ratio between their population sizes

Year	Un-impacted population mean	Impacted population mean	Median impacted as % of un-impacted
Start	62,516	62,516	100.00%
End 2028	62,451	62,451	100.00%
End 2029	62,424	62,268	99.89%
End 2032	62,524	62,403	99.89%
End 2037	62,307	62,180	99.89%
End 2047	62,036	61,908	99.89%
End 2052	61,876	61,750	99.89%

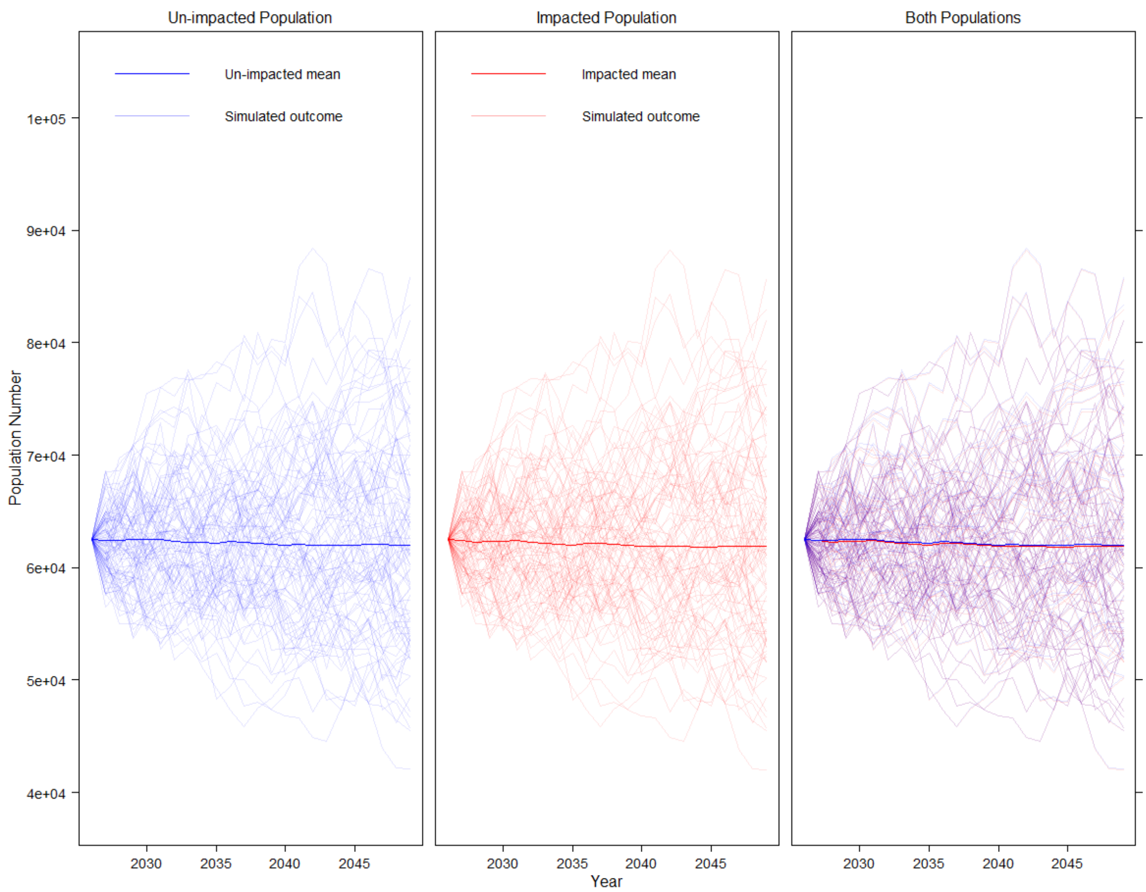

Plate 11.2 Simulated worst-case harbour porpoise population sizes for both the un-impacted and the impacted populations (scientific notation used in these charts, e.g. 4e+04 = 40,000)

Bottlenose dolphin

11.338 Assuming a worst-case of 56.3 bottlenose dolphin disturbed and 0.001 estimated animals with PTS on every piling day (**Table 11.37**), the iPCoD model estimated there to be no discernible impact to the IS MU population (**Plate 11.3** and **Table 11.39**).

11.339 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 has been completed). By the end of 2029 (2 years after piling ends) the median population size for the impacted population was predicted to be 100% of the un-impacted population size. This lack of discernible effect on the impacted population was maintained until 2052, which was the end point of the modelling.

11.340 For bottlenose dolphin, the magnitude of the potential impact was assessed as **negligible** due to there being less than a 1% population level impact over both the first six years and 25-year modelled periods.

Table 11.39 Results of the iPCoD modelling for the Project, giving the mean population size of the bottlenose dolphin population (IS MU) for years up to 2052 for both impacted and un-impacted populations in addition to the mean and median ratio between their population sizes

Year	Un-impacted population mean	Impacted population mean	Median impacted as % of un-impacted
Start	296	296	100.00%
End 2028	295	295	100.00%
End 2029	293	288	100.00%
End 2032	287	283	100.00%
End 2037	278	275	100.00%
End 2047	262	259	100.00%
End 2052	255	252	100.00%

Plate 11.3 Simulated worst-case bottlenose dolphin population sizes for both the un-impacted and the impacted populations

Minke whale

11.341 Assuming a worst-case of 24.88 disturbed and 2.9 estimated animals with PTS on every piling day (**Table 11.37**), the iPCoD model estimated there to be only the slightest discernible impact to the minke whale population (**Plate 11.4** and **Table 11.40**).

11.342 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 has been completed). By the end of 2029 (2 years after piling ends) the population size for the impacted population was predicted to be 99.94% of the un-impacted population size. The impacted population at the end of 2047 (20 years after piling) was expected to be 99.63% of un-impacted population, a ratio that remained until 2052, which was the end point of the modelling.

11.343 For minke whale, the magnitude of the potential impact was assessed as **negligible** due to there being less than a 1% population level impact over both the first six years and 25-year modelled periods.

Table 11.40 Results of the iPCoD modelling for the Project, giving the mean population size of the minke whale population (CGNS MU) for years up to 2052 for both impacted and un-impacted populations in addition to the mean and 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 2028	20,188	20,188	100.00%
End 2029	20,222	20,203	99.94%
End 2032	20,193	20,145	99.81%
End 2037	20,189	20,114	99.70%
End 2047	20,115	20,026	99.63%
End 2052	19,976	19,887	99.63%

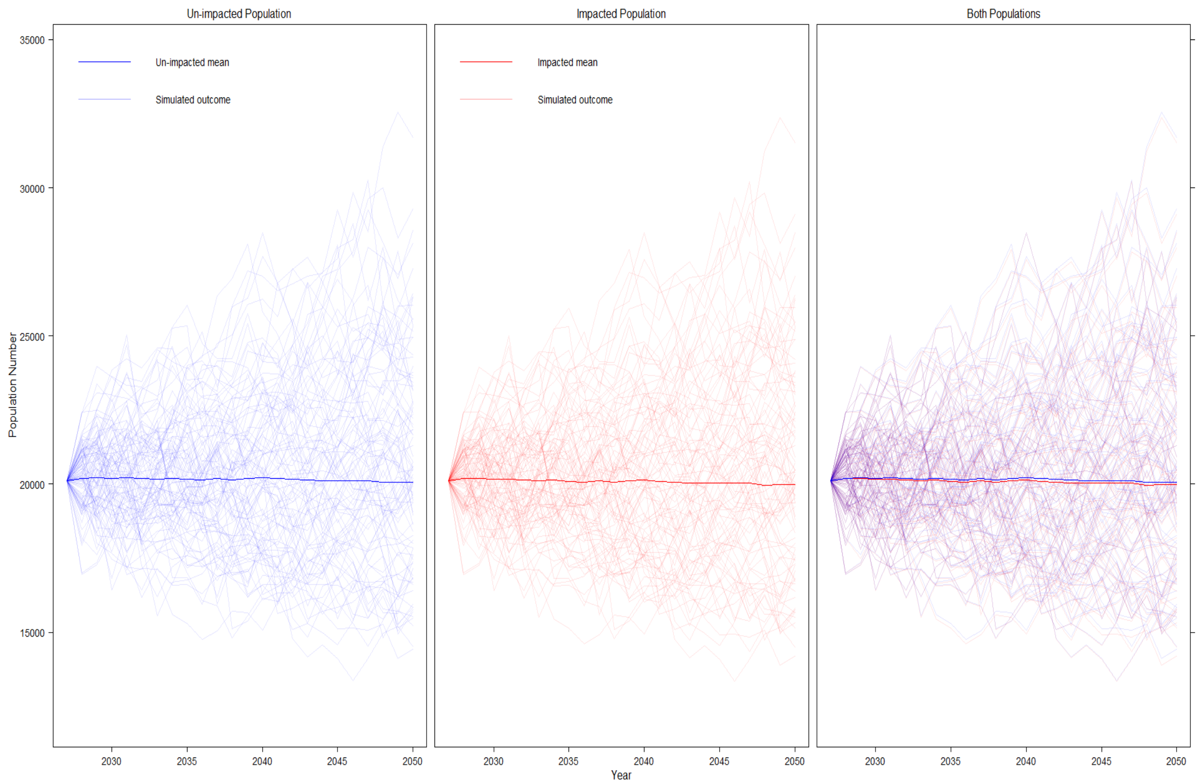

Plate 11.4 Simulated worst-case minke whale population sizes for both the un-impacted and the impacted populations

Grey seal

11.344 Assuming a worst-case of 196 disturbed and 0.2 estimated animals with PTS on every piling day (**Table 11.37**), the iPCoD model estimated there to be no discernible impact to the grey seal population (**Plate 11.5** and **Table 11.41**).

11.345 The median population size was predicted to be 100% of the un-impacted population size at the end of 2028 (after the piling has completed). This lack of discernible effect on the impacted population was maintained until 2052, which was the end point of the modelling.

11.346 For grey seal, the magnitude of the potential impact was assessed as **negligible** for the combined and wider populations due to there being less than a 1% population level impact over both the first six years and 25-year modelled periods.

*Table 11.41 Results of the iPCoD modelling for the Project, giving the mean population size of the grey seal population (wider population (see **Section 11.5.9**) for years up to 2052 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	13,288	13,288	100.00%
End 2028	13,388	13,388	100.00%
End 2029	13,443	13,444	100.00%
End 2032	13,735	13,736	100.00%
End 2037	14,202	14,203	100.00%
End 2047	15,116	15,118	100.00%
End 2052	15,583	15,585	100.00%

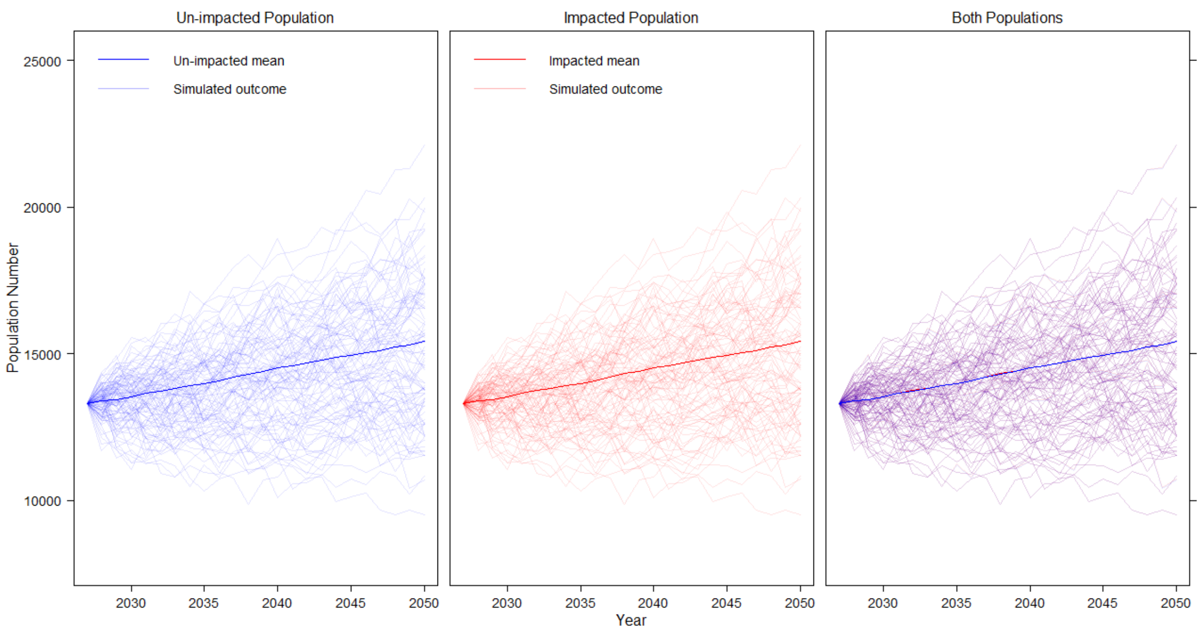

Plate 11.5 Simulated worst-case grey seal population sizes for both the un-impacted and the impacted populations

11.347 In addition to the wider population, the model was also run for the smaller 'combined population' (NW England MU and IoM population, see **Section 11.5.9**), again assuming a worst-case of 196 disturbed and 0.2 estimated animals with PTS on every piling day (**Plate 11.6** and **Table 11.42**).

11.348 Once again, no discernible effect to the combined population was predicted.

Table 11.42 Results of the iPCoD modelling for the Project, giving the mean population size of the grey seal combined population (NW England MU and IoM population) for years up to 2052 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	1,592	1,592	100.00%
End 2028	1,605	1,605	100.00%
End 2029	1,617	1,617	100.00%
End 2032	1,650	1,649	100.00%
End 2037	1,701	1,701	100.00%
End 2047	1,814	1,814	100.00%
End 2052	1,876	1,876	100.00%

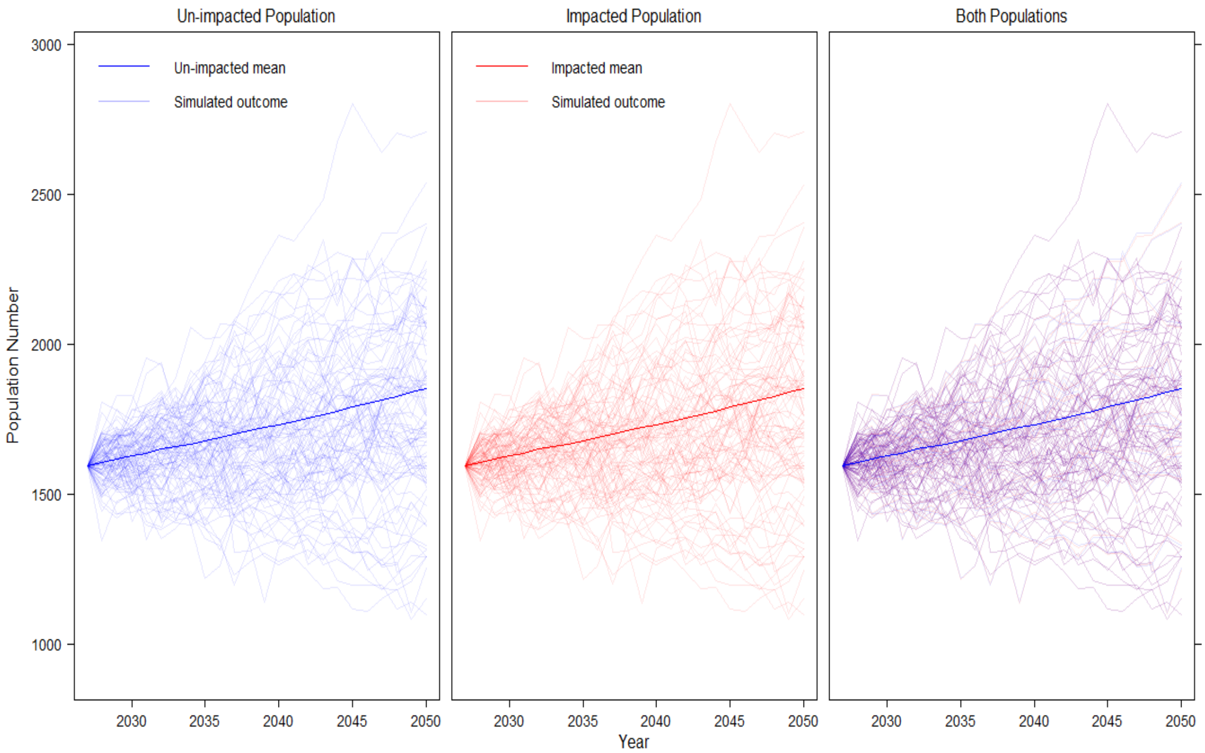

Plate 11.6 Simulated worst-case grey seal population sizes for both the un-impacted and the impacted populations

Harbour seal

11.349 Assuming a worst-case of 0.216 disturbed and 0.00002 estimated animals with PTS on every piling day (**Table 11.37**), the iPCoD model estimated there to be only the slightest discernible impact to the harbour seal population (**Plate 11.7** and **Table 11.43**).

11.350 The median population size was predicted to be 100% of the un-impacted population size at the end of 2028 (after the piling has completed). This lack of discernible effect on the impacted population was maintained until 2052, which was the end point of the modelling.

11.351 For harbour seal, the magnitude of the potential impact was assessed as **negligible** for wider populations due to there being less than a 1% population level impact over both the first six years and 25-year modelled periods.

Table 11.43 Results of the iPCoD modelling for the Project, giving the mean population size of the harbour seal population (NW England MU and NI MU) for years up to 2052 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	1,412	1,412	100.00%
End 2028	1,413	1,413	100.00%
End 2029	1,413	1,413	100.00%
End 2032	1,417	1,417	100.00%
End 2037	1,425	1,425	100.00%
End 2047	1,428	1,428	100.00%
End 2052	1,426	1,426	100.00%

Plate 11.7 Simulated worst-case harbour seal population sizes for both the un-impacted and the impacted populations

11.352 In addition to the wider population, the model was also run for the smaller NW England MU (7 individuals), again assuming a worst-case of 0.216 disturbed and 0.00002 estimated animals with PTS on every piling day (**Table 11.37**). For this modelling the resulting figure was rendered uninformative due to the number of errors and population crashes during the modelling.

11.353 Once again, the model showed no discernible effect from piling on the population. The model has a built-in environmental and demographic stochasticity, allowing the simulation of numerous dynamic processes, where deaths and births may fluctuate annually. Consequently, even if two populations with identical parameters undergo the same environmental conditions, they will follow slightly different trajectories over time. Irrespective of whether the population was affected by piling or not, the model predicted extinction of the population in the majority of cases. As described in **Section 11.5.8**, considering that there are no known harbour seal haul-out sites, the seven harbour seal are unlikely to be an isolated population in the NW England MU, but are most likely connected to other populations of the wider region of the Irish Sea. Thus, using the assessment including the wider reference population is much more appropriate.

Table 11.44 Results of the iPCoD modelling for the Project, giving the mean population size of the harbour seal population (North West MU) for years up to 2052 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	4	100.00%
End 2028	3	3	100.00%
End 2029	3	3	100.00%
End 2032	3	3	100.00%
End 2037	3	3	100.00%
End 2047	3	3	100.00%
End 2052	3	3	100.00%

Summary of magnitude of population level consequences due to disturbance

11.354 For all species assessed, the modelled impact of piling from the Project fell below the threshold of a 1% annual decline in population that would be considered significant. The greatest impact magnitude occurred for minke whale, with a predicted 0.37% decline in population size over a 25-year period, which fell well below a 1% annual decline in population size. The population consequences of disturbance were therefore assessed as **negligible** for all species assessed.

Significance of effect

11.355 A summary of the assessment of significance of effect for disturbance of marine mammals from underwater noise during piling and ADD activation is set out in **Table 11.45**, including assigned magnitude and sensitivity ratings.

11.356 Taking into account the sensitivity, and the potential negligible magnitude of the temporary impact, the significance of effect based on the iPCoD modelling for harbour porpoise, bottlenose dolphin and minke whale was assessed as **minor adverse** (not significant in EIA terms), and **negligible adverse** (not significant in EIA terms) for both seal species. The significance of effect based on the dose-response curves for common dolphin, Risso's dolphin, and white-beaked dolphin have been assessed as **negligible adverse** (not significant in EIA terms) (**Table 11.45**).

11.357 Disturbance during ADD activation had a potential magnitude of the temporary impact (e.g. number of individuals as a percentage of the reference population) assessed as negligible for all scoped in species except grey seal, that was assessed as having a low magnitude (**Table 11.45**). Consequently, the significance of effect for disturbance during ADD activation, has been assessed as **negligible** or **minor adverse** (not significant in EIA terms) for marine mammal receptor species (**Table 11.45**).

11.358 The assessment of significance of effect for disturbance takes into account the duration of active piling for the Project, plus time before and after active piling, during which marine mammals could be disturbed.

11.359 The results of the population modelling have shown that there would be no effect at the population level for any of the modelled species. No mitigation for disturbance is therefore currently proposed (or required) for piling at the Project.

Residual significance of effect

11.360 No additional mitigation is required or proposed. The residual significance of effect of the potential disturbance at the Project to marine mammals, as a result of underwater noise during piling (including disturbance from ADD), would be **minor adverse** (not significant in EIA terms) for all species (**Table 11.45**).

Table 11.45 Assessment of significance of effect for disturbance of marine mammals from underwater noise during piling and ADD activation

Species/ receptor	Impact	Sensitivity	Magnitude	Significance of effect	Additional mitigation measures proposed	Residual effect
Harbour porpoise	Disturbance during ADD activation	Medium	Negligible	Not Significant (Minor adverse)	None required	Not Significant (Minor adverse)
	iPCoD modelling	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Bottlenose dolphin	Disturbance during ADD activation	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)
	iPCoD modelling	Low	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Common dolphin	Disturbance based on dose-response curve	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)
	Disturbance during ADD activation	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)
Risso's dolphin	Disturbance based on dose-response curve	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)
	Disturbance during ADD activation	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)

Species/ receptor	Impact	Sensitivity	Magnitude	Significance of effect	Additional mitigation measures proposed	Residual effect
White-beaked dolphin	Disturbance based on dose-response curve	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)
	Disturbance during ADD activation	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)
Minke whale	Disturbance during ADD activation	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	iPCoD modelling	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Grey seal	Disturbance during ADD activation	Low	Low (negligible)*	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	iPCoD modelling	Low	Negligible (negligible)*	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)
Harbour seal	Disturbance during ADD activation	Low	Negligible (negligible)*	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)
	iPCoD modelling	Low	Negligible (negligible)*	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)

* Magnitude in brackets is for the wider reference population for grey seals (incl. Wales, SW Scotland, NI and RoI) and harbour seal (incl. NI)

11.6.3.3 Impact 3: TTS and disturbance from underwater noise during other construction activities

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

11.362 The cable installation methods that are currently being considered include ploughing and trenching (via jetting or mechanical cutting), in addition to surface laid, with cable protection, where burial is not possible.

11.363 Dredging/seabed preparation and cable installation activities have the potential to generate underwater noise at sound levels and frequencies, and for sufficient durations, to disturb marine mammals.

11.364 There are no clear indications that underwater noise, caused by the installation of sub-sea cables, poses a high risk of harming marine mammals (Oslo and Paris Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR), 2009). However, behavioural responses of marine mammals to dredging, an activity emitting comparatively higher underwater noise levels, are predicted to be similar to those during cable installation (OSPAR, 2009).

11.365 The noise levels produced during dredging and cable installation activities can vary, for example, with dredger type, cable installation method, as well as environmental conditions, including sediment type, water depth, salinity and thermoclines, and ambient noise levels (Jones and Marten, 2016; Robinson *et al*., 2011; Theobald *et al*., 2011). These factors influence the distance at which sounds can be detected.

11.366 Reviews of published sources of underwater noise during dredging activity and cable installation activities (e.g., Thomsen *et al*., 2006; Theobald *et al*., 2011; Todd *et al*., 2014), indicated that the sound levels that marine mammals may be exposed to are typically below auditory injury thresholds (PTS) exposure criteria (as defined in Southall *et al*., 2019). Therefore, the potential risk of any auditory injury in marine mammals due to dredging activity is highly unlikely.

11.367 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 (<1km), which is highly unlikely (Todd *et al*., 2014).

11.368 Underwater noise as a result of dredging and cable installation activities has the potential to disturb or result in behavioural responses in marine mammals (Pirotta *et al*., 2013; Todd *et al*., 2014; Southall *et al*., 2007).

11.369 If the response to underwater noise from other construction activities is displacement from the area, it is predicted that marine mammals would return once the activity has been completed and, therefore, any impacts from underwater noise due to construction activities other than piling, would be both localised and temporary.

11.370 To conduct a quantitative assessment of disturbance, displacement as a metric of disturbance was used to present worst-case behavioural scenario for marine mammals. However, other behavioural responses occur that do not involve moving away from an area but are observations and not quantifiable. These include changes in breathing pattern and diving behaviour, cessation of echolocation, or alterations in typical foraging behaviour.

11.371 These non-quantifiable responses depend on individual factors, such as the hearing sensitivity, habituation through past exposure, noise tolerance and demographic factors, as well as external factors that influence the response, such as the environmental conditions that influences the sound transmission, the proximity to the sound source and whether the source is moving or stationary (Wartzok *et al*., 2003).

11.372 There is limited data on the potential for a behavioural response or disturbance from other construction activities (or other continuous noise sources), but a few studies provide relevant evidence. For example, the results of tagged harbour seal in the Wash in 2012 (Russell, 2016) indicated foraging activity during windfarm construction activities at Sheringham Shoal and found that there was no significant displacement during construction.

11.373 Southall *et al*. (2007) presented a summary review of behavioural response studies in marine mammals from various sources, according to behavioural severity scores. The severity response scale ranges from score 0, where no behavioural response is observed, to nine, in which the animal avoids the area. The observed corresponding behaviours were further separated into free-ranging and laboratory subjects, but responses were overlapping in similarity. 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 related to a study involving migrating grey whales, a species commonly found along the Pacific coast.

11.374 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 to much higher received levels of up to 140dB re 1 μPa (RMS).

11.375 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 up to

172dB re 1 µPa @ 1m (RMS), compared to a source level of 168dB re 1 µPa@ 1m (RMS) for a large vessel (**Appendix 11.1**)).

11.376 Studies undertaken during the construction of two Scottish windfarms (Beatrice OWF and Moray East OWF) (Benhemma-Le Gall *et al*., 2021), found that there was a reduction in porpoise presence detected at up to 12km from pile driving, and up to 4km from construction activities. With construction activities 2km from Cetacean Porpoise Detectors (CPOD) locations, harbour porpoise activity decreased by up to 35.2%; with construction activities 3km from the CPODs, there was a decrease of up to 24%. At 4km from construction activities, there was an increase of harbour porpoise detection of 7.2%. This implies that harbour porpoise activity decreases within a 4km radius from the distance to the activity. At the time of the detections, there were multiple construction activities being undertaken with a variety of support vessels present.

11.377 Outside of the piling period, the study found that the presence of harbour porpoise decreased by 17%, with SPLs of 57dB (above ambient noise). While the study did not define which activities were taking place to cause the disturbance, the study occurred whilst a number of construction vessels were on site (Benhemma-Le Gall *et al*., 2021). Therefore, the reported 4km distance in which harbour porpoise detections decreased, has been used as a conservative potential disturbance range for other construction activities in this assessment.

Underwater noise modelling

11.378 To determine the potential risk for PTS and TTS from underwater noise during dredging, trenching, cable laying and rock placement, site specific underwater noise modelling was undertaken.

11.379 The underwater noise propagation modelling was undertaken using a simple modelling approach, using measured sound source data, scaled to relevant parameters for the Project (see **Appendix 11.1** for further information). The activities and source levels assessed were:

- Dredging: seabed preparation. Suction dredger has been assumed as a worst-case (estimated sound source of 186dB re 1µPs @1m (RMS))
- Trenching: plough trenching may be required during cable installation (estimated sound source of 172dB re 1µPs @1m (RMS))
- Cable laying: noise from the cable laying vessel and any other associated activities during the offshore cable installation (estimated sound source of 171dB re 1µPs @1m (RMS))

- Rock placement: potentially required for cable crossings, cable protection and scour protection around foundation structures (estimated sound source of 172dB re 1µPs @1m (RMS))

11.380 For SEL_{cum} calculations, the duration of the noise was also considered, with all sources operating for a worst-case of 24-hours in a day, for non-impulsive noise.

11.381 To account for the weightings required for modelling using the Southall *et al*. (2019) criteria, reductions in source level were applied to the various noise sources (see **Appendix 11.1** for further information).

11.382 The cumulative impact ranges were modelled to the nearest 100m; however, the ranges are likely to be less than 100m, especially for PTS. It should be noted that the predicted impact ranges are the distances which represent the minimum exposure that could potentially lead to an effect. In most hearing groups, the noise levels were low enough that there is negligible risk.

11.383 The results of the underwater noise modelling (**Table 11.46**) indicated that any marine mammal would have to be less than 100m (precautionary maximum range) from the continuous noise source for 24 hours, to be exposed to noise levels that could induce PTS or TTS, with the exception of harbour porpoise for which the predicted impact ranges for TTS was 0.99km for rock placement and 0.23km for dredging, based on the Southall *et al*. (2019) non-impulsive thresholds and criteria for SEL_{cum} (**Table 11.20**).

11.384 For SEL_{cum} calculations, the duration the noise is present also needs to be considered, with all sources assumed to operate constantly for 24 hours to give a worst-case assessment of the noise. It is important to note that PTS is unlikely to occur in marine mammals, as the modelling indicated that the marine mammal at the onset of the works would have to be within less than 100m for any potential risk of PTS (**Appendix 11.1**). It is unlikely that any one activity would be undertaken for 24 hours straight so the range calculated is conservative. Therefore, PTS as a result of construction activities other than piling is highly unlikely and has not been assessed further.

11.385 As a precautionary approach, the potential impact area for all activities occurring at the same time has also been determined (**Table 11.46**).

Table 11.46 Predicted impact ranges (and areas) for TTS from 24-hour cumulative exposure during other construction activities

Species	**Impact**	**Criteria and threshold (Southall *et al*., 2019)**	**Cable laying**	**Dredging**	**Trenching**	**Rock placement**	**All activities**
Harbour porpoise (VHF)	TTS	SEL_{cum} Weighted (153 dB re 1 µPa^{2}s) Non-impulsive	<0.1km (<0.03km^2)	0.23km (0.17km^2)	<0.1km (<0.03km^2)	0.99km (3.08km^2)	3.31km^2
Dolphin species (HF)	TTS	SEL_{cum} Weighted (178 dB re 1 µPa^{2}s) Non-impulsive	<0.1km (<0.03km^2)	<0.1km (<0.03km^2)	<0.1km (<0.03km^2)	<0.1km (<0.03km^2)	0.12km^2
Minke whale (LF)	TTS	SEL_{cum} Weighted (179 dB re 1 µPa^{2}s) Non-impulsive	<0.1km (<0.03km^2)	<0.1km (<0.03km^2)	<0.1km (<0.03km^2)	<0.1km (<0.03km^2)	0.12km^2
Grey and Harbour seal (PCW)	TTS	SEL_{cum} Weighted (181 dB re 1 µPa^{2}s) Non-impulsive	<0.1km (<0.03km^2)	<0.1km (<0.03km^2)	<0.1km (<0.03km^2)	<0.1km (<0.03km^2)	0.12km^2

Sensitivity

11.386 The sensitivity of marine mammals to temporary changes in hearing sensitivity (TTS) as a result of underwater noise during construction activities (other than piling and vessels) was considered to be **medium** in this assessment, as a precautionary approach (see **Section 11.6.2**).

11.387 For disturbance, harbour porpoise and minke whale had a **medium** sensitivity, while all other species were considered **low** sensitivity (**Table 11.8**). Marine mammals within the potential disturbance area were considered to have the 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 or the presence of vessels.

Magnitude

TTS

11.388 The number of marine mammals that could be impacted, as a result of underwater noise during construction activities, other than piling, has been assessed based on the number of animals that could be present in each of the modelled impact ranges (**Table 11.46**).

11.389 There is unlikely to be any significant risk of any TTS, as marine mammals would have to be within less than 100m of the activity at the onset to cause an effect. The exception is for harbour porpoise, which would have to remain within 1km during rock placement or 230m or less during dredging to be at risk of TTS (**Table 11.46**).

11.390 The magnitude of the potential impact for any TTS as a result of non-piling construction activities, for each activity individually or all together, was **negligible** for all species, with less than 1% of the reference populations exposed to any temporary impact (**Table 11.47**).

11.391 The potential for TTS effects that could result from underwater noise during other construction activities would be temporary in nature, not consistent throughout the Project offshore construction period and would be limited to only part of the overall construction period and area at any one time.

Table 11.47 Maximum number of individuals (and % of reference population) that could be at risk of TTS as a result of underwater noise associated with other (non-piling) construction activities at the Project

Species	Potential Impact	Maximum number of individuals (% of reference population) for each individual activity	Maximum number of individuals (% of reference population) for all four activities	Magnitude (temporary effect)
Harbour porpoise	TTS from cumulative SEL, based on 24-hour exposure for: ▪ Cable laying ▪ Trenching	0.05 (0.00008% of CIS MU)	5.4 (0.009% of CIS MU)	Negligible
	TTS from cumulative SEL, based on 24-hour exposure for: Dredging	0.3 (0.0004% of CIS MU)		
	TTS from cumulative SEL, based on 24-hour exposure for: Rock placement	5 (0.008% of CIS MU)		
Bottlenose dolphin	TTS from cumulative SEL, based on 24-hour exposure for: ▪ Cable laying ▪ Dredging ▪ Trenching ▪ Rock placement	0.0003 (0.0001% of IS MU)	0.001 (0.0004% of IS MU)	Negligible
Common dolphin		0.001 (0.000001% of CGNS MU)	0.003 (0.00000002% of CGNS MU)	Negligible
Risso's dolphin		0.00002 (0.0000002% of CGNS MU)	0.000004 (0.000003% of CGNS MU)	Negligible
White-beaked dolphin		0.0002 (0.0000005% of CGNS MU)	0.001 (0.000002% of CGNS MU)	Negligible

Species	Potential Impact	Maximum number of individuals (% of reference population) for each individual activity	Maximum number of individuals (% of reference population) for all four activities	Magnitude (temporary effect)
Minke whale		0.0003 (0.000001% of CGNS MU)	0.001 (0.000005% of CGNS MU)	Negligible
Grey seal		0.003 (0.0002% of combined MUs; or 0.00002% of wider ref pop)	0.01 (0.001% of combined MUs; or 0.0001% of wider ref pop)	Negligible (negligible)*
Harbour seal		0.000003 (0.0000005% of the NW MU; or 0.0000002% of wider ref pop)	0.00001 (0.0002% of the NW MU; or 0.000001% of wider ref pop)	Negligible (negligible)*

* Magnitude in brackets is for the wider reference population for grey seals (incl. Wales, SW Scotland, NI and RoI) and harbour seal (incl. NI)

Disturbance

11.392 As outlined above, the following assessments were based on the precautionary approach of 4km disturbance distance for construction activities and vessels that could be on site during the construction period (Benhemma-Le Gall *et al*., 2021).

11.393 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 (**Table 11.48**).

11.394 As a precautionary approach, the potential disturbance from two activities occurring at the same time was also assessed, based on a maximum impact area of 100.54km^2 (**Table 11.48**). This was considered a conservative impact range as the original 4km disturbance range was based on multiple activities and vessels ongoing at any one given time.

11.395 All related construction activities were considered to be moving sources, and therefore, once the activity/vessel moved past a certain area, the marine mammals would return to the area.

11.396 The magnitude of the potential impact was assessed as **negligible** for all species for individual activities and two activities together (**Table 11.48**).

Table 11.48 Maximum number of individuals (and % of reference population) that could be disturbed as a result of underwater noise associated with other (non-piling) construction activities at the Project

Species	Maximum number of individuals (% of reference population) that could be disturbed for one activity (50.27km^2)	Maximum number of individuals (% of reference population) that could be disturbed for two activities (100.54km^2)	Magnitude (temporary effect)
Harbour porpoise	82.0 (0.13% of CIS MU)	163.0 (0.3% of CIS MU)	Negligible
Bottlenose dolphin	0.5 (0.2% of IS MU)	1.0 (0.4% of IS MU)	Negligible
Common dolphin	1.4 (0.001% of CGNS MU)	2.8 (0.003% of CGNS MU)	Negligible
Risso's dolphin	0.03 (0.0002% of CGNS MU)	0.06 (0.0005% of CGNS MU)	Negligible
White-beaked dolphin	0.4 (0.0008% of CGNS MU)	0.7 (0.002% of CGNS MU)	Negligible
Minke whale	0.4 (0.002% of CGNS MU)	0.9 (0.004% of CGNS MU)	Negligible

Species	Maximum number of individuals (% of reference population) that could be disturbed for one activity (50.27km²)	Maximum number of individuals (% of reference population) that could be disturbed for two activities (100.54km²)	Magnitude (temporary effect)
Grey seal	5 (0.32% of combined MUs; or 0.04% of wider ref pop)	10.1 (0.6% of combined MUs; or 0.08% of wider ref pop)	Negligible (negligible)*
Harbour seal	0.006 (0.08% of NW MU; or 0.0004% of wider ref pop	0.01 (0.16% of NW MU; or 0.0008% of wider ref pop	Negligible (negligible)*

* Magnitude in brackets is for the wider reference population for grey seals (incl. Wales, SW Scotland, NI and RoI) and harbour seal (incl. NI)

Duration

11.397 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.

11.398 The maximum duration for the offshore construction period, including piling, is up to two and a half years (**Table 11.1**). However, construction activities would not be underway constantly throughout this period.

Significance of effect

11.399 Taking into account the medium marine mammal sensitivity to TTS (**Table 11.8**), and the potential negligible magnitude of the impact, as assessed in **Table 11.47**, the significance of effect for TTS from underwater noise during construction activities (other than piling) at the Project, has been assessed as **minor adverse** (not significant in EIA terms) for all species (**Table 11.47**).

11.400 Disturbance from all other noisy activity assessed in this section would have a **minor adverse** effect (not significant in EIA terms) on harbour porpoise and minke whale with a medium sensitivity, whilst all other species were assessed to have a **negligible adverse** effect (not significant in EIA terms) (**Table 11.48**).

Residual significance of effect

11.401 No additional mitigation is required or proposed. Therefore, the residual significance of effect for TTS or disturbance from underwater noise during construction activities (other than piling) at the Project, would be **negligible** or **minor adverse** (not significant in EIA terms) for all species (**Table 11.49**).

Table 11.49 Assessment of significance of effect for TTS and disturbance from underwater noise during construction activities other than piling

Potential impact	Species/receptor	Sensitivity	Magnitude	Significance of effect	Additional mitigation measures proposed	Residual effect
TTS from cumulative SEL during all construction activities (other than piling)	Harbour porpoise	Medium	Negligible	Not Significant (Minor adverse)	No mitigation required	Not Significant (Minor adverse)
	Bottlenose dolphin	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Common dolphin	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Risso's dolphin	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	White-beaked dolphin	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Minke whale	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Grey seal	Medium	Negligible (negligible)*	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Harbour seal	Medium	Negligible (negligible)*	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Disturbance during all construction activities	Harbour porpoise	Medium	Negligible	Not Significant (Minor adverse)	No mitigation required	Not Significant (Minor adverse)
	Bottlenose dolphin	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)

Potential impact	Species/receptor	Sensitivity	Magnitude	Significance of effect	Additional mitigation measures proposed	Residual effect
(other than piling)	Common dolphin	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)
	Risso's dolphin	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)
	White-beaked dolphin	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)
	Minke whale	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Grey seal	Low	Negligible (negligible)*	Not Significant (Negligible adverse)		Not Significant (Minor adverse)
	Harbour seal	Low	Negligible (negligible)*	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)

* Magnitude in brackets is for the wider reference population for grey seals (incl. Wales, SW Scotland, NI and RoI) and harbour seal (incl. NI)

11.6.3.4 Impact 4: TTS and disturbance from underwater noise due to presence of vessels

11.402 During the construction phase, vessels onsite would generally be associated with piling and other construction activities, as assessed in **Sections 11.6.3.2** and **11.6.3.3** respectively. As a precautionary approach, and to take into account of vessels that could be in the windfarm site when these activities are not being conducted, the potential for TTS and disturbance from underwater noise due to the presence of vessels has been assessed separately.

11.403 Vessel movements to and from any port would be incorporated within existing vessel routes as far as possible, the assessment therefore focussed on considering the increase in disturbance, as a result of underwater noise from construction vessels which would be within the windfarm site.

11.404 There would be an increase in the number of vessels in the windfarm site during the construction phase. The maximum number of vessels that could be within the windfarm site, at any one time, has been estimated to be 37 vessels. The number, type and size of vessels would vary, depending on the activities taking place, at any one time.

11.405 As outlined in **Chapter 14 Shipping and Navigation**, on average there were 127 transits each month during 2019, and 91 transits each month during 2022 that intersected the windfarm site. On average, the study area (defined in **Chapter 14 Shipping and Navigation**) experienced approximately 1,308 transits per month in 2019 and 842 transits per month in 2022.

11.406 The vessels in the windfarm site would be slow moving (or stationary), and, therefore, 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 PTS in marine mammals as a result of vessel noise is highly unlikely, as the sound levels are well below the threshold for PTS (Southall *et al*., 2019).

11.407 A study of the noise source levels from several different vessels (Jones *et al*., 2017) indicated 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). These levels could be sufficient enough to cause local disturbance to marine mammals in the immediate vicinity of the vessel, depending on ambient noise levels. Trigg *et al*. (2020) found the predicted exposure of grey seals to shipping noise did not exceed thresholds for TTS.

11.408 Thomsen *et al*. (2006) reviewed the effects of ship noise on harbour porpoise and seal species. The review 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.

Underwater noise modelling

11.409 To determine the potential risk for PTS and TTS from vessel underwater noise, underwater noise modelling was undertaken (**Appendix 11.1**).

11.410 The underwater noise propagation modelling was undertaken using a simple modelling approach, using measured sound source data, scaled to relevant parameters for the Project (see **Appendix 11.1** for further information).

11.411 The size of vessels and source levels assessed were:

- Large vessels: more than 100m in length. Vessel speed assumed as 10 knots (estimated sound source of 168dB re 1µPs @1m (RMS))
- Medium vessels: less than 100m in length. Vessel speed assumed as 10 knots (estimated sound source of 161dB re 1µPs @1m (RMS))

11.412 To account for the weightings required for modelling using the Southall *et al*. (2019) criteria, reductions in source level were applied to the various noise sources (**Appendix 11.1**).

11.413 Cumulative impact ranges were modelled to the nearest 100m; however, ranges are likely to be less than 100m. It should be noted that the predicted impact ranges are the distances which represent the minimum exposure that could potentially lead to an effect. In most hearing groups, the noise levels are low enough that there is negligible risk.

11.414 PTS and TTS impact ranges for both large and medium vessels, for all species, were less than 100m (**Appendix 11.1**). Results and assessments were based on risk of TTS.

11.415 As a precautionary approach, the potential impact area for all vessels on site at the same time, has been determined for each species hearing group (**Table 11.50**).

Table 11.50 Predicted impact ranges (and areas) for TTS from 24-hour cumulative exposure for construction vessels

Species	Criteria and threshold (Southall *et al.*, 2019)	Large vessel	Medium vessels	Up to 37 vessels
Harbour porpoise (VHF)	SEL_{cum} Weighted (153 dB re 1 µPa²s) Non-impulsive	<0.1km (<0.03km²)	<0.1km (<0.03km²)	1.16km²
Dolphin species (HF)	SEL_{cum} Weighted (178 dB re 1 µPa²s) Non-impulsive	<0.1km (<0.03km²)	<0.1km (<0.03km²)	1.16km²
Minke whale (LF)	SEL_{cum} Weighted (179 dB re 1 µPa²s) Non-impulsive	<0.1km (<0.03km²)	<0.1km (<0.03km²)	1.16km²
Grey and Harbour seal (PCW)	SEL_{cum} Weighted (181 dB re 1 µPa²s) Non-impulsive	<0.1km (<0.03km²)	<0.1km (<0.03km²)	1.16km²

Sensitivity

11.416 As a precautionary approach, the sensitivity of marine mammals to temporary changes in hearing sensitivity (TTS) as a result of underwater noise from construction vessels, was considered to be **medium** (see **Section 11.6.2**).

11.417 For disturbance effects, harbour porpoise and minke whale were considered **medium** sensitivity, while all other species were considered **low** sensitivity (**Table 11.8**). Marine mammals within the potential disturbance area were considered to have the 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 noise had ceased, or they had become habituated to the sound.

Magnitude

TTS

11.418 The number of marine mammals that could be impacted as a result of underwater noise from construction vessels has been assessed based on the number of animals that could be present in each of the modelled impact ranges (**Table 11.50**).

11.419 SELs have been estimated for vessels based on 24 hours continuous operation, although it is important to note that it is highly unlikely that any marine mammal would stay at a stationary location or within a fixed radius of a vessel for 24hours. It is also important to note that PTS is unlikely to occur in marine mammals, as the modelling indicates that the marine mammal would only be exposed to any potential risk of PTS within less than 100m of the vessel (**Appendix 11.1**). Therefore, PTS due to vessel activity is highly unlikely and has not been assessed further.

11.420 There is also unlikely to be any significant risk of any TTS, as the modelling also indicated that a marine mammal would have to be within less than 100m of vessels based on 24-hours of activity (**Table 11.50**). Although TTS due to construction vessel noise is highly unlikely, it has been assessed as a precautionary approach.

11.421 The magnitude of the potential impact for any TTS (considering up to 37 vessels within the windfarm site) was **negligible** for all marine mammal receptors, with less than 1% of the reference populations exposed to any temporary impact (**Table 11.51**).

11.422 The potential for TTS effects that could result from construction vessel underwater noise 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.

Table 11.51 Maximum number of individuals (and % of reference population) that could be at risk of TTS as a result of underwater noise associated with construction vessels at the Project

Species	Maximum number of individuals (% of reference population) for one vessel	Maximum number of individuals (% of reference population) for up to 37 vessels	Magnitude (temporary effect)
Harbour porpoise	0.05 (0.0001% of CIS MU)	2 (0.003% of CIS MU)	Negligible
Bottlenose dolphin	0.0003 (0.0001% of IS MU)	0.01 (0.004% of IS MU)	Negligible
Common dolphin	0.001 (0.000001%of CGNS MU)	0.03 (0.00003% of CGNS MU)	Negligible
Risso's dolphin	0.00002 (0.0000002% of CGNS MU)	0.0007 (0.000006% of CGNS MU)	Negligible
White-beaked dolphin	0.0002 (0.0000005% of CGNS MU)	0.01 (0.00002% of CGNS MU)	Negligible
Minke whale	0.0003 (0.000001% of CGNS MU)	0.01 (0.00005% of CGNS MU)	Negligible
Grey seal	0.003 (0.0002% of combined MUs; or 0.00002% of wider ref pop)	0.1 (0.01% of combined MUs; or 0.001% of wider ref pop)	Negligible (negligible)*

Species	Maximum number of individuals (% of reference population) for one vessel	Maximum number of individuals (% of reference population) for up to 37 vessels	Magnitude (temporary effect)
Harbour seal	0.000003 (0.00005% of NW MU; or 0.0000002% of wider ref pop	0.0001 (0.002% of NW MU; or 0.00001% of wider ref pop	Negligible (negligible)*

* Magnitude in brackets is for the wider reference population for grey seals (incl. Wales, SW Scotland, NI and RoI) and harbour seal (incl. NI)

Disturbance

11.423 As previously outlined, 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 due to increased construction related activities and vessels. Similarly, studies in the Moray Firth during piling of the Beatrice OWF, indicated higher vessel activity within 1km was associated with an increased probability of response in harbour porpoise (Graham *et al*., 2019).

11.424 Studies in the Moray Firth indicated 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).

11.425 During the periods when piling and other construction activities are underway, vessel noise is unlikely to add an additional impact, as the vessels and vessel noise would be within the maximum impact areas assessed.

11.426 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 (more details in **Appendix 11.2,** Section 8).

11.427 Vessel type and speed, rather than their presence, seemed to be the relevant factors for the reactions of harbour porpoise to vessel traffic in the coastal waters of SW Wales (Oakley *et al*., 2017). There was a significant correlation between numbers of vessels and number of harbour porpoise sightings. During 729 hours of survey effort (268 total surveys), there were 39 occasions when porpoise exhibited neutral or negative behaviour to vessels, with 75% of all negative reactions in response to high-speed, planing-hulled vessels (Oakley *et al*., 2017).

11.428 As outlined in **Appendix 11.2**, modelling by Heinänen and Skov (2015) indicated that the number of ships represents a relatively important factor in determining the density of harbour porpoise in the CIS in summer, with markedly lower densities with increasing levels of traffic. A threshold level, in terms of impact, seemed to be approximately 15,000 ships per year (approximately 50 vessels per day, within a 5km grid cell). This equates to 50 vessels per day in 25km^2 (approximately two vessels per km^2). Taking into account the maximum number of 37 vessels that could be in the windfarm site during construction at any one time, the number of vessels would not exceed the Heinänen and Skov (2015) threshold. For example, 37 vessels within the windfarm site area of 87km^2 would equate to less than 0.43 vessels per km^2.

11.429 As a precautionary approach, based on the studies by Brandt *et al*. (2018) and Benhemma-Le Gall *et al*. (2021) that indicated harbour porpoise could be disturbed up to 4km from construction vessels, assessments for all species have been based on a disturbance impact range of 4km (**Table 11.52**).

11.430 For the 37 construction vessels that could be in the windfarm site at any one time and considering the 4km disturbance range for each vessel, the total impact area of 1859.8km^2 was considered an unrealistic worst-case. This scenario did not consider the overlap in the 4km disturbance range between vessels and the area is approximately 21 times the size of the 87km^2 windfarm site alone.

11.431 **Plate 11.8** presents the scenario (for illustrative purpose only) which was considered a more representative worst-case for the assessment. This scenario assumes the 37 vessels are onsite and a 4km buffer was applied to the windfarm site boundary to allow for the 4km disturbance range. The resultant disturbance impact area, consisting of the windfarm site and the 4km buffer (285.4km^2), was considered sufficient to assess the impacts of onsite vessels during construction.

11.432 The assessment considered the impact of one vessel with a 4km disturbance buffer (50.27km^2), and the impact of 37 vessels within the windfarm site with the 4km site disturbance buffer (285.4km^2). Results are set out in **Table 11.52**.

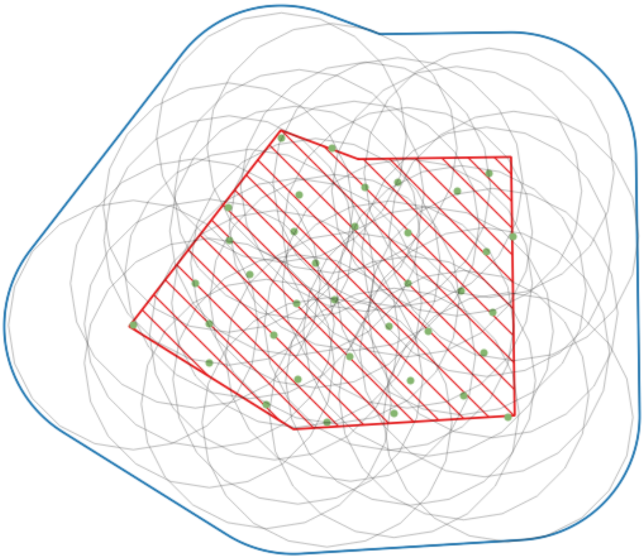

Plate 11.8 Project windfarm site (hatched in red), with 4km buffer (blue), and 37 vessels (green dots) and their 4km buffer (grey) randomly allocated within the site.

11.433 The magnitude of the potential impact of one vessel was assessed as **negligible** for all species. The magnitude of impact of 37 vessels operating within the windfarm site was assessed as **low** for bottlenose dolphin, **low (negligible)** for grey seals, and **negligible** for all remaining species (**Table 11.52**).

Table 11.52 Maximum number of individuals (and % of reference population) that could be disturbed as a result of underwater noise associated with construction vessels at the Project

Species	Maximum number of individuals (% of reference population) for one vessel (50.27km^2)	Magnitude (temporary effect)	Maximum number of individuals (% of reference population) for revised site+4km buffer (285.4 km^2)	Magnitude (temporary effect)
Harbour porpoise	81.5 (0.13% of CIS MU)	Negligible	462.6 (0.74% of CIS MU)	Negligible
Bottlenose dolphin	0.5 (0.2% of IS MU)	Negligible	3 (1.0% of IS MU)	Low
Common dolphin	1.4 (0.001% of CGNS MU)	Negligible	8 (0.008% of CGNS MU)	Negligible
Risso's dolphin	0.03 (0.0002% of CGNS MU)	Negligible	0.2 (0.001% of CGNS MU)	Negligible
White-beaked dolphin	0.4 (0.0008% of CGNS MU)	Negligible	2.5 (0.005% of CGNS MU)	Negligible

Species	Maximum number of individuals (% of reference population) for one vessel (50.27km^2)	Magnitude (temporary effect)	Maximum number of individuals (% of reference population) for revised site+4km buffer (285.4 km^2)	Magnitude (temporary effect)
Minke whale	0.4 (0.002% of CGNS MU)	Negligible	2.5 (0.01% of CGNS MU)	Negligible
Grey seal	5 (0.32% of combined MUs; or 0.04% of wider ref pop)	Negligible	28.5 (1.8% of combined MUs; or 0.2% of wider ref pop)	Low (negligible)*
Harbour seal	0.006 (0.08% of NW MU; or 0.0004% of wider ref pop	Negligible	0.03 (0.4% of NW MU; or 0.002% of wider ref pop)	Negligible (negligible)*

* Magnitude in brackets is for the wider reference population for grey seals (incl. Wales, SW Scotland, NI and RoI) and harbour seal (incl. NI)

Significance of effect

11.434 Taking into account the medium marine mammal sensitivity to TTS and disturbance (**Table 11.8**), and the potential magnitude of the impact, as assessed in **Table 11.51** and **Table 11.52**, the significance of effect for TTS and disturbance from underwater noise of construction vessels at the Project has been assessed as **negligible** to **minor adverse** (not significant in EIA terms) for all species (see **Table 11.53**).

Residual significance of effect

11.435 No additional mitigation is required or proposed. Therefore, the residual significance of effect for TTS or disturbance from underwater noise of construction vessels at the Project would be **minor adverse** (not significant in EIA terms) for all species (**Table 11.53**).

11.436 It is noted that the best practice measures as outlined in **Section 11.3.3**, would reduce the potential disturbance from vessels.

Table 11.53 Assessment of significance of effect for TTS and disturbance from underwater noise of construction vessels

Potential impact	Species/receptor	Sensitivity	Magnitude	Significance of effect	Additional mitigation measures	Residual effect
TTS from cumulative SEL for all construction vessels	Harbour porpoise	Medium	Negligible	Not Significant (Minor adverse)	No additional mitigation is required. Best practice measures as outlined in **Section 11.3.3.**	Not Significant (Minor adverse)
	Bottlenose dolphin		Negligible			
	Common dolphin		Negligible			
	Risso's dolphin		Negligible			
	White-beaked dolphin		Negligible			
	Minke whale		Negligible			
	Grey seal		Negligible (negligible)*			
	Harbour seal		Negligible (negligible)*			
Disturbance from all construction vessels (maximum area of 285.4km^2)	Harbour porpoise	Medium	Negligible	Not Significant (Minor adverse)	No additional mitigation required. Best practice measures as outlined in **Section 11.3.3.**	Not Significant (Minor adverse)
	Bottlenose dolphin	Low	Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Common dolphin	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)
	Risso's dolphin	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)

Potential impact	Species/receptor	Sensitivity	Magnitude	Significance of effect	Additional mitigation measures	Residual effect
	White-beaked dolphin	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)
	Minke whale	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Grey seal	Low	Low (Negligible)*	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Harbour seal	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)

* Magnitude in brackets is for the wider reference population for grey seals (incl. Wales, SW Scotland, NI and RoI) and harbour seal (incl. NI)

11.6.3.5 Impact 5: Barrier effects caused by underwater noise

11.437 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 area and go around it.

11.438 The windfarm site is located approximately 30km from the nearest point on the coast and is not located on any known migration routes for marine mammals.

11.439 It was assessed that grey seals, particularly those close to the coast, might experience mild disturbance during piling activities. However, this disturbance is unlikely to create barrier effects which would prevent these animals from utilizing their foraging grounds along the coast. It is improbable that these animals would be completely excluded from coastal areas. Grey seals possess a vast foraging range, with reported ranges of up to 448 kilometres according to Carter *et al*., 2022. Hence, during piling activities, they could potentially move to alternative foraging grounds. It is important to note that these animals would likely avoid offshore areas where received noise levels surpass thresholds that cause strong disturbance. Additionally, there could be an associated energetic cost due to longer foraging trips, and alternative habitats might not offer optimal conditions in terms of the abundance of essential prey species.

11.440 The marine mammal species that could potentially be most affected by barrier effects from underwater noise are harbour porpoise accessing foraging areas, bottlenose dolphin, if they are moving between areas, and grey and harbour seal, as they move to and from haul-out sites.

Harbour porpoise

11.441 Harbour porpoise have relatively high daily energy demands and need to capture enough prey to meet these requirements. It has been estimated that, depending on the environmental conditions, harbour porpoise can rely on stored energy (primarily blubber) for three to five days, depending on body condition (Kastelein *et al*., 1997). Therefore, any barrier effect that could restrict harbour porpoise accessing foraging areas could have implications for individuals. As outlined in **Appendix 11.2**, the several studies that modelled harbour porpoise distribution in relation to environmental variables, have found that harbour porpoise densities are typically associated with the shallow waters of less than 80m water depths (water depths within the windfarm site range from 18m to 40m) and with areas of high eddy activity. Furthermore, higher abundances of harbour porpoises were found in areas where habitat was heterogenous with a degree of coarseness of sediments. These environmental features are underlying the presence of prey aggregation that this species favours.

11.442 In the Project windfarm site, there is predominantly muddy sand and sand, with finer sediment along the English north-west coast (as per assessment in **Chapter 9 Benthic Ecology**), indicating that harbour porpoise would not be predicted to be foraging there. However, the site-specific surveys (**Appendix 11.2**) show otherwise, with high numbers of harbour porpoise recorded utilising the area throughout the two survey years.

11.443 Taking into account that construction would not be underway constantly throughout the 2.5 year construction phase, harbour porpoise are unlikely to be restricted due to its wide range of prey species, and foraging ranges.

11.444 Temporary barrier effects as a result of construction phase underwater noise at the windfarm site are unlikely to restrict marine mammal species from accessing foraging areas.

Bottlenose dolphin

11.445 As outlined in **Section 11.5.2**, there is the potential for bottlenose dolphin to move between areas to the north and south of the windfarm site. However, as reflected in the distribution of bottlenose dolphin in the Irish and Celtic Seas, bottlenose dolphin have a predominantly coastal distribution (see **Appendix 11.2**). Bottlenose dolphin are a primarily inshore species, with most sightings within 10km of land. Studies of bottlenose dolphin off the east coast of Scotland found that the majority of sightings and movements were within 2km of the coastline, and in waters that are less than 30m deep (Quick *et al*., 2014).

11.446 Taking into account the movements of bottlenose dolphin along the coast, and that only two bottlenose dolphins were surveyed in two years, underwater noise at the windfarm site is unlikely to result in any barrier effects to bottlenose dolphin.

Seals

11.447 As outlined in **Section 11.5.8**, there are no significant harbour seal breeding or haul out sites in the NW England MU (SCOS, 2021).

11.448 As outlined in **Section 11.5.7**, the two main grey seal haul-out sites in the NW England MU were identified at West Hoyle Bank (often referred to as Hilbre Island, approximately 45km from the windfarm site); and at South Walney (approximately 30km from the windfarm site) (SCOS, 2021).

11.449 Taking into account the distance of the windfarm site from the coast and from grey seal haul-out sites, there is no potential for underwater noise (PTS or TTS ranges) at the windfarm site to result in a barrier to seals moving to and from the haul-out sites. Seals have a wide range of diet and are therefore not limited to specific areas where suitable prey could be found.

11.450 The maximum impact range for TTS (SEL_{cum}) was 15km from the location of piling providing a substantial area for foraging and transit between the windfarm site and the coast. Grey seals possess a vast foraging range, with reported ranges of up to 448km according to Carter *et al*. (2022). Hence, during piling activities, they could potentially move to alternative foraging grounds and the animals would likely avoid offshore areas where the received noise levels surpass thresholds that cause strong disturbance.

Sensitivity

11.451 In line with their sensitivity to disturbance from underwater noise, harbour porpoise and minke whale have been assessed as having a **medium** sensitivity, while all other marine mammals species were considered to have **low** sensitivity (**Table 11.16**) to barrier effects from underwater noise.

Magnitude

11.452 The maximum duration for the offshore construction period, including piling, is two and a half years (**Table 11.1**). However, construction activities would not be underway constantly throughout this period.

11.453 The maximum area for any potential barrier effects, due to underwater noise for the construction phase, would be during impact piling. The maximum predicted impact range for TTS from cumulative exposure (SEL_{cum}) during installation of monopile with maximum hammer energy of 6,600kJ, was modelled to be 27km for harbour porpoise and 34km for minke whale, based the on worst-case modelling without any additional mitigation (**Table 11.22**).

11.454 The most recent advice from the SNCBs was that the potential disturbance range (EDR) for harbour porpoise was 26km for monopiles (without noise abatement) and 15km for pin piles (with and without noise abatement) for designated SACs in England, Wales and NI (JNCC *et al*., 2020).

~~11.454~~11.455 The potential for barrier effects is acknowledged, however it should be noted, that the minimum TTS range was modelled to be 15km, and the maximum 34 km range does not extend uniformly in all directions from the SW modelling station. The noise contours (Figure 6.1 in Appendix 11.2 Marine Mammal Information and Survey Data)) show that the noise extends further westward from the SW corner of the Project, leaving a buffer zone between the coast and the Project on the eastern side.

~~11.455~~11.456 Taking into account the potential impact ranges during piling at the windfarm site, there would be no potential for any barrier effects between the windfarm site and the coast (30km) as a result of underwater noise during piling.

~~11.456~~11.457 As outlined in **Section 11.6.3.2**, piling would not be constant during the piling phases and construction period. There would be gaps between the installations of individual piles, and, if installed in groups, there would be time periods when piling would not be taking place due to supply vessel transit to and from the site. There are also likely to be potential breaks caused by weather or other technical issues. The estimated duration of active piling is up to 26 days (610 hours and 49 minutes) during the installation campaign for the WTGs and OSPs (**Table 11.35**).

~~11.457~~11.458 As outlined in **Sections 11.6.3.3** and **11.6.3.4**, the potential for underwater noise from other construction activities and vessels that could result in barrier effects would be temporary, 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.

~~11.458~~11.459 As a worst-case, a maximum of 37 vessels would within the windfarm site for prolonged periods of time, for which the vessel impact area was re-evaluated and assessed as 285.4km^2, as discussed in **Section 11.6.3.4.**

~~11.459~~11.460 If there were potential barrier effects across the windfarm site (87km^2 or 285km^2, with disturbance buffer for vessel noise), this is a small area in relation to the movements and foraging ranges of marine mammals in and around the area.

~~11.460~~11.461 As there is unlikely to be any significant long-term effects arising from any temporary underwater noise barrier effects, any areas affected would be relatively small in comparison to the range of marine mammals. Additionally, any effects would not be continuous throughout the offshore construction period. The magnitude of impact for any potential temporary barrier effects, based on the realistic worst-case disturbance area, was assessed as **negligible** for all species.

Significance of effect

~~11.461~~11.462 Considering the medium sensitivity for harbour porpoise and minke whale and the negligible potential impact magnitude, the significance of any potential barrier effects due to construction underwater noise, has been assessed as **minor adverse** (not significant in EIA terms).

~~11.462~~11.463 For all other species, considering the low marine mammal sensitivity and negligible impact magnitude, the significance of effect was assessed as **negligible adverse** (not significant in EIA terms) (**Table 11.54**).

Residual significance of effect

~~11.463~~11.464 No additional mitigation is required or proposed. Therefore, the residual significance of effect would be **minor adverse** (not significant in EIA terms) for harbour porpoise and minke whale, and **negligible adverse** (not significant in EIA terms) for all other species (**Table 11.54**).

Table 11.54 Assessment of significance of effect for any potential barrier effects due to underwater noise during construction

Species/receptor	Sensitivity	Magnitude	Significance of effect	Additional mitigation measures	Residual effect
Harbour porpoise	Medium	Negligible	Not Significant (Minor adverse)	None required	Not Significant (Minor adverse)
Bottlenose dolphin	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)
Common dolphin	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)
Risso's dolphin	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)
White-beaked dolphin	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)
Minke whale	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Grey seal	Low	Negligible (negligible)*	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)
Harbour seal	Low	Negligible (negligible)*	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)

* Magnitude in brackets is for the wider reference population for grey seals (incl. Wales, SW Scotland, NI and RoI) and harbour seal (incl. NI)

11.6.3.6 Impact 6: Increased collision risk with vessels during construction

11.46411.465 During the construction phase, there would be an increase in the number of vessels in the windfarm site. The maximum number of vessels that could be on the windfarm site at any one time has been estimated as 37 vessels (**Table 11.1**). The number, type and size of vessels would vary, depending on the activities taking place at any one time.

11.46511.466 Vessel movements to and from any port would be incorporated within existing vessel routes, wherever possible. Vessels in the windfarm site are likely to be stationary or slow moving, depending on the activity they are involved in.

11.46611.467 As outlined in **Chapter 14 Shipping and Navigation**, on average there were 127 transits each month during 2019, and 91 transits each month during 2022 that intersected the windfarm site. On average, the study area (defined in **Chapter 14 Shipping and Navigation**) experienced approximately 1,308 transits per month in 2019 and 842 transits per month in 2022.

11.46711.468 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 outwith recognised vessel routes, can pose an increased risk of vessel collision to marine mammals.

11.46811.469 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).

11.46911.470 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).

11.47011.471 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 Automatic Identification System (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).

~~11.471~~11.472 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 vessels. As previously outlined, the Heinänen and Skov (2015) modelling indicated a negative relationship between the number of ships and the distribution of harbour porpoise in the Irish and Celtic Seas during summer, suggesting that the species could exhibit avoidance behaviour, which reduces the risk of collision with vessels.

~~11.472~~11.473 Approximately 4% of all harbour porpoise post-mortem examinations from the Baltic, North-East Atlantic, Irish and North Seas (ASCOBANS area) were thought to present evidence of interaction with vessels (Evans *et al*., 2011).

~~11.473~~11.474 There was limited information on the collision risk of marine mammals in the Irish and Celtic Sea areas.

Sensitivity

~~11.474~~11.475 Given the existing levels of marine traffic in the area (see **Chapter 14 Shipping and Navigation**), marine mammals in and around the windfarm site would typically be habituated to the presence of vessels and would be able to detect and avoid vessels. However, as a precautionary approach, the sensitivity of marine mammals to collision risk with construction vessels was considered to be **low** for all species, except minke whale which was assessed as **medium** sensitivity.

~~11.475~~11.476 Being highly mobile, marine mammals have the potential to avoid vessels but if an individual receptor collides with a vessel, there is the potential for a very limited capacity to recover from the worst-case impact (**Table 11.8**).

Magnitude

~~11.476~~11.477 The Cetacean Strandings Investigation Programme (CSIP)[5] records strandings of marine mammals in Wales and England and undertakes investigations to determine causes of fatalities, wherever possible.

~~11.477~~11.478 Both the Scottish Marine Animal Stranding Scheme (SMASS), CSIP and Cornwall Wildlife Trust (CWT) record strandings of marine mammals and undertake investigations to determine causes of fatalities where 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. Data for RoI is also available from the Marine Institute (2022). There are no reported seal strandings by the CSIP, however, there is a Natural England (2019) report on seal necropsies in England between November 2015 and March 2016. Information from the

[5] http://ukstrandings.org/csip-reports/

SMASS[6], from 2009 to 2020, has therefore been used to determine causes of death in grey and harbour seal that could be related to vessels.

~~11.478~~11.479 **Table 11.55** summarises the most recent available data from the schemes for the relevant species, detailing the number of deaths caused by either vessel strike or physical trauma with an unknown cause, which could be attributed to vessel strike. The collision risk rate has been calculated by dividing the number of deaths attributed to vessel strike or other physical trauma (where the cause of death could potentially be collision with a vessel) by the total known causes of death for each species (**Table 11.55**).The CSIP and SMASS data (**Table 11.55**) show that mortality of cetaceans and seals 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 they may not be representative of all deaths.

[6] https://strandings.org/publications/

Table 11.55 Summary of strandings in the whole of the UK and causes of death of marine mammals from physical trauma of unknown cause and physical trauma following possible collision with a vessel (Data from CSIP[7], SMASS[8], CWT[9], MEM[9], Marine Institute[9])

Species	Number of strandings	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 vessel	Collision risk rate: (deaths from vessels strike or physical trauma) / (total known cause of death)	Collision risk rate (%)
Harbour porpoise	5582	1203	69	14	0.056	5.6
Bottlenose dolphin	152	32	1	0	0.022	2.2
Common dolphin	1805	458	22	12	0.048	4.8
Risso's dolphin	139	23	1	1	0.073	7.3
White-beaked dolphin	186	61	2	0	0.045	4.5
Minke whale	236	48	2	1	0.07	7.0
Grey seal	1909	417	3	4	0.043	4.3
Harbour seal	624	185	5	0	0.034	3.4

[7] CSIP (2004); CSIP (2005); CSIP (2006); CSIP (2011); CSIP (2016); CSIP (2018); CSIP (2019); CSIP (2020) [available from: https://ukstrandings.org/csip-reports/] (Welsh Coast 2018-2020: CSIP (2019), CSIP (2020))

[8] 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://strandings.org/publications/]

[9] CWT (2021), CWT (2020), CWT (2019), CWT (2018), CWT (2017), CWT (2016) [9] MEM & CSIP (2019), MEM & CSIP (2020) [9] Marine Institute, 2022

~~11.479~~11.480 To estimate the potential collision risk of Project construction vessels, the potential risk rate per vessel calculated for all relevant species (**Table 11.55**) was then used to calculate the risk to marine mammal species due to the increased number of vessel movements during construction (**Table 11.56**).

~~11.480~~11.481 The estimated number of construction vessel movements is 2,583 return vessel trips per year during the 2.5 year construction period (**Table 11.1**).

~~11.481~~11.482 The number of marine mammals at risk of collision per vessel in UK waters has been estimated based on the total number of each marine mammal species in UK waters and the total number vessels present in UK waters, and by applying the potential collision risk rate of each species (based on the CSIP and SMASS data).

~~11.482~~11.483 Total UK populations were taken from IAMMWG (2023) for all cetacean species, and from SCOS (2022) for seal species. The total presence of vessels in UK waters was derived from the total vessel transits recorded within the 2015 AIS data[10], which was the latest publicly available data.

~~11.483~~11.484 The number of marine mammals (the percentage of the relevant reference population) at risk of collision from the increased number of vessel movements during the Project construction period has then been used to determine the possible magnitude of the permanent impact (**Table 11.56**).

~~11.484~~11.485 As shown in **Table 11.56**, the magnitude for harbour seal was determined to be **high**, whilst the magnitude for harbour porpoise and grey seal was **medium**, as well as the wider reference population for both harbour and grey seal. For all other cetacean species, the magnitude of impact was **low**.

~~11.485~~11.486 This assessment was highly precautionary as it is unlikely that marine mammals would be at increased collision risk with vessels during construction considering the existing number of vessel movements in the area, and that vessels within the windfarm would be stationary for much of the time, or very slow moving.

[10]https://www.data.gov.uk/dataset/963c1a7b-5b72-4cce-93f5-3f1e223fd575/anonymised-ais-derived-track-lines-2015

Table 11.56 Predicted number of marine mammals at risk of collision with construction vessels, based on current UK collision rates and vessel presence (magnitude of impact based on the percentage of the reference population at risk)

Species	Collision risk rate (%)	Estimated total number of individuals in UK waters	Number of marine mammals at risk of collision in UK waters	Annual number of vessel transits in UK and RoI for 2015	Number of marine mammals at risk of collision per vessel in UK waters	Number of annual vessel transits associated with construction	Number of marine mammals at increased risk from Project construction	% of reference population[11]	Magnitude (permanent effect)
Harbour porpoise	5.6	200,714	11,423	3,852,030	0.003	2,583	8	0.012%	Medium
Bottlenose dolphin	2.2	7,252	168	3,852,030	0.00004	2,583	<1	0.04%	Low
Common dolphin	4.8	57,417	3,076	3,852,030	0.001	2,583	2	0.002%	Low
Risso's dolphin	7.3	8,687	636	3,852,030	0.0002	2,583	<1	0.004%	Low
White-beaked dolphin	4.5	34,025	1,597	3,852,030	0.0004	2,583	1	0.002%	Low
Minke whale	7.0	10,288	748	3,852,030	0.0002	2,583	<1	0.002%	Low
Grey seal	4.3	178,262	6,993	3,852,030	0.0018	2,583	5	0.3% (0.04%)*	Medium (medium)*
Harbour seal	3.34	48,419	1,438	3,852,030	0.0004	2,583	1	15.5% (0.08%)*	High (medium)*

* Percentage in brackets is for the wider reference population for grey seal (including the Wales, NI and RoI) and harbour seal (incl. NI)

[11] Refer to **Table 11.14** in **Section 11.5.9** for a summary of the species reference populations.

Significance of effect

~~11.486~~11.487 Taking into account the low to medium marine mammal sensitivity, and the potential magnitude of impact as assessed in **Table 11.56**, the impact significance for any potential increased collision risk, as a result of construction vessels, has been assessed as a very precautionary **moderate** (**minor**) **adverse** for harbour seal, and **minor adverse** for harbour porpoise, dolphin species, minke whale and grey seal (**Table 11.57**).

~~11.487~~11.488 A global review of marine mammal collisions (Schoeman *et al*., 2020) highlighted the required factors needed for collision risk assessments. The assessments require information about how much time marine animals spend near the surface, their behaviour around vessels, and ideally, details about the size and speed of the vessels involved.

~~11.488~~11.489 A review, detailed in Section 8 of **Appendix 11.2**, indicated that most marine mammals are affected by vessel noise. The discussion above highlights that these animals typically respond to this noise by exhibiting avoidance or fleeing behaviours, particularly observed in harbour porpoise (as described in Benhemma-Le Gall *et al*., 2021 and 2023) or by coexisting with ships and seals. Furthermore, the above calculations do not take speed and vessel size into account. Nonetheless, it is noteworthy that vessels within the windfarm area would predominantly remain stationary or operate at very low speeds.

~~11.489~~11.490 Additionally, it is important to consider that marine mammals in the study area are accustomed to high volumes of vessel traffic, with over 1,000 vessels transiting per month. Taking all these factors into account, the actual risk of collision for marine mammals in this scenario is likely to be extremely low, if not negligible.

Best practice measures

~~11.490~~11.491 As outlined in **Section 11.3.3**, in order to reduce any increased collision risk, vessel movements, where possible, would follow set vessel routes and, hence, would be located in areas where marine mammals are already accustomed to vessels. All vessel movements would be kept to the minimum number that is required to develop the Project. Additionally, vessel operators would use industry best practice to reduce any risk of collisions with marine mammals.

~~11.491~~11.492 These measures would be detailed within the final PEMP, with an Outline PEMP included with the DCO Application.

Residual significance of effect

~~11.492~~11.493 Taking into account the best practice measures to reduce the risk of collision with vessels, the residual significance of effect would be **minor adverse** (not significant in EIA terms) for all species (**Table 11.57**).

Table 11.57 Assessment of significance of effect for increased collision risk with vessels during construction

Species/receptor	Sensitivity	Magnitude	Significance of effect	Additional mitigation measures proposed	Residual effect
Harbour porpoise	Low	Medium	Not Significant (Minor adverse)	Best practice measures, as identified in the Outline PEMP (see **Section 11.3.3**).	Not Significant (Minor adverse)
Bottlenose dolphin	Low	Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Common dolphin	Low	Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Risso's dolphin	Low	Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)
White-beaked dolphin	Low	Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Minke whale	Medium	Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Grey seal	Low	Medium (medium)*	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Harbour seal	Low	High (medium)*	Significant (Moderate adverse) – Not Significant (minor adverse)		Not Significant (Minor adverse)

* Magnitude in brackets is for the wider reference population for grey seals (incl. Wales, SW Scotland, NI and RoI) and harbour seal (incl. NI)

11.6.3.7 Impact 7: Changes to prey resources

~~11.493~~11.494 As outlined in **Chapter 10 Fish and Shellfish Ecology**, the potential impacts on fish species during construction can result from:

- Temporary habitat loss/physical seabed disturbance
- Increased SSCs and sediment re-deposition
- Remobilisation of contaminated sediments
- Underwater noise and vibration, including barrier effects
- Changes in fishing activity

~~11.494~~11.495 Any impacts on prey species have the potential to affect marine mammals.

Sensitivity

~~11.495~~11.496 As outlined in **Appendix 11.2**, the diet of harbour porpoise consists of a wide variety of prey species and varies geographically and seasonally, reflecting changes in available food resources. Harbour porpoise have relatively high daily energy demands and need to capture enough prey to meet daily energy requirements. It has been estimated that, depending on the environmental 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 were therefore considered to have **low** to **medium** sensitivity to changes in prey resources.

~~11.496~~11.497 Dolphin species, including bottlenose dolphin, common dolphin and white-beaked dolphin have a broad diet, feeding on a wide range of prey species. Risso's dolphin prey mainly upon cephalopods. All dolphin species are considered to have large foraging ranges, and a broad range of prey species, and were therefore considered to have **low** sensitivity to changes in prey resources.

~~11.497~~11.498 Minke whale feed on a variety of prey species, but in some areas, they have been found to prey upon specific species. Therefore, minke whale were considered to have a **low** to **medium** sensitivity to changes in prey resource.

~~11.498~~11.499 Grey and harbour seal are considered to be opportunistic feeders, feeding on a wide range of prey species. They are able to forage in other areas and have relatively large foraging ranges. Grey seal and harbour seal were therefore considered to have **low** sensitivity to changes in prey resources.

~~11.499~~11.500 Further information on the diet of marine mammal species is provided in **Appendix 11.2**.

Magnitude

Physical seabed disturbance

~~11.500~~11.501 During construction, the maximum total area of seabed habitat that could be disturbed is 2.4km^2. As outlined in **Table 11.1**, this area is the seabed preparation area required for installation of the infrastructure and includes the worst-case seabed footprint for all WTG and OSP foundations (based on GBS), scour protection, disturbance from jack-up vessels, and installation of inter-array and platform link cables. The total area of seabed disturbance (2.4km^2) represents approximately 2.8% of the windfarm site (87km^2).

~~11.501~~11.502 The magnitude of impact of physical disturbance to seabed habitat during construction has been assessed as low in **Chapter 9 Benthic Ecology**, with a minor adverse significance of effect. In **Chapter 10 Fish and Shellfish Ecology**, the magnitude of impact for temporary habitat loss/physical disturbance was considered to be negligible for all species (apart from molluscs which had a magnitude of low), due to species being able to use similar adjacent habitats and there not being a major effect at a population level.

~~11.502~~11.503 The magnitude of any potential changes to prey resources due to physical seabed disturbance, was therefore assessed as **negligible** for all marine mammal species.

Increased SSCs and sediment re-deposition

~~11.503~~11.504 Construction activities, such as seabed preparation, dredging, foundation and cable installation, may lead to the potential for increased SSCs in the water column and subsequent sediment re-deposition. Activities such as jack-up vessel and anchor deployment, placement of cable protection or scour protection were not expected to increase the SSCs to the extent to which it would cause an impact to benthic or fish receptors (**Chapter 9 Benthic Ecology**).

~~11.504~~11.505 As outlined in **Chapter 8 Marine Sediment and Water Quality**, the windfarm site is predominantly composed of sand and fine sand. Based on the sediment sizes present, finer suspended sediment is expected to exist as a passive plume, extending to a maximum of one spring tidal ellipse (10km) from the construction activity. Other sediments would settle quickly in proximity to its release, within a few hundred metres and up to around a kilometre away from the construction activity.

~~11.505~~11.506 The total volume of sediment that could be disturbed, and may potentially be brought into suspension, is approximately 1.1km^3 (**Table 11.1**). Any disturbance would be temporary and intermittent over the construction period and any increases in SSCs would last a matter of hours to days around the point of seabed disturbance.

~~11.506~~11.507 Any increases in SSCs are expected to cause localised and short-term changes at the point of disturbance. These temporary impacts would only represent a very small proportion of the subtidal sand and mud habitats present across the wider Eastern IS. Therefore, the potential magnitude of impact was considered to be low in **Chapter 9 Benthic Ecology**, with a negligible to minor adverse significance of effect.

~~11.507~~11.508 The significance of effects in **Chapter 10 Fish and Shellfish Ecology** was assessed as negligible to minor adverse.

~~11.508~~11.509 Any potential changes to prey resources as a result of increased SSCs and sediment deposition were therefore assessed as **negligible** for all marine mammal species.

Remobilisation of contaminated sediments

~~11.509~~11.510 As outlined in **Chapter 8 Marine Sediment and Water Quality**, site specific data collected indicated that, for all parameters, sediment contaminant concentrations were low across the windfarm site. The magnitude of impact was therefore negligible.

~~11.510~~11.511 The risk to fish and, therefore, marine mammals from remobilisation of contaminated sediments was therefore assessed as negligible.

~~11.511~~11.512 As contaminant levels are not found to be present at levels where effects would arise, this impact to marine mammals was not assessed further for the construction, operation and maintenance or decommissioning phases.

Underwater noise and vibration

~~11.512~~11.513 High levels of underwater noise can cause physiological (mortality, permanent injury or temporary injury), behavioural (startled movements, swimming away from noise source, changed migratory patterns or ceased reproductive activities) and environmental (changes to prey species or feeding behaviours) effects on fish species.

~~11.513~~11.514 **Table 11.58** summaries the maximum predicated impact ranges for those fish species that are most sensitive to hearing and therefore have the biggest impact ranges (more details are provided in **Chapter 10 Fish and Shellfish Ecology**). The table shows the underwater noise modelling results for SEL_{cum} during piling of three sequential monopiles with a maximum hammer energy of 6,600kJ, and SEL_{cum} during piling of four sequential jacket pin piles with a maximum hammer energy of 2,500kJ.

~~11.514~~11.515 The assessments of piling underwater noise and vibration in **Chapter 10 Fish and Shellfish Ecology** concluded that the impact magnitude levels were negligible to low, thus the significance of effect was defined as negligible to minor adverse (not significant in EIA terms).

~~11.515~~11.516 The assessment also concluded that the barrier effects to fish species caused by underwater noise during construction, were assessed as negligible magnitude, with a negligible to minor adverse (not significant in EIA terms) effect significance in **Chapter 10 Fish and Shellfish Ecology**.

Table 11.58 Summary of maximum predicted impact ranges for all fish species from underwater noise

Fish group	Species included	Potential impact	Impact areas and ranges			
			Monopile (maximum hammer energy 6,600kJ) (SEL_{cum} relates to three sequential monopiles within 24 hours)		Pin pile (maximum hammer energy 2,500kJ) (SEL_{cum} relates to four sequential pin-piles within 24 hours)	
			Area	**Max**	**Area**	**Max**
Group 3 and 4 - Fish: swim bladder involved in hearing (primarily pressure detection)	Sprat, Ling, Hake, Cod European eel, Whiting, Blue ling, Atlantic herring, European bass	Mortality and potential mortal injury (SPL_{peak})	0.32km^2	320m	0.19km^2	250m
		Mortality and potential mortal injury	180km^2	8.2km	110km^2	6.4km
		Recoverable injury	360km^2	12km	240km^2	9.6km
		TTS	2,400km^2	33km	1,900km^2	30km

~~11.516~~11.517 Fish or prey species that have a recoverable injury, TTS or behavioural response would still be available for marine mammals, and as such, there would be no effect on the prey resources for marine mammals as a result of such impacts on fish species.

~~11.517~~11.518 Fish or prey species that die or have a mortal injury, in theory, could reduce the prey resource for marine mammal species. As a precautionary approach, the number of marine mammals that could potentially be affected by this change in prey resource has been assessed in **Table 11.59**. The potential impact area of 180km^2 has been used based on the maximum impact for stationary fish (SEL_{cum}).

~~11.518~~11.519 Although the potential effect would be permanent for fish, it would only be temporary for marine mammals as other prey species would be available from the surrounding area. After piling, those fish that did not die would return to the area, once the underwater noise had ceased.

~~11.519~~11.520 It is 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 be disturbed from the area (**Section 11.6.3.2**).

~~11.520~~11.521 The magnitude of impact for any changes in prey resource due to construction piling underwater noise would be **negligible** for all marine mammals, but **low** for the combined reference population of grey seal.

Table 11.59 Maximum number of individuals (and % of reference population) that could be affected by any changes in prey resource (180km^2) as a result of underwater noise during construction of the Project

Species	Maximum number of individuals (% of reference population)	Magnitude (temporary effect)
Harbour porpoise	291.8 (0.47% of CIS MU)	Negligible
Bottlenose dolphin	1.87 (0.64% of IS MU)	Negligible
Common dolphin	5.40 (0.005% of CGNS MU)	Negligible
Risso's dolphin	0.1 (0.0009% of CGNS MU)	Negligible
White-beaked dolphin	1.3 (0.003% of CGNS MU)	Negligible
Minke whale	1.6 (0.008% of CGNS MU)	Negligible
Grey seal	18 (1.13% of combined MUs; or 0.14% of wider ref pop)	Low (negligible)*
Harbour seal	0.02 (0.28% of NW MU; or 0.0014 of wider ref pop)	Negligible (negligible)*

* Magnitude in brackets is for the wider reference population for grey seals (incl. Wales, SW Scotland, NI and RoI) and harbour seal (incl. NI)

Changes in fishing activity

~~11.521~~11.522 As outlined in **Chapter 13 Commercial Fisheries**, there is the potential for commercial fishing activity to be displaced from within the windfarm site, due to the presence of work vessels, WTG/OSP foundation installation activity and laying of cabling. However, the windfarm site is not heavily fished compared to surrounding areas, except in the case of potting vessels that are predominantly targeting whelk. As such, any potential changes in fishing activity due to the construction activities were considered to be low. Development, prior to construction, of a Fisheries Liaison and Co-existence Plan (FLCP), in line with the Outline FLCP (Document Reference 6.3) submitted with the DCO Application, has set out in detail the planned approach to fisheries liaison and means of delivering any other relevant mitigation measures.

~~11.522~~11.523 Any changes in prey resources as a result of changes in fishing activity, would be **negligible** for all marine mammal species, except for grey seal which was assessed as **low** magnitude.

Significance of effect

~~11.523~~11.524 Taking into account the marine mammal sensitivity for each species, and the low to negligible potential magnitude of the impact, the significance for any changes in prey resource during construction (**Table 11.60**) has been assessed as:

- **Negligible** to **minor adverse** (not significant in EIA terms) for grey seal, harbour porpoise and minke whale
- **Negligible adverse** (not significant in EIA terms) for all other species

Residual significance of effect

~~11.524~~11.525 No mitigation is required or proposed. Therefore, the residual significance of effect for any changes to prey resource during the construction at the windfarm site would be **negligible** to **minor adverse** (not significant in EIA terms) for all species (**Table 11.60**).

Table 11.60 Assessment of significance of effect for any changes in prey resources during construction

Species/receptor	Sensitivity	Magnitude	Significance of effect	Additional mitigation measures proposed	Residual effect
Harbour porpoise	Low to Medium	Negligible	Not Significant (Negligible to Minor adverse)	None required	Not Significant (Minor adverse)
Bottlenose dolphin	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)
Common dolphin	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)
Risso's dolphin	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)
White-beaked dolphin	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)
Minke whale	Low to Medium	Negligible	Not Significant (Negligible to Minor adverse)		Not Significant (Minor adverse)
Grey seal	Low	Low (negligible)*	Not Significant (Negligible to Minor adverse)		Not Significant (Minor adverse)
Harbour seal	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)

* Magnitude in brackets is for the wider reference population for grey seals (incl. Wales, SW Scotland, NI and RoI) and harbour seal (incl. NI)

11.6.3.8 Impact 8: Changes to water quality

~~11.525~~11.526 As outlined in **Chapter 8 Marine Sediment and Water Quality**, potential changes in water quality could occur during construction as a result of:

- Increase in SSCs
- Deterioration in water quality associated with the release of sediment bound contamination.

~~11.526~~11.527 All vessels involved with the Project would be required to comply with the International Convention for the Prevention of Pollution from Ships (MARPOL) 73/78. The PEMP would set out all procedures and measures (in the form of a MPCP) to be followed to minimise the risk of, and effects in the event of an accidental spill or leak. The potential risk of spills and leaks to the marine environment was therefore not assessed further in **Chapter 8 Marine Sediment and Water Quality**, as agreed in the Scoping Opinion for the Project.

~~11.527~~11.528 Taking into account the proposed mitigation and management plans (see **Section 11.3.3**), there would be no potential for any direct impact of spills or leaks to significantly affect marine mammals. Therefore, this has not been assessed further. An Outline PEMP has been included as part of the DCO Application.

Increase in SSCs

~~11.528~~11.529 As outlined in **Section 11.6.3.7**, the magnitude of impact for increased SSCs due to foundation installation and other construction related activities, was predicted to be low and significance of effect was assessed as minor adverse.

~~11.529~~11.530 Increased SSCs is unlikely to have any direct or indirect impacts on marine mammals. 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).

Remobilisation of contaminated sediments

~~11.530~~11.531 As outlined in **Chapter 8 Marine Sediment and Water Quality**, site-specific data collected indicated that, for all parameters, sediment contaminant concentrations were low. The magnitude of impact was therefore negligible.

~~11.531~~11.532 There is no potential for any direct or indirect impact on marine mammals from remobilisation of contaminated sediments and, therefore, the significance of effect was negligible adverse.

~~11.532~~11.533 As contaminant levels were not found to be present at levels where effects would arise, this impact was not assessed further for the construction, operation and maintenance or decommissioning phases.

Sensitivity

~~11.533~~11.534 The sensitivity of marine mammals to any increased SSCs was assessed as **negligible**.

Magnitude

~~11.534~~11.535 The magnitude of impact for any changes in water quality due to increased SSCs was assessed to be **negligible** for marine mammals.

Significance of effect

~~11.535~~11.536 The significance of effect for any changes in water quality during construction was assessed to be **negligible adverse** (and not significant in EIA terms) for marine mammals (**Table 11.61**).

Table 11.61 Assessment of significance of effect for any changes in water quality during construction

Species/receptor	Sensitivity	Magnitude	Significance of effect	Additional mitigation measures	Residual effect
Harbour porpoise	Negligible	Negligible	Not Significant (Negligible)	None required	Not Significant (Negligible adverse)
Bottlenose dolphin	Negligible	Negligible	Not Significant (Negligible)		Not Significant (Negligible adverse)
Common dolphin	Negligible	Negligible	Not Significant (Negligible)		Not Significant (Negligible adverse)
Risso's dolphin	Negligible	Negligible	Not Significant (Negligible)		Not Significant (Negligible adverse)
White-beaked dolphin	Negligible	Negligible	Not Significant (Negligible)		Not Significant (Negligible adverse)
Minke whale	Negligible	Negligible	Not Significant (Negligible)		Not Significant (Negligible adverse)
Grey seal	Negligible	Negligible	Not Significant (Negligible)		Not Significant (Negligible adverse)
Harbour seal	Negligible	Negligible	Not Significant (Negligible)		Not Significant (Negligible adverse)

11.6.3.9 Impact 9: Disturbance of seals at haul-out sites

~~11.536~~11.537 Seals vary in their reaction to construction disturbance depending on the disturbance type (vessel noise/presence, piling etc,) and proximity to haul-out sites.

~~11.537~~11.538 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) and approaches from land (Cates and Acevedo-Gutierrez, 2017; Paterson *et al*., 2019; Machernis *et al*., 2018). The most common disturbance effects 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).

~~11.538~~11.539 During construction, piling represents the loudest and most likely source of disturbance to seal haul-outs, as well as increased vessel activity. The number of seals spending time on land has been shown to decrease during the construction phase of windfarms (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).

~~11.539~~11.540 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). As per **Table 11.1**, the nearest haul-out at South Walney is 30km away and seals are unlikely to be disturbed from piling at this distance.

~~11.540~~11.541 Disturbance to seals from vessel noise and presence has been demonstrated at haul-out sites in the UK up to 500m away (Cates and Acevedo-Gutierrez, 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). Beyond 600m, there was no discernible effect on the behaviour of harbour seal.

~~11.541~~11.542 A study was carried out by SMRU (Paterson *et al*., 2015), using a series of controlled disturbance tests at harbour seal haul-out sites, which consisted of regular (every three days) disturbance through direct approaches by vessel and effectively 'chasing' the seals into the water. The seal behaviour was recorded via GPS tags and found that even intense levels of disturbance did not cause seals to abandon their haul-out sites more than would be considered normal (for example, seals travelling between sites), and the seals were found to haul-out at nearby sites, or to undertake a foraging trip in response to the disturbance (but would later return).

~~11.542~~11.543 Further studies on the effects of vessel disturbance on harbour seals when they are hauled out suggest that, even with repeated disturbance events that are severe enough to cause individuals to flee into the water, the likelihood of harbour seals moving to a different haul-out site would not increase. Furthermore, this appeared to have little effect on their movements and foraging behaviour (Paterson *et al*., 2019).

~~11.543~~11.544 In areas of high vessel traffic, there can be habituation effects and disturbance behaviours are generally reduced over time (Strong *et al*., 2010).

Sensitivity

~~11.544~~11.545 As outlined above, based on the current information available, it was considered that, for grey seal and harbour seal, there was the potential for disturbance at haul-out sites from passing vessels 500m away, with an increased risk of significant disturbance within a precautionary 200m buffer.

~~11.545~~11.546 As a precautionary approach, both grey and harbour seals were considered to have **low** sensitivity to disturbance at seal haul-out sites. As defined in **Table 11.8**, individual receptors have some tolerance to avoid, adapt to, tolerate, or recover, from the anticipated impact.

Magnitude

~~11.546~~11.547 As outlined in **Section 11.5.7**, the two main grey seal haul-out sites in the NW England MU are at West Hoyle Bank (often referred to as Hilbre Island; approximately 45km from the Project) and at South Walney (approximately 30km from the Project) (SCOS, 2022). As outlined in **Section 11.5.8**, there are no significant harbour seal breeding or haul-out sites in the NW England MU (SCOS, 2022).

~~11.547~~11.548 Two studies determined that there were no long-term effects observed during construction of OWFs (Edren *et al*. 2010; Russel *et al*. 2016). During piling activity, however, seals were temporarily disturbed at their haul-out 4km away (Edren *et al*. 2010) from the windfarm, whereas Russel *et al*. (2016) observed a short-term displacement of seals up to 25km distance from the piling location. Considering the range of potential disturbance distances, the closest haul-out is 30km away from the Project and, therefore, beyond the maximum range observed by Russel *et al*. (2016). As such, there would be no direct effect on the closest haul-out and the potential effect on seals at sea in the wider area has been assessed as **minor adverse** (Not Significant) in EIA terms (**Section 11.6.3.2**).

~~11.548~~11.549 It is expected that, if there is any disturbance to seals at haul-out sites from construction activities, it is a short-term effect. For example, a 2019 study on harbour seals in Scotland found that 30 minutes after a disturbance event seals returned to 52% pre-disturbance levels at haul-out sites, and to 94% pre-disturbance levels four hours after a disturbance event (Paterson *et* *al*., 2019). In line with that, Russel *et al*. (2016) determined that within two hours of the cessation of pile driving, seals were distributed as they had been prior to piling.

~~11.549~~11.550 Based on the above information, the magnitude of impact for disturbance at seal haul-out sites during piling and other construction activities in the windfarm site has been assessed as **negligible**.

~~11.550~~11.551 During the 2.5 year construction period, there would be an increase in the number of vessels in the windfarm site, and the number of vessel trips to and from the windfarm site. The number of vessels in the windfarm site is unlikely to result in a direct disturbance at seal haul-out sites, given the distance from the coast (30km) and to the nearest haul-out (35km).

~~11.551~~11.552 Depending on the ports used, and the vessel routes to and from the site, there could be the potential for vessels to pass seal haul-out sites. One of the haul-out sites, South Walney, is approximately 5km south and adjacent to the approach channel to the port of Barrow (within the area of search for the Project). Seals at such locations are most likely to be tolerant to high vessel activity.

~~11.552~~11.553 However, the Cumbria Wildlife Trust (2023) has appealed to boat users to keep their distance from the grey seal breeding colony at South Walney, particularly during pupping season in autumn. This appeal came following the recent deaths of mothers and a few pups, whose deaths had been attributed to vessel collision and disturbance from seal-watching boats that had been seen too close to the pupping site. Pups have been born there since 2015, and since then the colony has grown, indicated by a count of 518 grey seal in 2021.

~~11.553~~11.554 In the instance of Project related vessels transiting to and from the port, the vessels would use main shipping channels and endeavour to stay at least 1km from the coast where possible.

~~11.554~~11.555 To date, there have been no long-term population effects on seals from disturbance at haul-out sites, as a result of vessels or OWF construction activities (Edren *et al*., 2010; Russel *et al*., 2016; Cates and Acevedo-Gutierrez, 2017).

~~11.555~~11.556 A **low** magnitude of impact was therefore assigned to the disturbance at seal haul-out sites from vessel movement during construction.

Significance of effect

~~11.556~~11.557 Taking into account the low sensitivity of grey and harbour seal and the negligible magnitude of the impact for disturbance from piling and other construction activities at the windfarm site, the significance of effect has been assessed as **negligible adverse** (not significant in EIA terms) (**Table 11.62**).

~~11.557~~11.558 Taking into account the low sensitivity of grey and harbour seal and the precautionary low magnitude of the impact for disturbance at seal haul-out sites from vessels during construction, the significance of effect has been assessed as **minor adverse** (not significant in EIA terms) (**Table 11.62**).

Best practice measures

~~11.558~~11.559 As outlined in **Section 11.3.3**, vessel movements, where possible, would follow set vessel routes and, hence, would be located in areas where marine mammals are accustomed to vessels, which would also reduce the disturbance at seal haul-out sites. All vessel movements would be kept to the minimum number that is required to undertake the works to reduce disturbance.

~~11.559~~11.560 Additionally, if required, vessel operators would use best practice measures, including a consideration of distances from seal haul-out sites when transiting outside of main shipping channels, particularly during sensitive periods for breeding and moulting.

~~11.560~~11.561 These measures would be detailed within the final PEMP, with an Outline included with the DCO Application.

Residual significance of effect

~~11.561~~11.562 Taking into account the best practice measures, the residual significance of effect for any disturbance at seal haul-out sites during construction at the windfarm site would be at worst-case **minor adverse** (not significant in EIA terms) (**Table 11.62**).

Table 11.62 Assessment of significance of effect for disturbance at seal haul-out sites during construction and from vessels

Potential impact	Species/receptor	Sensitivity	Magnitude	Significance of effect	Additional mitigation measures proposed	Residual effect
Disturbance at seal haul-out sites during piling and construction at windfarm site	Grey seal	Low	Negligible	Not Significant (Negligible adverse)	No additional mitigation required in relation to disturbance at seal haul-out sites	Not Significant (Negligible adverse)
	Harbour seal	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)
Disturbance at seal haul-out sites form vessel movement during construction	Grey seal	Low	Low	Not Significant (Minor adverse)	Best practice measures, including consideration of distances from seal haul-out sites, as provided in the Outline PEMP (see **Section 11.3.3**)	Not Significant (Negligible to Minor adverse)
	Harbour seal	Low	Low	Not Significant (Minor adverse)		Not Significant (Negligible to Minor adverse)

11.6.4 Potential effects during operation and maintenance

~~11.562~~11.563 Potential effects during operation and maintenance assessed for marine mammals were:

- Impact 1: TTS and disturbance from underwater noise of operational WTGs
- Impact 2: TTS and disturbance from underwater noise during maintenance activities such as cable repairs and rock placement
- Impact 3: TTS and disturbance from underwater noise and presence of vessels
- Impact 4: Barrier effects from underwater noise during operation and maintenance
- Impact 5: Barrier effects from physical presence of windfarm infrastructure
- Impact 6: Increased collision risk with vessels during operation and maintenance
- Impact 7: Changes to prey resources
- Impact 8: Changes to water quality
- Impact 9: Disturbance of seals at haul-out sites

11.6.4.1 Impact 1: TTS and disturbance from underwater noise of operational wind turbines

~~11.563~~11.564 The operational WTGs would operate nearly continuously, except for occasional shutdowns for maintenance or severe weather. The Project operation and maintenance period is 35 years. There is, therefore, the potential that underwater noise from operational WTGs could contribute to a consistent, long duration of sound to the marine environment. The underwater noise levels emitted during the operation of the WTGs 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 WTGs (Tougaard *et al*., 2009a; Sigray and Andersson, 2011).

~~11.564~~11.565 The main source of underwater noise from operational WTGs would be mechanically generated vibration from the rotating machinery within the WTGs, which is transmitted into the sea through the structure of the WTG tower and foundations (Nedwell *et al*., 2003; Tougaard *et al*., 2020). Noise levels generated above the water surface are expected to be low enough that no significant airborne sound would pass from the air to the water (e.g., Godin, 2008).

11.56511.566 Underwater noise from operational WTGs has been described as continuous and non-impulsive and is characterised by one or more tonal components that are typically at frequencies below 1kHz (Madsen *et al*., 2006).

11.56611.567 Measurements made at three different OWFs, in Denmark and Sweden, at ranges between 14m and 40m from the foundations, found that the sound generated due to operational WTGs was only detectable over underwater ambient noise at frequencies below 500Hz (Tougaard *et al*., 2009a).

11.56711.568 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 windfarm 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).

11.56811.569 There is the potential for the proposed larger project WTGs to have greater noise levels compared to smaller WTGs currently in operation elsewhere (Stöber and Thomsen, 2021). This increase in size of operational WTGs at the Project has been taken into account in the underwater noise modelling (see **Appendix 11.1**).

11.56911.570 The most recent available data indicated that there was no lasting disturbance or exclusion of harbour porpoise or seals around windfarm 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 suggested 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).

11.57011.571 Monitoring was carried out at the Horns Rev and Nysted windfarms in Denmark, during their 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 windfarm 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 effect on the abundances of harbour porpoise at varying wind velocities at either of the OWFs studied, following two years of operation.

~~11.571~~11.572 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 windfarm sites (Alpha Ventus in Germany and Sheringham Shoal in the UK), with the movement of several of the seals suggesting foraging behaviour around WTG fixed foundation structures (Russell *et al.,* 2014). Both harbour porpoise and seals have been shown to forage within operational windfarm sites (e.g., Lindeboom *et al.,* 2011; Russell *et al.,* 2014), indicating no restriction to movements in operational OWF sites.

~~11.572~~11.573 Modelling of noise effects of operational offshore WTGs suggested that marine mammals were not considered to be at risk of displacement by operational windfarms (Marmo *et al.,* 2013).

Underwater noise modelling

~~11.573~~11.574 To determine the potential risk for PTS and TTS from underwater noise of operational WTGs, site-specific underwater noise modelling was undertaken (see **Appendix 11.1**).

~~11.574~~11.575 The maximum WTGs sizes considered at the Project were much larger than the currently available recorded SEL information that has been extrapolated for use in the modelling (see **Appendix 11.1**). Therefore, caution must be used when considering the predicted impact ranges.

~~11.575~~11.576 The modelling assumed an average 6m/s wind speed, although wind speeds, and thus operational noise levels, may be greater than this. However, it is worth noting that the background noise level will also naturally increase with increased wind speed.

~~11.576~~11.577 All SEL_{cum} criteria applied used the same assumptions as previously outlined in **Section 11.6.3.1**. Ranges smaller than 100m for SEL_{cum} have not been presented and, therefore, may overestimate the maximum impact range. The operational WTG source is considered a non-impulsive, or continuous, source. For SEL_{cum} calculations, it has been assumed that the operational WTG noise is present 24 hours a day.

~~11.577~~11.578 The results of the underwater noise modelling (**Table 11.63**) indicated that any marine mammal would have to be less than 100m (precautionary maximum range) from the continuous noise source, to be exposed to noise levels that could induce PTS or TTS, based on the Southall *et al*. (2019) non-impulsive thresholds and criteria for SEL_{cum} (**Table 11.20**).

~~11.578~~11.579 As a precautionary approach, the potential impact area for up to 35 WTGs has also been determined (**Table 11.63**).

Table 11.63 Predicted impact ranges (and areas) for PTS or TTS from 24-hour cumulative exposure of underwater noise from operational WTGs

Species	One operational WTG	Up to 35 WTGs
Harbour porpoise	<0.1km ($<0.03km^2$)	$1.1km^2$
Dolphin species	<0.1km ($<0.03km^2$)	$1.1km^2$
Minke whale	<0.1km ($<0.03km^2$)	$1.1km^2$
Grey and Harbour seal	<0.1km ($<0.03km^2$)	$1.1km^2$

Sensitivity

~~11.579~~11.580 The sensitivity of marine mammals to temporary changes in hearing sensitivity (TTS) as a result of underwater noise from operational WTGs was considered to be **medium** in this assessment, as a precautionary approach (see **Section 11.6.2**).

~~11.580~~11.581 For disturbance effects, harbour porpoise and minke whale have a **medium** sensitivity, while all other species were considered **low** sensitivity (**Table 11.16**). Marine mammals within the potential disturbance area would be expected to return to the area once the disturbance had ceased or they had become habituated to the sound.

Magnitude

~~11.581~~11.582 The number of marine mammals that could be impacted due to underwater noise from operational WTGs has been assessed based on the number of animals that could be present in the modelled impact area (**Table 11.63**).

~~11.582~~11.583 It is important to note that PTS is unlikely to occur in marine mammals, as the modelling indicated that the marine mammal would have to remain within less than 100m for any potential risk of PTS (**Appendix 11.1**). Therefore, PTS is highly unlikely and has not been assessed further.

~~11.583~~11.584 There is unlikely to be any significant risk of any TTS as the modelling also indicated that the marine mammal would have to remain within less than 100m of operational WTGs (**Table 11.63**). However, as a precautionary approach, the number of marine mammals that could be at risk of TTS has been estimated (**Table 11.64**). As outlined above, this is likely to be an overestimation as ranges smaller than 100m for SEL_{cum} have been rounded up to 100m.

11.58411.585 The magnitude of the potential impact for any TTS, as a result of underwater noise from operational WTGs (individually or up to 35 WTGs), was assessed as **negligible** for all marine mammal receptor species with less than 0.01% of the reference populations exposed based on potential long term effect criteria (**Table 11.64**).

Table 11.64 Maximum number of individuals (and % of reference population) that could be at risk of TTS as a result of underwater noise associated with operational WTGs at the Project

Species	Maximum number of individuals (% of reference population) for one WTG	Maximum number of individuals (% of reference population) for 35 WTGs	Magnitude (long term effect)
Harbour porpoise	0.05 (0.00008% of CIS MU)	1.8 (0.003% of CIS MU)	Negligible
Bottlenose dolphin	0.0003 (0.0001% of IS MU)	0.01 (0.004% of IS MU)	Negligible
Common dolphin	0.0009 (0.0000009% of CGNS MU)	0.03 (0.00003% of CGNS MU)	Negligible
Risso's dolphin	0.00002 (0.000000002% of CGNS MU)	0.0007 (0.000005% of CGNS MU)	Negligible
White-beaked dolphin	0.0002 (0.0000005% of CGNS MU)	0.008 (0.00002% of CGNS MU)	Negligible
Minke whale	0.0003 (0.000001% of CGNS MU)	0.01 (0.00005% of CGNS MU)	Negligible
Grey seal	0.003 (0.0002% of combined MUs; or 0.00002% of wider ref pop)	0.11 (0.007% of combined MUs; or 0.0008% of wider ref pop)	Negligible (negligible)*
Harbour seal	0.000003 (0.00005% of NW MU; or 0.0000002% of wider ref pop)	0.0001 (0.002% NW MU; or 0.00001% of wider ref pop)	Negligible (negligible)*

* Magnitude in brackets is for the wider reference population for grey seals (incl. Wales, SW Scotland, NI and RoI) and harbour seal (incl. NI)

Disturbance

11.58511.586 Based on the review of marine mammals and operational windfarms, the noise levels associated operational WTGs, and the duration of the operational life of the Project, a precautionary magnitude of **low** has been given to all marine mammal species.

Significance of effect

11.58611.587 Taking into account the medium sensitivity of all marine mammal species, and the negligible magnitude of the impact for TTS, the significance of effect for TTS from underwater noise of operational WTGs during the operational life of the Project, has been assessed as **minor adverse** (not significant in EIA terms) (**Table 11.65**).

~~11.587~~11.588 Taking into account the low to medium sensitivity of the relevant marine mammal species, and the precautionary low impact magnitude for disturbance, the significance of disturbance effect has been assessed as **minor adverse** (not significant in EIA terms) for underwater noise arising from operational WTGs during the operational life of the Project (**Table 11.65**).

Residual significance of effect

~~11.588~~11.589 No mitigation is required or proposed. Therefore, the residual significance of effect for TTS or disturbance from underwater noise of Project operational WTGs would be **minor adverse** (not significant in EIA terms) for all species (**Table 11.65**).

Table 11.65 Assessment of significance of effect for TTS or disturbance from underwater noise of operational WTGs at the Project

Species/receptor	Potential impact	Sensitivity	Magnitude	Significance of effect	Additional mitigation measures proposed	Residual effect
All marine mammal species	TTS	Medium	Negligible	Not Significant (Minor adverse)	None required	Not Significant (Minor adverse)
Harbour porpoise, minke whale	Disturbance	Medium	Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Bottlenose dolphin, common dolphin, Risso's dolphin, white-beaked dolphin, grey seal and Harbour seal		Low	Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)

11.6.4.2 Impact 2: TTS and disturbance from underwater noise during maintenance activities such as cable repairs and reburial

~~11.589~~11.590 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 effects to marine mammals, would be less than those during construction. **Table 11.1** provides estimates for potential cable repairs and reburial during the operational period.

~~11.590~~11.591 As outlined in **Section 11.6.3.3** and **Appendix 11.1**, the potential for PTS is only likely in very close proximity to cable reburial/repair or rock placement activities, and if the marine mammal remains within close proximity at onset. Therefore, it is highly unlikely for there to be any PTS due to maintenance activities.

~~11.591~~11.592 The effects from additional cable repair and reburial are temporary in nature and would 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.

Sensitivity

~~11.592~~11.593 The sensitivity of marine mammals to temporary changes in hearing sensitivity (TTS), as a result of underwater noise from maintenance activities, such as, cable repair or reburial, was considered to be **medium** in this assessment, as a precautionary approach (see **Section 11.6.2**).

~~11.593~~11.594 For disturbance effects, harbour porpoise and minke whale were assigned a **medium** sensitivity while all other species were considered **low** sensitivity (**Table 11.16**). Marine mammals within the potential disturbance area would be expected to return to the area once the disturbance had ceased or they had become habituated to the sound.

Magnitude

TTS

~~11.594~~11.595 The magnitude of impact for TTS from underwater noise during maintenance activities (e.g., cable repair, reburial and rock placement) has been based on the underwater noise modelling undertaken for other construction activities (see **Section 11.6.3.3** and **Appendix 11.1**).

~~11.595~~11.596 The results of the underwater noise modelling (**Table 11.66**) indicated that any marine mammal would have to remain less than 100m (the precautionary maximum range) from the continuous noise source for 24 hours to be exposed to noise levels that could induce TTS. The exception was for harbour porpoise for which the predicted impact ranges for TTS was determined to be 0.99km for rock placement activities, based on the Southall *et al*. (2019) non-impulsive thresholds and criteria for SEL_{cum} (**Table 11.20**).

~~11.596~~11.597 As a precautionary approach, the potential impact area for cable repair, reburial and rock placement occurring at the same time has also been determined (**Table 11.66**).

Table 11.66 Predicted impact ranges (and areas) for TTS from 24-hour cumulative exposure during operational maintenance activities

Species	Cable reburial/repair	Rock placement	Cable reburial/repair and rock placement at the same time
Harbour porpoise	<0.1km (<0.03km^2)	0.99km (3.08km^2)	3.11km^2
Dolphin species	<0.1km (<0.03km^2)	<0.1km (<0.03km^2)	0.06km^2
Minke whale	<0.1km (<0.03km^2)	<0.1km (<0.03km^2)	0.06km^2
Grey and Harbour seal	<0.1km (<0.03km^2)	<0.1km (<0.03km^2)	0.06km^2

~~11.597~~11.598 The magnitude of the potential impact for any TTS as a result of maintenance activities, for each activity individually or both together, was **negligible** for all marine mammal receptor species, with less than 1% of the reference populations exposed to any temporary effect (**Table 11.67**).

~~11.598~~11.599 The potential for TTS effects that could result from underwater noise during operational maintenance activities would be localised and temporary to where and when the work was undertaken.

Table 11.67 Maximum number of individuals (and % of reference population) that could be at risk of TTS as a result of underwater noise associated with operational maintenance activities at the Project

Species	Potential Impact	Maximum number of individuals (% of reference population) for each activity	Maximum number of individuals (% of reference population) for two activities	Magnitude (temporary effect)
Harbour porpoise	TTS from cumulative SEL, based on 24-hour activity for: ▪ Cable repair/reburial ▪ Rock placement	Same as during construction; see **Table 11.47** (Negligible magnitude for all species)	5.4 (0.009% of CIS MU)	Negligible
Bottlenose dolphin			0.0007 (0.0002% of IS MU)	Negligible
Common dolphin			0.002 (0.000002% of CGNS MU)	Negligible
Risso's dolphin			0.00004 (0.000000003% of CGNS MU)	Negligible
White-beaked dolphin			0.0004 (0.000001% of CGNS MU)	Negligible
Minke whale			0.0006 (0.000003% of CGNS MU)	Negligible
Grey seal			0.01 (0.0004% of NW MU; or 0.00005% of wider ref pop)	Negligible (negligible)*
Harbour seal			0.00001 (0.0001% of NW MU; or 0.0000005% of wider ref pop)	Negligible (negligible)*

* Magnitude in brackets is for the wider reference population for grey seals (incl. Wales, SW Scotland, NI and RoI) and harbour seal (incl. NI)

Disturbance

~~11.599~~11.600 As a precautionary approach, 4km has been used as a potential disturbance range for maintenance activities and vessels, based on assumptions used for construction activities (see **Section 11.6.3.3**). Thus, the area disturbed for one activity would be 50.27 km^2.

~~11.600~~11.601 The maximum number of individuals (% of reference population) that could be disturbed for one activity is the same as assessed for construction activities (see **Table 11.48**), with a **negligible** magnitude determined for all species.

~~11.601~~11.602 The potential disturbance from two activities (cable repair/reburial and rock placement) occurring at the same time has also been assessed, based on a maximum impact area of 100.53km^2 (**Table 11.68**). The magnitude of the potential impact was assessed as **negligible** for all species for individual activities and both activities together.

~~11.602~~11.603 The potential for disturbance that could result from underwater noise during maintenance activities (including, cable repair/reburial and rock placement), would be localised and temporary to where and when the work is being undertaken.

Table 11.68 Maximum number of individuals (and % of reference population) that could be disturbed as a result of underwater noise associated with maintenance activities at the Project

Species	Maximum number of individuals (% of reference population) that could be disturbed for two activities (100.53km^2)	Magnitude (temporary effect)
Harbour porpoise	163 (0.3% of CIS MU)	Negligible
Bottlenose dolphin	1.05 (0.36% of IS MU)	Negligible
Common dolphin	2.8 (0.003% of CGNS MU)	Negligible
Risso’s dolphin	0.06 (0.0005% of CGNS MU)	Negligible
White-beaked dolphin	0.7 (0.002% of CGNS MU)	Negligible
Minke whale	0.9 (0.004% of CGNS MU)	Negligible
Grey seal	10 (0.6% of combined MUs; or 0.08% of wider ref pop)	Negligible (negligible)*
Harbour seal	0.01 (0.16% of NW MU; or 0.0008% wider ref pop)	Negligible (negligible)*

* Magnitude in brackets is for the wider reference population for grey seals (incl. Wales, SW Scotland, NI and RoI) and harbour seal (incl. NI)

Significance of effect

~~11.603~~11.604 Taking into account the medium marine mammal sensitivity to TTS, the medium to low sensitivity for disturbance, and the potential negligible magnitude of the impact, the significance of effect for both TTS and disturbance from underwater noise during maintenance activities has been assessed as **negligible** to **minor adverse** (not significant in EIA terms) for all species (**Table 11.69**).

Residual significance of effect

~~11.604~~11.605 No mitigation is required or proposed. Therefore, the residual significance of effect for TTS or disturbance from underwater noise during maintenance activities at the Project would remain at **negligible** to **minor adverse** (not significant in EIA terms) for all species (**Table 11.69**).

Table 11.69 Assessment of significance of effect for TTS or disturbance from underwater noise during maintenance activities at the Project

Species/receptor	Potential impact	Sensitivity	Magnitude	Significance of effect	Additional mitigation measures proposed	Residual effect
All species	TTS	Medium	Negligible	Not Significant (Minor adverse)	None required	Not Significant (Minor adverse)
Harbour porpoise, minke whale	Disturbance	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Bottlenose dolphin, common dolphin, Risso's dolphin, white-beaked dolphin, grey seal and Harbour seal		Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)

11.6.4.3 Impact 3: TTS and disturbance from underwater noise due to the presence of vessels

~~11.605~~11.606 Vessels would generally be within the windfarm site during the maintenance activities, as assessed in **Section 11.6.4.2**. However, as a precautionary approach, and to take into account vessels that could be in the windfarm site when these activities are not being conducted, the potential for TTS and disturbance effects from underwater noise and due to the presence of vessels has also been assessed separately.

~~11.606~~11.607 During the operation and maintenance phase, there would be an increase in the number of vessels in the windfarm site from the baseline. The maximum number of Project vessels that could be within the windfarm site at any one time has been estimated as 10 vessels in a heavy maintenance year (**Table 11.1**). On an average operational and maintenance year, it is expected that there could be up to three vessels at any one time. The number, type and size of vessels would vary, depending on the activities taking place at any one time.

~~11.607~~11.608 Vessel movements to and from any port would be incorporated within existing vessel routes where possible the assessment therefore focussed on considering the increase in disturbance, as a result of underwater noise from O&M vessels which would be within the windfarm site.

~~11.608~~11.609 As outlined in **Chapter 14 Shipping and Navigation**, on average there were 127 transits each month during 2019, and 91 transits each month during 2022 that intersected the windfarm site. On average, the study area (defined in Chapter 14) experienced approximately 1,308 transits per month in 2019 and 842 transits per month in 2022. During the operation and maintenance period, there would be an estimated 65 return vessel trips per month (**Table 11.1**).

~~11.609~~11.610 The vessels in the windfarm site during operation and maintenance activities would be slow moving or stationary.

Sensitivity

~~11.610~~11.611 The sensitivity of marine mammals to TTS as a result of underwater noise from vessels was considered to be **medium**, as a precautionary approach (see **Section 11.6.2**).

~~11.611~~11.612 For disturbance effects, harbour porpoise and minke whale had a **medium** sensitivity assigned, while all other species were considered **low** sensitivity (**Table 11.16**). Marine mammals within the potential disturbance area were considered to have the capacity to avoid such effects (**Table 11.8**), although any disturbance to marine mammals would be temporary and they would be expected to return to the area once the noise had ceased or they had become habituated to the sound.

Magnitude

TTS

~~11.612~~11.613 The magnitude of impact for TTS from underwater noise associated with operation and maintenance vessels has been based on the underwater noise modelling undertaken for construction vessels (see **Section 11.6.3.4** and **Appendix 11.1**).

~~11.613~~11.614 SELs have been estimated for vessels based on 24 hours continuous operation, although it is important to note that it is highly unlikely that any marine mammal would stay at a stationary location or within a fixed radius of a vessel for 24hours. It is important to note that PTS is unlikely to occur in marine mammals, as the modelling indicates that the marine mammal would only be exposed to any potential risk of PTS within less than 100m of the vessel (Appendix 11.1). PTS due to vessel activity is, therefore, highly unlikely and has not been assessed further.

~~11.614~~11.615 The results of the underwater noise modelling (**Appendix 11.1**) indicated that any marine mammals would have to be less than 100m (precautionary maximum range) from the continuous noise source, to be exposed to noise levels that could induce TTS, based on the Southall *et al*. (2019) non-impulsive thresholds and criteria for SEL_{cum} (**Section 11.6.3.3**). As the modelling indicated that the marine mammal would have to remain within less than 100m from the vessel noise source there is also unlikely to be any significant risk of TTS. Although TTS due to vessels is highly unlikely, it has been assessed as precautionary approach.

~~11.615~~11.616 The potential impact area for the worst-case scenario of up to 10 vessels within the windfarm site at the same time has been determined as $0.31km^2$ as a precautionary approach (**Table 11.70**).

Table 11.70 Predicted impact ranges (and areas) for TTS from 24-hour cumulative exposure of underwater noise associated with operational and maintenance vessels at the Project

Species	One large or medium vessel	Up to 10 vessels
Harbour porpoise	<0.1km (<0.03km^2)	0.31km^2
Dolphin species	<0.1km (<0.03km^2)	0.31km^2
Minke whale	<0.1km (<0.03km^2)	0.31km^2
Grey and Harbour seal	<0.1km (<0.03km^2)	0.31km^2

~~11.616~~11.617 The magnitude of the potential impact for any TTS due to operational vessel movements (for individual vessels or up to 10 vessels within the windfarm site at the same time) was determined as **negligible** for all marine mammal receptor species, with less than 1% of the reference populations exposed to any temporary impact (**Table 11.71**).

~~11.617~~11.618 The potential for TTS effects that could result from underwater noise from operation and maintenance vessels would be localised and temporary.

Table 11.71 Maximum number of individuals (and % of reference population) that could be at risk of TTS as a result of underwater noise associated with operation and maintenance vessels at the Project

Species	Maximum number of individuals (% of reference population) for one vessel	Maximum number of individuals (% of reference population) for up to 10 vessels	Magnitude (temporary effect)
Harbour porpoise	Same as for construction (see **Table 11.51**) (Magnitude assessed as negligible for all species)	0.5 (0.0008% of CIS MU)	Negligible
Bottlenose dolphin		0.003 (0.001% of IS MU)	Negligible
Common dolphin		0.009 (0.000009% of CGNS MU)	Negligible
Risso's dolphin		0.0002 (0.000002% of CGNS MU)	Negligible
White-beaked dolphin		0.002 (0.000005% of CGNS MU)	Negligible
Minke whale		0.003 (0.00001% of CGNS MU)	Negligible

Species	Maximum number of individuals (% of reference population) for one vessel	Maximum number of individuals (% of reference population) for up to 10 vessels	Magnitude (temporary effect)
Grey seal		0.03 (0.002% of combined MUs; or 0.0002% of wider ref pop)	Negligible (negligible)*
Harbour seal		0.00003 (0.0005% of NW Mu; or 0.000002% of wider ref pop)	Negligible (negligible)*

* Magnitude in brackets is for the wider reference population for grey seals (incl. Wales, SW Scotland, NI and RoI) and harbour seal (incl. NI)

Disturbance

~~11.618~~11.619 As a precautionary approach, based on the studies by Brandt *et al*. (2018) and Benhemma-Le Gall *et al*. (2021) (see **Section 11.6.3.4**), assessments for all species has been based on a disturbance impact range of 4km for operational and maintenance vessels. Thus, the area disturbed for one vessel would be 50.27km^2, or 502.7km^2 for 10 vessels that could be at site at any one time during a heavy maintenance year (**Table 11.1**).

~~11.619~~11.620 The disturbance area of up to 502.7km^2 for 10 vessels, is considered an unrealistic worst-case, as it does not consider the overlap of individual 4km disturbance ranges for each vessel. The total disturbed area would be approximately six times the size than the windfarm site alone (87km^2).

~~11.620~~11.621 As previously discussed in **Section 11.6.3.4**, it has been assumed that the windfarm site plus 4km buffer is a sufficiently large area that could be disturbed by 37 construction phase vessels. As this scenario presented the worst-case, ten vessels would be utilising even less space. **Plate 11.9** presents such a scenario (for illustrative purpose only), where ten vessels could be operating within the site, and demonstrates that ten vessels would be covering less area than has been assessed for 37 construction vessels.

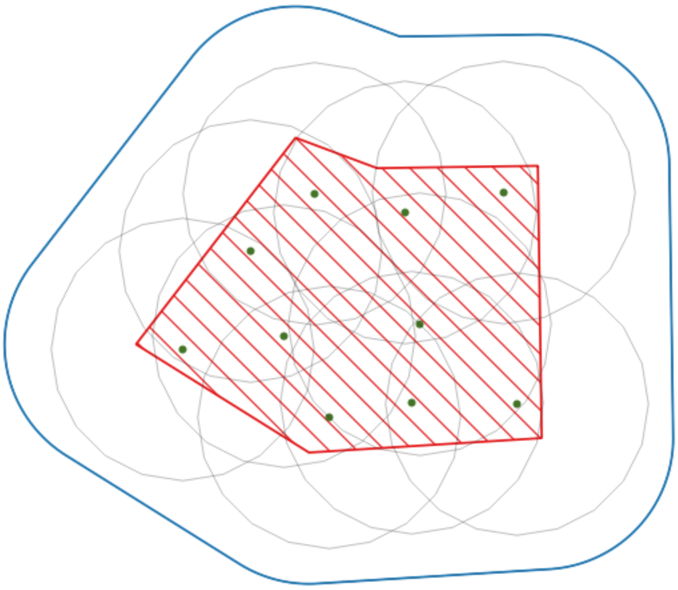

Plate 11.9 Revised site (hatched in red), with 4km buffer (blue), and 10 vessels (green dots) and their 4km buffer (grey) randomly allocated within the site.

~~11.621~~11.622 Thus, the impact area (285.4km^2) that has been assessed for 37 vessels onsite during construction was considered to also present the worst-case for the operation and maintenance vessels and was therefore not assessed again (see **Section 11.6.3.4** for details in **Table 11.52**).

~~11.622~~11.623 Based on a standard year of maintenance, it is expected that up to three vessels could be on site at any given time. As such an assessment of the number of animals potentially disturbed by three vessels (150.81km^2) has been presented in **Table 11.72.** This assessment has been based on the long-term criteria (**Table 11.10**) due to the lifetime of the Project.

~~11.623~~11.624 The impact magnitude for disturbance of marine mammals during standard operation and maintenance was assessed as **low** for harbour porpoise and bottlenose dolphin, **low (low)** for grey seal, **low (negligible)** for harbour seals and **negligible** for all remaining species. The magnitude for disturbance that could result from underwater noise from operation and maintenance vessels would be considered long-term, as vessels would be present in the area over the full operational period.

Table 11.72 Maximum number of individuals (and % of reference population) that could be disturbed as a result of underwater noise associated with operation and maintenance vessels at the Project

Species	Maximum number of individuals (% of reference population) for one vessel (150.81km^2)	Magnitude (long term effect)
Harbour porpoise	244.5 (0.39% of CIS MU)	Low
Bottlenose dolphin	1.6 (0.53% of IS MU)	Low
Common dolphin	4.2 (0.004% of CGNS MU)	Negligible
Risso's dolphin	0.09 (0.0007% of CGNS MU)	Negligible
White-beaked dolphin	1.1 (0.002% of CGNS MU)	Negligible
Minke whale	1.3 (0.007% of CGNS MU)	Negligible
Grey seal	15.1 (0.95% of combined MUs; or 0.11% of wider ref pop)	Low (Low)*
Harbour seal	0.02 (0.24% of NW MU; or 0.001% of wider ref pop	Low (Negligible)*

* Magnitude in brackets is for the wider reference population for grey seals (incl. Wales, SW Scotland, NI and RoI) and harbour seal (incl. NI)

Significance of effect

~~11.624~~11.625 Taking into account the medium marine mammal sensitivity to TTS, and the negligible impact magnitude, the significance of effect for TTS from underwater noise of operation and maintenance vessels at the Project has been assessed as **minor adverse** (not significant in EIA terms) for all species (**Table 11.73**).

~~11.625~~11.626 Based on the medium to low sensitivity for disturbance (**Table 11.8**), and the potential negligible to low magnitude of the impact, the significance of effect of disturbance from operation and maintenance vessels at the Project has been assessed as **minor adverse** (not significant in EIA terms) for harbour porpoise, minke whale, bottlenose dolphin and both seal species, and **negligible** (not significant in EIA terms) for all other dolphins (**Table 11.73**).

Residual significance of effect

~~11.626~~11.627 No additional mitigation is required or proposed. Therefore, the residual significance of effect for TTS or disturbance due to underwater noise from operation and maintenance vessels at the Project would be **negligible** to **minor adverse** (not significant in EIA terms) for all species (**Table 11.73**). It is noted that the best practice measures as outlined in **Section 11.3.3**, would reduce the potential disturbance from vessels.

Table 11.73 Assessment of significance of effect for TTS and disturbance from underwater noise of operation and maintenance vessels

Potential impact	Species/receptor	Sensitivity	Magnitude	Significance of effect	Additional mitigation measures proposed	Residual effect
TTS from cumulative SEL for operation and maintenance vessels	Harbour porpoise	Medium	Negligible	Not Significant (Minor adverse)	No additional mitigation required. Best practice measures as outlined in **Section 11.3.3**	Not Significant (Minor adverse)
	Bottlenose dolphin	Medium	Negligible	Not Significant (Minor adverse)		
	Common dolphin	Medium	Negligible	Not Significant (Minor adverse)		
	Risso's dolphin	Medium	Negligible	Not Significant (Minor adverse)		
	White-beaked dolphin	Medium	Negligible	Not Significant (Minor adverse)		
	Minke whale	Medium	Negligible	Not Significant (Minor adverse)		
	Grey seal	Medium	Negligible (negligible)*	Not Significant (Minor adverse)		
	Harbour seal	Medium	Negligible (negligible)*	Not Significant (Minor adverse)		
Disturbance from all operation and maintenance vessels	Harbour porpoise	Medium	Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Bottlenose dolphin	Low	Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Common dolphin	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)
	Risso's dolphin	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)

Potential impact	Species/receptor	Sensitivity	Magnitude	Significance of effect	Additional mitigation measures proposed	Residual effect
	White-beaked dolphin	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)
	Minke whale	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Grey seal	Low	Low (low)*	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Harbour seal	Low	Low (negligible)*	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)

* Magnitude in brackets is for the wider reference population for grey seals (incl. Wales, SW Scotland, NI and RoI) and harbour seal (incl. NI)

11.6.4.4 Impact 4: Barrier effects from underwater noise during operation and maintenance

~~11.627~~11.628 No barrier effects as a result of underwater noise during operation and maintenance are anticipated. As outlined in **Section 11.6.4.1**, currently available information indicates that there is no lasting disturbance or exclusion of marine mammals in and around windfarm sites with fixed foundations during operation.

~~11.628~~11.629 Any behavioural responses or disturbance would be limited to the close vicinity of the operational WTG. Additionally, the minimum spacing between Project WTGs (**Table 11.1**) means that there is no potential for underwater noise around individual WTGs to overlap.

~~11.629~~11.630 Taking into account the relatively small impact areas for underwater noise around operational WTGs, there is unlikely to be the potential for barrier effects to marine mammals as a result of operational noise.

~~11.630~~11.631 As assessed in **Section 11.6.4.1**, the magnitude for disturbance as a result of underwater noise from operational WTGs has been assessed as low for all marine mammal species, with a significance of effect of **minor adverse** (not significant in EIA terms).

~~11.631~~11.632 As assessed in **Sections 11.6.4.2** and **11.6.4.3**, the magnitude for disturbance from underwater noise from operational maintenance activities and vessels was assessed as negligible to low for all marine mammal species based on maximum impact areas for all activities, with a resultant **negligible** to **minor adverse** effect (not significant in EIA terms).

~~11.632~~11.633 Therefore, any potential barrier effects as a result of underwater noise during operation and maintenance have not been assessed further.

11.6.4.5 Impact 5: Barrier effects from physical presence of the windfarm

~~11.633~~11.634 The presence of a windfarm could be perceived as having the potential to create a physical barrier, 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 round it.

~~11.634~~11.635 The windfarm site is situated outside any known migration routes for marine mammals, particularly cetaceans. Possible migration routes for harbour porpoise include connections outside the wider Project area, namely from the northern UK to locations such as Iceland (Figure 1 in Andersen, 2003). Notably, porpoises from the CIS sup-population did, however, exhibit seasonal movements towards the northwest of Scotland, as observed by Gaskin (1984).

11.63511.636 There are also no know migration routes for white-beaked and Risso's dolphin, mainly for the reason that both are shelf-species preferring deeper water (**Appendix 11.2**). Risso's dolphin may migrate seasonally between shelf and offshore regions (Reid *et al.,* 2003), whereas white-beaked dolphin sightings increased during the summer month when the animals moved inshore (Canning *et al.,* 2008).

11.63611.637 Data regarding the migration patterns and winter habitats of Minke whales are currently limited. However, there is a general understanding that these whales undergo seasonal migrations between high and low latitudes, primarily for feeding and breeding purposes, as indicated by Risch *et al.* (2014).

11.63711.638 For seals, the interconnectivity between regions is better known (**Appendix 11.2**), as it has been based on tracking data. It is also known that marine mammals have been utilising the space of operational windfarms and the minimum spacing between WTGs (**Table 11.1**) would allow marine mammals to move between WTGs and through the operational windfarm site.

11.63811.639 The windfarm site would not restrict movement of marine mammals as it is also located 30km offshore, providing plenty of space for the movements of seals to and from haul-out sites (see **Section 11.6.3.5**).

11.63911.640 As outlined in **Section 11.6.4.1**, information from operational windfarms showed no evidence of exclusion of harbour porpoise or seals (for example, 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).

11.64011.641 Based on the review of marine mammal presence within operational windfarms, the potential for any barrier effect due to the physical presence of the windfarm was **negligible adverse** (not significant in EIA terms) and has not been assessed further.

11.6.4.6 Impact 6: Increased collision risk with vessels during operation and maintenance

11.64111.642 The increased risk of marine mammal collision with operational and maintenance vessels would be less than was assessed for the construction period (**Section 11.6.3.6**), given the number of vessels required would be lower.

11.64211.643 During the operation and maintenance phase, the maximum number of vessels that could be on the windfarm site at any one time has been estimated as 10 vessels (during heavy maintenance years) (**Table 11.1**). The number, type and size of vessels would vary, depending on the activities taking place at any one time. The vessels in the windfarm site during operation and maintenance would typically be slow moving or stationary.

~~11.643~~11.644 As outlined in **Chapter 14 Shipping and Navigation**, on average there were 127 transits each month during 2019, and 91 transits each month during 2022 that intersected the windfarm site. On average, the study area (defined in **Chapter 14 Shipping and Navigation**) experienced approximately 1,308 transits per month in 2019 and 842 transits per month in 2022.

~~11.644~~11.645 To provide context, the increased vessel return trips linked to operation and maintenance would not substantially contribute to the existing baseline vessel movements. During the operation and maintenance period, there would be up to 832 vessel return trips (averaging 69 per month) in a heavy maintenance year. However, this number is expected to decrease significantly to 384 return trips (approximately 32 per month) in a standard maintenance year (see **Table 11.1**).

Sensitivity

~~11.645~~11.646 As outlined in **Section 11.6.3.6**, given the existing levels of marine traffic (see **Chapter 14 Shipping and Navigation**), marine mammals in and around the windfarm site would typically be habituated to the presence of vessels and would be able to detect and avoid vessels. However, as a precautionary approach, the sensitivity of marine mammals to collision risk with vessels was considered to be **low** for all species, except minke whale which was assessed as **medium**.

~~11.646~~11.647 Marine mammals have the potential to avoid vessels being highly mobile but if an individual receptor collides with a vessel, there is the potential for a very limited capacity to recover from the worst-case impact (**Table 11.8**).

Magnitude

~~11.647~~11.648 Based on the collision rate calculated in **Section 11.6.3.6**, the increased risk of vessel collision during operation and maintenance has been estimated, based on up to 832 Project vessel return trips to and from the windfarm site per year (**Table 11.74**).

~~11.648~~11.649 For harbour porpoise, bottlenose dolphin, Risso’s dolphin and minke whale the magnitude of impact was assessed as l**ow**, and for common and white-beaked dolphin it was **negligible**. For grey seal from the combined MUs the magnitude was **medium**, and **medium** for the wider reference population. For harbour seal, the magnitude was assessed to be **high** for the NW England MU and **medium** for the wider reference population (**Table 11.74**).

~~11.649~~11.650 This assessment was highly precautionary, as it is unlikely that marine mammals would be at an increased risk of collision with vessels during operation and maintenance, considering the existing number of vessel movements in the area, and that vessels within the windfarm would be stationary for much of the time or very slow moving.

Table 11.74 Predicted number of marine mammals at risk of collision with operation and maintenance vessels

Species	Collision risk rate (%)	Number of marine mammals at risk of collision per vessel in UK waters	Number annual vessel transits associated with operation and maintenance	Number of marine mammals at increased risk	% of reference population[12]	Magnitude (permanent effect)
Harbour porpoise	5.7	11,423	832	2	0.004%	Low
Bottlenose dolphin	2.2	168	832	<1	0.012%	Low
Common dolphin	5.4	3,076	832	<1	0.0006%	Negligible
Risso's dolphin	7.3	636	832	<1	0.0011%	Low
White-beaked dolphin	4.6	1,597	832	<1	0.0008%	Negligible
Minke whale	6.9	748	832	<1	0.002%	Low
Grey seal	4.3	6,993	832	2	0.1% (0.013%)	Medium (Medium)*
Harbour seal	3.4	1,438	832	<1	5.1% (0.02%)	High (Medium)*
* Magnitude in brackets is for the wider reference population for grey seals (incl. Wales, SW Scotland, NI and RoI) and harbour seal (incl. NI)						

[12] Refer to **Table 11.14** in **Section 11.5.9** for a summary of the species reference populations

Significance of effect

~~11.650~~11.651 Taking into account the low to medium marine mammal sensitivity, and the potential magnitude of impact to the receptors, as assessed in **Table 11.74**, the impact significance for any potential increased collision risk as a result of operation and maintenance vessels has been assessed as a very precautionary **moderate adverse** (significant in EIA terms) for harbour seal, which reduced to **minor adverse** (not significant in EIA terms) for the wider reference population. Harbour porpoise, bottlenose dolphin, Risso's dolphin, minke whale and grey seal were assessed as **minor adverse** (not significant in EIA terms), whilst common dolphin and white-beaked dolphin have both been assessed as **negligible adverse** (not significant in EIA terms) (**Table 11.75**).

~~11.651~~11.652 As outlined above, this was highly precautionary, as it is unlikely that marine mammals would be at increased collision risk with vessels considering the existing number of vessel movements in the area, and that vessels within the windfarm would be stationary for much of the time or very slow moving. Taking into account the disturbance from vessels, the actual risk is likely to be very low or negligible for all species.

Additional mitigation

~~11.652~~11.653 As outlined in **Section 11.3.3**, vessel movements, where possible, would follow set vessel routes and, hence, areas where marine mammals are accustomed to vessels, to reduce any increased collision risk. All vessel movements would be kept to the minimum number that is required for Project works to reduce any potential collision risk. Additionally, vessel operators would use best practice to reduce any risk of collisions with marine mammals. These measures are detailed within the Outline PEMP.

Residual significance of effect

~~11.653~~11.654 Taking into account the best practice mitigation to reduce the risk of collision with vessels, the residual significance of effect would be **minor adverse** (not significant in EIA terms) for all species (**Table 11.75**).

Table 11.75 Assessment of significance of effect for increased collision risk with vessels during operation and maintenance

Species/receptor	Sensitivity	Magnitude	Significance of effect	Additional mitigation measures proposed	Residual effect
Harbour porpoise	Low	Low	Not Significant (Minor adverse)	Best practice measures, as identified in the Outline PEMP (see **Section 11.3.3**).	Not Significant (Minor adverse)
Bottlenose dolphin	Low	Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Common dolphin	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)
Risso's dolphin	Low	Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)
White-beaked dolphin	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)
Minke whale	Medium	Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Grey seal	Low	Medium (medium)*	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Harbour seal	Low	High (Medium)*	Significant (Moderate to minor adverse)		Not Significant (Minor adverse)

* Magnitude in brackets is for the wider reference population for grey seals (incl. Wales, SW Scotland, NI and RoI) and harbour seal (incl. NI)

11.6.4.7 Impact 7: Changes to prey resources

~~11.654~~11.655 Any changes to prey resources, such as fish and shellfish, during operation and maintenance would be less than those assessed for construction (**Section 11.6.3.7**).

~~11.655~~11.656 As outlined in **Chapter 10 Fish and Shellfish Ecology**, the potential impacts on fish species during operation and maintenance can result from:

- Permanent habitat loss
- Temporary habitat loss, physical disturbance of the seabed, increased SSCs and sediment deposition
- Underwater noise
- EMF
- Barrier effects from underwater noise or EMF
- Introduction of hard substrate
- Changes in fishing activity

~~11.656~~11.657 Any impacts on prey species have the potential to affect marine mammals.

Sensitivity

~~11.657~~11.658 As outlined in **Section 11.6.3.7**, harbour porpoise and minke whale were assessed to have **low** to **medium** sensitivity to changes in prey resources. All dolphin and seal species were considered to have **low** sensitivity to changes in prey resources.

Magnitude

Permanent habitat loss

~~11.658~~11.659 As outlined in **Table 11.1**, the worst-case area of total habitat loss due to the footprint of infrastructure within the windfarm site is 0.51km^2, including WTGs, OSPs, scour protection and cable protection. This represents approximately 0.6% of seabed habitat in the windfarm site (87km^2).

~~11.659~~11.660 The magnitude of associated impact on spawning/nursery grounds, molluscs and crustaceans was assessed as negligible, with negligible to minor adverse significance of effect (**Chapter 10 Fish and Shellfish Ecology**).

~~11.660~~11.661 The magnitude of impact for any change to prey resources for marine mammals due to permanent habitat loss would be **negligible**.

Temporary habitat loss, physical disturbance of the seabed, increased SSCs and sediment deposition

~~11.661~~11.662 The magnitude of temporary habitat loss, physical seabed disturbance, increases in SSCs and sediment deposition due to operation and maintenance activities would be less than during the construction phase (**Section 11.6.3.7**). Such impacts would arise from periodic jack-up vessel and anchor deployment, and cable repair, replacement and reburial activities.

~~11.662~~11.663 The significance of effect on fish species due to such impacts was assessed as negligible to minor adverse (**Chapter 10 Fish and Shellfish Ecology**).

~~11.663~~11.664 The magnitude of impact for any change to prey resources for marine mammals would be **negligible**.

Underwater noise

~~11.664~~11.665 As outlined in **Appendix 11.1** and **Chapter 10 Fish and Shellfish Ecology,** the risk of recoverable injury or TTS from continued exposure to underwater noise from operational WTGs was minimal, with predicted impact ranges of less than 50m around the WTGs. For other for maintenance activities (such as cable repair/reburial and rock placement) and vessels, the impact ranges were also less than 50m for recoverable injury and TTS.

~~11.665~~11.666 The assessments of underwater noise during operation and maintenance in **Chapter 10 Fish and Shellfish Ecology** indicated that the significance of effect was negligible adverse (not significant in EIA terms) for all fish and shellfish species.

~~11.666~~11.667 The magnitude of impact for any changes in prey resource for marine mammals from underwater noise during operation and maintenance would be **negligible**.

Electromagnetic Fields

~~11.667~~11.668 The Project would transmit energy produced along the network of inter-array and platform link cables, linking the individual WTGs, and the WTGs to the OSPs. As energy is transmitted, the cables emit low-energy EMF. The electrical and magnetic fields generated increase proportionally to the amount of electricity transmitted.

~~11.668~~11.669 Cables would have a burial depth of 0.5-3m, with a target depth of 1.5m, substantially reducing the levels of EMF in the surrounding area. Where cable burial is not possible (e.g., due to hard substrate or at cable crossings), cable protection would be added, which would reduce the levels of EMF.

~~11.669~~11.670 There would be no direct effects of EMF on marine mammals, but EMF has the potential to interfere with the navigation of sensitive migratory and pelagic prey species by affecting the speed and/or course of their movements (see **Chapter 10 Fish and Shellfish Ecology** for further information).

~~11.670~~11.671 Given the small area around the inter-array/platform link cables where the presence of EMF may be detected by fish and shellfish, contact with EMF would be limited. In the context of the wider available habitat, the magnitude of this impact on fish and shellfish receptors was considered to be negligible to low, and the significance of effect was assessed as negligible to minor adverse (not significant in EIA terms).

~~11.671~~11.672 The magnitude of impact for any changes in prey resource for marine mammals from EMF during operation and maintenance would be **negligible**.

Barrier effects

~~11.672~~11.673 There is the potential for underwater noise or EMF to cause a barrier effect to the movement of fish species during operation and maintenance. Mobile migratory, diadromous, and pelagic species may temporarily adjust their movement direction when encountering EMF, but it is not expected to create significant barriers in the Irish Sea. Thus, the significance of effect was deemed to be minor adverse for all fish and shellfish groups (see **Chapter 10 Fish and Shellfish Ecology**) with regard to barrier effects during operation and maintenance.

~~11.673~~11.674 Therefore, there would be no impact on prey resources of marine mammals as a result of barrier effects during operation and maintenance.

Introduction of hard substrate

~~11.674~~11.675 As outlined in **Chapter 10 Fish and Shellfish Ecology**, man-made structures introduced to the area, such as foundations, scour and rock protection, may be colonised by a range of benthic invertebrate species, potentially increasing ecological diversity by acting as an artificial reef, and with the potential to act as fish aggregating devices.

~~11.675~~11.676 The area of hard substrate within the windfarm site from GBS foundations, and associated scour and cable protection, that has the potential to be colonised, is approximately 0.51km^2. The hard substrate would remain in place for the lifetime of the Project and, therefore, the creation of any hard substrate habitat is assessed as a permanent effect.

~~11.676~~11.677 As a precautionary approach, **Chapter 10 Fish and Shellfish Ecology** has determined that, for fish species, there was an overall effect of negligible beneficial significance. This effect could have a positive effect on marine mammals through potential additional prey resources. A study at the Egmond aan Zee OWF showed an overall increase in acoustic activity of harbour porpoise inside the operating wind farm which may have been attributed to the reef effect, attracting more prey species, and/or the sheltering effect of the turbines from heavy ship traffic (Scheidat *et al.,* 2011).

~~11.677~~11.678 No adverse impact on prey resources of marine mammals would therefore occur as a result of the introduction of hard substrate during the operational phase of the Project.

Changes in fishing activity

~~11.678~~11.679 As outlined in **Chapter 13 Commercial Fisheries**, there is potential for commercial fishing activity to be displaced from within the windfarm site, due to presence of the subsurface structures. However, the windfarm site is located in an area with relatively low fishing intensity. Embedded mitigation relevant to commercial fisheries is outlined in **Chapter 13 Commercial Fisheries**, including measures to promote co-existence with fishers during the operation and maintenance phase.

~~11.679~~11.680 Any changes to prey resources as a result of changes to fishing activity during operational phase of the Project would therefore be **negligible** to marine mammals.

Significance of effect

~~11.680~~11.681 Taking into account the marine mammal sensitivity for each species, and the negligible potential magnitude of the impact, the significance for any changes in prey resource during the operation and maintenance phase has been assessed as **negligible** to **minor adverse** (not significant in EIA terms) for all species (**Table 11.76**).

Residual significance of effect

~~11.681~~11.682 No mitigation is required or proposed. Therefore, the residual significance of effect for any changes to prey resource during the operation and maintenance phase would be **negligible** to **minor adverse** (not significant in EIA terms) for all species (**Table 11.76**).

Table 11.76 Assessment of significance of effect for any changes in prey resources during operation and maintenance

Species/receptor	Sensitivity	Magnitude	Significance of effect	Additional mitigation measures proposed	Residual effect
Harbour porpoise	Low to Medium	Negligible	Not Significant (Negligible to Minor adverse)	No additional mitigation required	Not Significant (Negligible to Minor adverse)
Bottlenose dolphin	Low	Negligible	Not Significant (Negligible adverse)		
Common dolphin	Low	Negligible			
Risso's dolphin	Low	Negligible			
White-beaked dolphin	Low	Negligible			
Minke whale	Low to Medium	Negligible	Not Significant (Negligible to Minor adverse)		
Grey seal	Low	Negligible (negligible)*	Not Significant (Negligible adverse)		
Harbour seal	Low	Negligible (negligible)*	Not Significant (Negligible adverse)		

* Magnitude in brackets is for the wider reference population for grey seals (incl. Wales, SW Scotland, NI and RoI) and harbour seal (incl. NI)

11.6.4.8 Impact 8: Changes to water quality

~~11.682~~11.683 During the operation and maintenance phase, there is the potential for maintenance activities to disturb sediment, potentially resulting in increases in SSCs.

~~11.683~~11.684 Cable repairs and reburial could be needed over the operational lifetime of the Project. It is estimated that reburial of an average of 100m of inter-array/ platform link cables could be required every year and up to 200m of inter-array/platform link cables could be repaired/replaced every year (**Table 11.1**). In practice, however, these activities are not anticipated to occur every year and would more likely involve less frequent unplanned reburial of cable. The scale of these impacts would be small, infrequent and of short-term duration and of a lower magnitude than during the construction phase.

~~11.684~~11.685 As assessed in **Chapter 8 Marine Sediment and Water Quality**, any changes to water quality during operation and maintenance would also be of **negligible** magnitude for marine mammals. Consequently, the effect significance is **negligible adverse**.

11.6.4.9 Impact 9: Disturbance of seals at haul-out sites

~~11.685~~11.686 As outlined in **Section 11.6.3.9**, there would be no direct impact from underwater noise arising from piling and other construction activities in the windfarm site that could disturb seals at haul-out sites, taking into account the distance from shore (30km) and distance the 35km from the nearest haul-out site. Consequently, noise generated from operation and maintenance activities would be lower compared to the construction period.

~~11.686~~11.687 Similarly, the annual vessel traffic that could potentially be passing seal haul-out sites during the operation and maintenance phase is projected to be lower than that during the construction period (**Table 11.1**).

Sensitivity

~~11.687~~11.688 As a precautionary approach, both grey and harbour seals were considered to have **low** sensitivity to disturbance at seal haul-out sites.

Magnitude

~~11.688~~11.689 The likelihood that seals at their haul-outs would be subject to increased vessels collision risk was deemed to be unlikely as evidence showed (**Section 11.6.3.6**). The section also outlines in more detail that the collision risk assessment was based on a very precautionary approach and that vessel movements associated with the Project during operation and maintenance were considered as a **low** magnitude of impact.

~~11.689~~11.690 Disturbance from operation and maintenance activities occurring at the windfarm site was considered a **negligible** magnitude of impact.

Significance of effect

~~11.690~~11.691 Taking into account the low sensitivity of grey and harbour seal, and the precautionary low magnitude of the impact for disturbance at seal haul-out sites from vessels, the significance of effect has been assessed as **minor adverse** (not significant in EIA terms) (**Table 11.77**).

~~11.691~~11.692 Taking into account the low sensitivity of grey and harbour seal, and the negligible magnitude of the impact for disturbance from operation and maintenance activities at the windfarm site, the significance of effect has been assessed as **negligible adverse** (not significant in EIA terms) (**Table 11.77**).

Additional mitigation

~~11.692~~11.693 As outlined in **Section 11.3.3**, vessel movements, where possible, would follow set vessel routes and, hence, areas where marine mammals are accustomed to vessels, which would also reduce the disturbance at seal haul-out sites. All vessel movements would be kept to the minimum number that is required to undertake the works. Additionally, vessel operators would use industry best practice measures, including, if necessary, minimum distances from seal haul-out sites, particularly during sensitive periods for breeding and moulting. These measures are detailed within the Outline PEMP.

Residual significance of effect

~~11.693~~11.694 The residual significance of effect for any disturbance at seal haul-out sites during operation and maintenance from vessels would be **negligible adverse** (not significant in EIA terms) and from activities would be **minor adverse** (not significant in EIA terms) (**Table 11.77**).

Table 11.77 Assessment of significance of effect for disturbance at seal haul-out sites during operation and maintenance activities and from vessels

Potential impact	Species /receptor	Sensitivity	Magnitude	Significance of effect	Additional mitigation measures proposed	Residual effect
Disturbance at seal haul-out sites during operation and maintenance activities at windfarm site	Grey seal	Low	Negligible	Not Significant (Negligible adverse)	No mitigation required in relation to disturbance at seal haul-out sites. Best practice measures, as identified in the Outline PEMP (see **Section 11.3.3**)	Not Significant (Negligible adverse)
	Harbour seal	Low	Negligible			
Disturbance at seal haul-out sites from vessel movement during operation and maintenance	Grey seal	Low	Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Harbour seal	Low	Low			

11.6.5 Potential effects during decommissioning

~~11.694~~11.695 The scope of the decommissioning works would most likely involve the removal of the accessible installed components (outlined in Chapter 5 Project Description). Prior to decommissioning, the Project would develop a Decommissioning Programme.

~~11.695~~11.696 Potential effects for marine mammals during decommissioning are:

- Impact 1: PTS or TTS from underwater noise during WTG/OSP foundation removal, cable removal (if required) and other offshore decommissioning activities
- Impact 2: Disturbance from underwater noise during WTG/OSP foundation removal, cable removal (if required) and other offshore decommissioning activities
- Impact 3: Disturbance from underwater noise, presence and movements of vessels
- Impact 4: Barrier effect from underwater noise
- Impact 5: Increased collision risk with vessels
- Impact 6: Changes to prey resource
- Impact 7: Changes to water quality
- Impact 8: Disturbance of seals at haul-out sites

~~11.696~~11.697 Potential effects on marine mammals associated with decommissioning have not been assessed in detail, as further assessments would be carried out ahead of any decommissioning works to be undertaken, taking account of known information at that time, including relevant guidelines and requirements. The detailed Decommissioning Programme would provide details of the techniques to be employed and any relevant mitigation measures required.

~~11.697~~11.698 It is not possible to provide details of the methods that would be used during decommissioning at this time. However, is it expected that the activity levels would be comparable to construction (with the exception of pile driving noise, which would not occur).

~~11.698~~11.699 During decommissioning, the potential effects on marine mammals are anticipated to be similar, or less, than the worst-case assessment for the construction phase, noting no piling (or UXO clearance) would be required. Level of effect would depend on the methods used.

~~11.699~~11.700 **Table 11.78** provides an indicative assessment of the potential impacts during decommissioning, based on the worst-case assessment undertaken for the construction phase.

Table 11.78 Indicative assessment of significance of effect for decommissioning, based on construction

Potential impact	Species/receptors	Sensitivity	Magnitude	Significance of effect	Additional mitigation measures proposed	Residual effect
Impact 1: PTS or TTS from underwater noise	All marine mammal species	High – Medium	Medium – Negligible	Significant (Major adverse) – Not Significant (Minor adverse)	MMMP to reduce risk of PTS	Not Significant (Minor adverse)
Impact 2: Disturbance from underwater noise	All marine mammal species	Medium – Low	Low - Negligible	Not Significant (Minor – Negligible adverse)	None required	Not Significant (Minor – Negligible adverse)
Impact 3: Disturbance from underwater noise, presence and movements of vessels	All marine mammal species	Medium – Low	Low – Negligible	Not Significant (Minor – Negligible adverse)	None required	Not Significant (Minor – Negligible adverse)
Impact 4: Barrier effect from underwater noise	All marine mammal species	Medium – Low	Negligible	Not Significant (Minor – Negligible adverse)	None required	Not Significant (Minor – Negligible adverse)
Impact 5: Increased collision risk with vessels	All marine mammal species14	Medium – Low	High - Low	Significant (Moderate) – Not Significant (Minor adverse)	Best practice measures (see **Section 11.3.3**).	Not Significant (Minor adverse)
Impact 6: Changes to prey resource	All marine mammal species	Low – Medium	Low – Negligible	Not Significant (Minor – Negligible adverse)	None required	Not Significant (Minor – Negligible adverse)

Potential impact	Species/receptors	Sensitivity	Magnitude	Significance of effect	Additional mitigation measures proposed	Residual effect
Impact 7: Changes to water quality	All marine mammal species	Negligible	Negligible	Not Significant (Negligible adverse)	None required	Not Significant (Negligible adverse)
Impact 8: Disturbance of seals at haul-out sites	Seal species	Low	Low – Negligible	Not Significant (Negligible – Minor adverse)	Best practice measures (see **Section 11.3.3**).	Not Significant (Minor – Negligible adverse)

11.7 Cumulative effects

~~11.700~~11.701 In order to undertake the CEA, and as per the PINS advice note (PINS, 2019), the potential for cumulative effects has been established considering each Project-alone effect and the Impact Area alongside the list of plans, projects and activities that could potentially interact. These stages are detailed below.

~~11.701~~11.702 The goal of the approach for evaluating the potential cumulative effects to marine mammals is to minimise uncertainties and complexities associated with utilizing various assessments from EIAs of projects considered in the CEA process. Differences in noise models, thresholds, criteria, and methods for estimating density among these assessments often create challenges.

11.7.1 Identification of potential cumulative effects

~~11.702~~11.703 Part of the cumulative assessment process was the identification of which individual impacts assessed for the Project have the potential for a cumulative effect on receptors (impact screening). This information is set out in **Table 11.79**. Impacts for which the significance of effect was assessed in the Project-alone assessment as 'negligible' or above, are considered in the CEA impact screening (i.e. those assessed as 'no change' are not taken forward as there is no potential for them to contribute to a cumulative effect).

~~11.703~~11.704 **Appendix 11.4** provides detailed information on the CEA project screening process. It further outlines the types of activities and industries that may contribute to the potential for cumulative effects during construction and operation and maintenance. The following impacts were considered:

- The risk of PTS from underwater noise
- The risk of TTS from underwater noise
- Disturbance from underwater noise
- Barrier effects
- Vessel collision risk
- Changes to prey availability
- Changes to water quality
- Disturbance at seal haul-out sites

~~11.704~~11.705 Cumulative effects due to decommissioning impacts have been screened out of the assessment (see **Appendix 11.4** for more information).

~~11.705~~11.706 Whilst the cumulative effects of increased collision risk with vessels, disturbance at haul-out sites and changes to prey resources have been based on the construction phase, presenting the worst-case scenario, it is expected that these impacts would be less significant during operation and maintenance.

Table 11.79 Summary of potential cumulative effects (impact screening)

Impact	Project-alone residual effects significance	Potential for cumulative effects	Rationale
Construction phase			
Auditory injury due to underwater noise (risk of permanent change in hearing sensitivity)	Not Significant (Minor adverse)	No	PTS can occur as part of piling activities during OWF installation, pile driving during O&G platform installation, and underwater explosives (used occasionally during the removal of underwater structures and UXO clearance) (JNCC, 2010b, 2010c). However, 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. Other activities, such as dredging, drilling, rock placement, vessel activity, operational windfarms, oil and gas installations or wave and tidal energy generating sites will emit broadband noise in lower frequencies, and PTS would be close range to the project and cumulative effects from these activities is very unlikely. Therefore, the potential risk of PTS has been screened out from further consideration in the CEA.
Auditory injury due to underwater noise (risk of temporary change in hearing sensitivity)	Not Significant (Minor adverse)	No	Where there is little information on the potential disturbance ranges for marine mammals, TTS has been used to indicate possible fleeing response. It is acknowledged that disturbance is likely to have greater impact ranges than for TTS. The risk of TTS would be within disturbance ranges for marine mammals. Therefore, the potential risk of TTS has been screened out from further consideration in the CEA.
Disturbance from underwater noise	Not Significant (Minor adverse)	Yes	There is a pathway for cumulative effects and disturbance to marine mammals from underwater noise (see **Table 5.1** in **Appendix 11.4** for the activities and projects screened in). This has been screened into the CEA. See **Section 11.7.3** for the full assessment.

Impact	Project-alone residual effects significance	Potential for cumulative effects	Rationale
Barrier effects due to disturbance from windfarms	Not Significant (Minor adverse)	Yes	There is a pathway for cumulative effects and barrier effect of multiple OWFs during construction. has been screened into the CEA. See **Section 11.7.3** or the full assessment.
Vessel collision risk	Not Significant (Minor adverse)	Yes	There is a pathway for cumulative effects and the increase in vessel collision risk due to an increase in vessels has been considered further in **Section 11.7.3** for the full assessment.
Changes to prey resources	Not Significant (Minor to negligible adverse)	Yes	There is a pathway for cumulative effects and changes to prey resources, has been considered further in **Section 11.7.3**.
Disturbance at seal haul-out sites	Not Significant (Minor to negligible adverse)	Yes	There is a pathway for cumulative effects and the disturbance at seal haul-out sites has been screened into the CEA. See **Section 11.7.3** for the full assessment.
Changes to water quality	Not Significant (Negligible adverse)	No	No significant impacts with regard to water quality are expected as a result of the Project. As discussed in **Section 11.6.3.8**, increased SSCs are unlikely to affect marine mammals because they have negligible sensitivity to this type of impact. Any changes to water quality as a result of aggregate extraction or dredging, or other construction projects/ maintenance activities would be very localised and temporary. Changes to water quality (including from aggregate extraction and dredging) has been screened out from the CEA.
Operation and maintenance phase			
Disturbance from operational WTGs	Not Significant (Minor adverse)	Yes	There is a pathway for cumulative effects and the operational noise from WTGs throughout the lifetime of the Project. See **Section 11.7.3** for the full assessment.

Impact	Project-alone residual effects significance	Potential for cumulative effects	Rationale
Underwater noise from the maintenance activities associated	Not Significant (Minor adverse)	No	No potential for cumulative impact has been identified and has therefore been screened out from the CEA. See **Section 3.1** of **Appendix 11.4** for more information.
Decommissioning phase			
Underwater noise from the decommissioning activities	Not Significant (Minor – Negligible adverse)	No	No potential for cumulative impact has been identified and has therefore been screened out form the CEA. See **Section 3.2** of **Appendix 11.4** for more information.

11.7.2 Identification of other plans, projects and activities

~~11.706~~11.707 The identification and review of the other plans, projects and activities that may result in cumulative effects for inclusion in the CEA (described as 'project screening') was undertaken alongside an understanding of Project-alone effects.

~~11.707~~11.708 The plans and projects screened into the CEA are located in the relevant marine mammal reference population areas. The area used for the CEA screening for projects was based on that of the CIS MU for harbour porpoise, common dolphin, Risso's dolphin, white-beaked dolphin, and minke whale. For bottlenose dolphin, it was that of the IS MU, while the boundaries for grey and harbour seal were those of all the relevant seal MUs (**Table 11.14**). Further information on the CEA screening (the screening of plans, projects and activities) is provided in **Appendix 11.4**.

~~11.708~~11.709 All projects considered for CEA across all topics have been identified within **Appendix 6.1 CEA Project Long List** (Document Reference 5.2.6.1), which forms an exhaustive list of plans, projects and activities relevant to the Project. Specific screening and a summary of projects screened in for marine mammals is provided in **Appendix 11.4**.

11.7.3 Assessment of cumulative effects

~~11.709~~11.710 Having established the residual effects from the Project with the potential for a cumulative effect, along with the other relevant plans, projects and activities, the following sections provide an assessment of the level of cumulative effect that may arise. These are detailed below per impact where the potential for cumulative effects has been identified (in line with **Table 11.79**).

~~11.710~~11.711 Given the interconnected nature of the Project and the Transmission Assets, a separate 'combined' assessment of these is provided within the CEA (**Section 11.7.3.1**). Thereafter, the cumulative assessment considers all plans, projects and activities screened into the CEA (**Section 11.7.3.2**).

11.7.3.1 Cumulative assessment – the Project and Transmission Assets (combined assessment)

~~11.711~~11.712 While the Transmission Assets[13] are being considered in a separate ES as part of a separate DCO Application, given the functional link, a 'combined' assessment has been made considering both the Project and the Transmission

[13] As the Transmission Assets includes infrastructure associated with both the Project and the Morgan Offshore Wind Project Generation Assets, it should be noted that the combined assessment considers the transmission infrastructure for both the Project and the Morgan Offshore Wind Project Generation Assets.

Assets. This provides an assessment of impact interactions and additive effects and thus any change in the significance of effects as assessed separately.

~~11.712~~11.713 The Transmission Assets PEIR (Morgan Offshore Wind Limited and Morecambe Offshore Windfarm Ltd, 2023a) informs the assessment.

~~11.713~~11.714 Only marine elements of the transmission infrastructure would interact with the Project in relation to marine mammals, including:

- Export cables adjoining the Morgan Offshore Wind Project Generation Assets and the Project and making landfall south of Blackpool
- Booster station required for the Morgan Offshore Wind Project Generation Assets
- OSP(s) (for the Project and Morgan Offshore Wind Project Generation Assets)

~~11.714~~11.715 The following (Project-alone) impacts to marine mammals were concluded in the Transmission Assets PEIR (Morgan Offshore Wind Limited and Morecambe Offshore Windfarm Ltd, 2023):

- Injury and disturbance from underwater sound generated from piling – **Minor adverse (not significant in EIA terms)**
- Injury and disturbance from underwater sound generated from UXO detonation – **Minor adverse (not significant in EIA terms)**
- Injury and disturbance to marine mammals from vessel use and other (non-piling) sound-producing activities – **Minor adverse (not significant in EIA terms)**
- Injury to marine mammals due to collision with vessels – **Minor adverse (not significant in EIA terms)**
- Effects on marine mammals due to changes in prey availability – **Minor adverse (not significant in EIA terms)**
- Injury and disturbance from sound generated from pre-construction survey sources – **Minor adverse (not significant in EIA terms)**

~~11.715~~11.716 These impacts align with those assessed for the Project (with small differences in wording). While all effects are additive between the Project and the Transmission Assets, due to the localised effects there is no material change in significance of effects when considering the majority of impacts together (see impact screening summary in **Table 11.83**).

~~11.716~~11.717 There would however be increased interaction relating to the following impacts, which were assessed in further detail below:

- Injury and disturbance from underwater noise due to construction activities such as piling
- Injury and disturbance from underwater noise due to non-piling activities
- Increase in collision risk with vessels
- Injury and disturbance from UXO detonation (assessed under cumulative effect 1c in **Section 11.7.3.2**, in which the potential for two UXO clearances for each of the projects was assessed)

~~11.717~~11.718 There was no assessment for white-beaked dolphin for the Transmission Assets PEIR (Morgan Offshore Wind Limited and Morecambe Offshore Windfarm Ltd, 2023) and therefore they have not been assessed any further.

Cumulative effect 1: Injury and disturbance from underwater noise

Cumulative effect 1a: Assessment of underwater noise impacts from piling

~~11.718~~11.719 The key components of the Transmission Assets that require piling comprise of four OSPs at Morgan, two OSPs at Morecambe, and the potential Morgan offshore booster station[14].

~~11.719~~11.720 For the combined assessment, the two OSPs at Morecambe are included as components of the Project and not be duplicated as components for the Transmission Assets.

Auditory injury during piling

~~11.720~~11.721 There may be temporal and spatial overlap of the construction phases with the Project in terms of piling generated underwater noise, potentially resulting in a cumulative impact. The assessment for piling alone for Transmission Assets has been presented as having a minor adverse effect based on a negligible magnitude for all marine mammal species. The cumulative exposure from single or sequential piling at maximum hammer energy at the Project (without mitigation) was assessed as having a **major adverse** effect on harbour porpoise and minke whale, **moderate adverse** for harbour seal and **minor adverse** for all other species (**Table 11.27** in **Section 11.6.3.1**).

[14] At the time of writing this ES a decision had been taken that the OSPs would not be included within the DCO Application for the Transmission Assets. This decision post-dated the Transmission Asset PEIR (within which the OSPs are also assessed). The final ES for the Transmission Assets will therefore not include the OSPs or associated interconnector cables. Additionally, a decision had been taken since the PEIR that the Morgan OBS would no longer be required. Whilst the OSPs, offshore booster station and interconnector cables will not form part of the DCO Application for the Transmission Assets, they are included here as they were contained within the Transmission Asset PEIR which has been used to inform this ES and summary document.

~~11.721~~11.722 **Table 11.80** summarises SEL_{cum} PTS impact ranges for all species groups for the key components of the Transmission Assets and the Project (noting that Morecambe OSPs are reflected as per the Project-alone ranges in **Table 11.21** as WTGs and OSPs have the same impact ranges). Given the impact ranges and mitigation that would be employed by both projects, there would be no significant cumulative impacts for auditory injury and thus, this has not been assessed further. The cumulative assessment has been undertaken on potential disturbance impacts.

Table 11.80 Summary of SEL_{cum} PTS impact ranges at maximum hammer energy for single piling and areas of effect of the Transmission Asset key components (ranges taken from the Project ES and the Transmission Asset PEIR); n/e= not exceeded the threshold

Species	Threshold (weighted SEL_{cum})	Location	Monopile		Pin-pile	
			Range (m)	Area (km^2)	Range (m)	Area (km^2)
Harbour porpoise (VHF)	155 dB re 1 µPa^{2}s	Morgan offshore booster station	2,065	13.40	*n/e*	
		Morgan OSP	1,665	8.71	*n/e*	
		Morecambe OSP / WTG	8,100	150	5100	60
Dolphins (HF)	185 dB re 1 µPa^{2}s	Morgan offshore booster station	*n/e*		*n/e*	
		Morgan OSP	*n/e*		*n/e*	
		Morecambe OSP / WTG	<100	<0.01	<100	<0.01
Minke whale (LF)	183 dB re 1 µPa^{2}s	Morgan offshore booster station	3,045	29.13	161	0.08
		Morgan OSP	3,865	46.93	656	1.35
		Morecambe OSP / WTG	13,000	330	8,900	150
Grey and harbour seal (PCW)	185 dB re 1 µPa^{2}s	Morgan offshore booster station	*n/e*		*n/e*	
		Morgan OSP	*n/e*		*n/e*	
		Morecambe OSP / WTG	950	1.9	<100	<0.01

Disturbance during piling

~~11.722~~11.723 The combined assessment in **Table 11.81** captures the cumulative impact of disturbance of all species groups for the key components. For harbour porpoise the magnitude was **medium**, and for bottlenose dolphin it was **high** if Transmission Assets and Morecambe were to pile at the same time. Grey seal was assessed as **low**, as well as Risso's dolphin with just over 1% of the reference population disturbed. For all other marine mammal species, the magnitude was **negligible**.

~~11.723~~11.724 The effect significance, based on a medium sensitivity for all marine mammal species assessed was therefore assessed as **major adverse** for bottlenose dolphin, **moderate adverse** for harbour porpoise and **minor adverse** for all other animals that have a low or negligible magnitude in the combined assessment.

~~11.724~~11.725 It should be noted that for the disturbance assessment the dose-response curves were utilised. These are based on the hearing sensitivity of harbour porpoise but were applied to all cetaceans (both Morgan and Morecambe used this approach). By using this approach, the likelihood of overestimating the number of disturbed animals is relatively high and should be used with precaution when interpreting the numbers.

~~11.725~~11.726 Population modelling has been conducted for other plans and projects with the potential for cumulative effects of disturbance from piling at the Project and Transmission Assets, as well as other projects (details in **Section 11.7.3.2**). The long-term population consequences were assessed as low for bottlenose dolphin and negligible for all species for the next 25 years (standard modelling period; details in **Appendix 11.2**). Similarly, the CEA population modelling results laid out in the Transmission Asset's PEIR described a low magnitude for both harbour porpoise and bottlenose dolphin, as the only species assessed using this method. The population modelling considered simultaneous piling of several projects, resulting in more realistic outcomes compared to the scenarios evaluated in **Table 11.81**. Consequently, these results should take precedence.

Table 11.81 Number of animals disturbed from the cumulative effects of piling at the Project and the key components of the Transmission Asset (DRC = dose-response curve) (values taken from Transmission Asset PEIR)

Harbour porpoise			
Project	**Harbour porpoise density (/km²)**	**Impact area (26km EDR)**	**Maximum number of individuals potentially disturbed during single piling**
The Project (incl. Morecambe OSP)	1.621	2123.7	3,442.5
Morgan offshore booster station	0.274	DRC	979.0
Transmission Assets (incl. Morgan OSP)	0.560	DRC	1,793.0
Total number of harbour porpoise			**6,214.5**
Percentage of CIS MU			9.94%
Magnitude of cumulative effect			Medium
Harbour porpoise			
Project	**Harbour porpoise density (/km²)**	**Impact area (15km EDR)**	**Maximum number of individuals potentially disturbed during single piling**
The Project (incl. Morecambe OSP)	1.621	706.9	1,145.8
Morgan offshore booster station	0.274	DRC	779.0
Transmission Assets (incl. Morgan OSP)	0.560	DRC	1289.0
Total number of harbour porpoise			**3,213.8**
Percentage of CIS MU			5.14%
Magnitude of cumulative effect			Medium
Bottlenose dolphin			
Project	**Bottlenose dolphin density (/km²)**	**Impact area (km²)**	**Maximum number of individuals potentially disturbed during single piling**
The Project (including Morecambe OSP)	0.0104	DRC	56.3
Morgan offshore booster station	0.0350	DRC	11
Transmission Assets (incl. Morgan OSP)	0.0010	DRC	4
Total number of bottlenose dolphin			**71.3**
Percentage of IS MU			24.3%
Magnitude of cumulative effect			High

Common dolphin			
Project	**Common dolphin density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed during single piling**
The Project (including Morecambe OSP)	0.028	DRC	127.6
Morgan offshore booster station	0.018	DRC	72
Transmission Assets (incl. Morgan OSP)	0.047	DRC	151
Total number of common dolphin			**350.6**
Percentage of CGNS MU			0.34%
Magnitude of cumulative effect			Negligible
Risso's Dolphin			
Project	**Risso's dolphin density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed during single piling**
The Project (including Morecambe OSP)	0.0006	DRC	2.4
Morgan offshore booster station	0.031	DRC	125
Transmission Assets (incl. Morgan OSP)	0.0034	DRC	4
Total number of Risso's dolphin			**131.4**
Percentage of CGNS MU			1.07%
Magnitude of cumulative effect			Low
Minke whale			
Project	**Minke whale density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed during single piling**
The Project (including Morecambe OSP)	0.0088	2827.43	24.9
Morgan offshore booster station	0.0173	DRC	69
Transmission Assets (incl. Morgan OSP)	0.0050	DRC	17
Total number of minke whale			**110.9**
Percentage of CGNS MU			0.55%
Magnitude of cumulative effect			Negligible

Grey seal			
Project	**Grey seal density (/km²)**	**Impact area (km²)**	**Maximum number of individuals potentially disturbed during single piling**
The Project (including Morecambe OSP)	0.1	1963.5	196.35
Morgan offshore booster station	0.041	DRC	31
Transmission Assets (incl. Morgan OSP)	0.106	DRC	28
Total number of grey seal			**255.4**
Percentage of wider reference population			1.92%
Magnitude of cumulative effect			Low
Harbour seal			
Project	**Minke whale density (/km²)**	**Impact area (km²)**	**Maximum number of individuals potentially disturbed during single piling**
The Project (including Morecambe OSP)	0.00011	1963.5	0.22
Morgan offshore booster station	0.00005	DRC	<1
Transmission Assets (incl. Morgan OSP)	0.00020	DRC	<1
Total number of harbour seal			**<2.22**
Percentage of wider reference population			<0.19%
Magnitude of cumulative effect			Negligible

Cumulative effect 1b: Assessment of underwater noise impacts from other noisy activities (other than piling) (including vessels)

~~11.726~~11.727 A qualitative approach to the assessment of noise generated from other (non-piling) sound-producing activities, including noise and disturbance through the presence of vessels, was undertaken for the Transmission Assets (Morgan Offshore Wind Limited and Morecambe Offshore Windfarm Limited, 2023). For the purpose of this combined assessment, impact results for the Project have been drawn from Impact 3 (**Section 11.6.3.3**) and Impact 4 (**Section 11.6.3.4**) and considered with those of the Transmission Assets in **Table 11.82**.

Auditory injury during construction (other than piling)

~~11.727~~11.728 Based on the underwater noise modelling for both projects, the assumption was that animals would swim away from the noise source and are more likely to be startled than having an injurious effect. The noise level from these activities is low enough to not exceed the PTS thresholds and would pose only a minimal risk. Given embedded mitigation, there would be no cumulative impact of permanent auditory injury (PTS) occurring to marine mammals as a result of elevated underwater sound due to vessel use, and all non-piling activities.

~~11.728~~11.729 Despite some variations in the modelled TTS distances for the Transmission Assets (PEIR Volume 1 Annex 5.2; Morgan Offshore Wind Limited and Morecambe Offshore Windfarm Ltd, 2023) and for the Project (as outlined in **Table 11.46**), the assessed significance for both projects was deemed minor.

~~11.729~~11.730 During construction, the cumulative number of vessel return trips for the Project (2,583/year) and Transmission Assets (up to 385/year) would total up to 2,968 per year. That means the Transmission Assets add on average an additional 32 vessel return trips to the 215 Project vessel return trips per month. This increase in vessel activity is unlikely to lead to any potential cumulative effect. The movements would be limited to the site boundaries (array areas and offshore cable corridor routes of the projects) during construction and would follow existing shipping routes to and from the ports.

~~11.730~~11.731 The impact magnitude for marine mammals was assessed as negligible for both the Transmission Assets and the Project (**Section 11.6.3.4**). As the majority of vessels are associated with the Project, the additional vessel increase is not likely to add an increased effect to marine mammals and would not alter the Project magnitudes further.

~~11.731~~11.732 As mentioned above, the impact ranges for construction related activities at the Transmission Assets have not exceeded the thresholds for either PTS or TTS. This applied to all species groups except harbour porpoise, for which only TTS ranges were listed (cable trenching: 4.5km; cable laying: 1.54km). Although the TTS ranges are relatively high for these activities, the Transmission Asset project has not further assessed them based on them being overestimates.

~~11.732~~11.733 As assessed in **Section 11.6.3.3** the impact magnitude for undertaking four (non-piling) Project construction activities at the same time was assessed as negligible for all marine mammals. It is therefore expected that activities like cable laying would not cause a cumulative effect, considering the extensive amount cable work anticipated for both projects. As such, the burial of up to 610km of export cable and 60km of interconnector (platform link) cables at Transmission Assets and those associated with the Project (70km of inter-array cables and 10km of platform link cables) was assessed as having a **negligible** magnitude.

~~11.733~~11.734 The Project has assessed auditory injury for vessels and ‘other (non-piling) construction’ activities separately, while for the Transmission Assets the assessment was undertaken in combination. Based on the information provided, the combined magnitude for vessel impact was defined as negligible, with a **minor adverse** effect significance concluded based on a medium/low sensitivity. The combined assessment for ‘other construction’ activities associated with the Project and the Transmission Assets also had a **minor adverse** effect significance, based on the negligible magnitude and a medium/low sensitivity.

Disturbance during construction

~~11.734~~11.735 With regard to disturbance from vessels and other construction activities, the Project assumed a precautionary 4km disturbance range based on literature (Benhemma-Le Gall *et al.*, 2021). Whereas the Transmission Assets based the underwater noise modelling for disturbance on Level B harassment thresholds[15] (NMFS, 2005) (Morgan Offshore Wind Limited and Morecambe Offshore Windfarm Limited, 2023). Consequently, the modelled disturbance impact ranges for marine mammals for the Transmission Assets varied from those of the Project (overview in **Table 11.82**).

~~11.735~~11.736 Despite the different approach to assessments and the varying disturbance ranges, both projects-alone were assessed as having a minor to negligible adverse effect significance for all species, with a low to negligible magnitude.

~~11.736~~11.737 The combined assessment concluded at worst-case a **low** magnitude for disturbance and so the significance of effect remained **minor to negligible adverse**.

[15] Level B harassment thresholds refer to noise level limits beyond which certain activities are deemed to disturb marine mammals.

Table 11.82 Disturbance ranges for vessels and other construction activities for the Project and Transmission Assets (values taken from Transmission Asset PEIR)

Activity	Transmission Assets	The Project
Vessel disturbance ranges (km)		
Sandwave clearance, installation vessel, construction vessel (Dynamic Positioning), rock placement vessel and cable installation vessels	8	4
Tug/anchor handlers, Guard vessels	6	
Survey vessel and support vessels, Crew transfer vessel, scour/cable protection/seabed preparation/installation vessels	20	
Jack-up rig	<0.01	
Other construction activities disturbance ranges (km)		
Boulder clearance	1.2	4
Cable trenching	18	
Cable laying	8	
Drilled piling	1.5	-

Operation and maintenance

~~11.737~~11.738 As assessed for construction, auditory injury and disturbance during operation and maintenance activities was anticipated to have limited additional impacts to the population of marine mammals in the wider IS. The activities associated with the operation and maintenance phase include maintenance, repairs, cable reburial and vessel transfer.

~~11.738~~11.739 The anticipated maximum number of vessels at site at any one time are 19 for Transmission Assets and 10 for the Project (**Table 11.1**), which can be considered relatively small in the context of the baseline traffic levels. When considering the Project and Transmission Assets together, the magnitude was assessed to be **low** and significance of effect remained **minor adverse** for vessels and other operation and maintenance activities.

Cumulative effect 1c: Assessment of disturbance from other industries and activities

~~11.739~~11.740 An assessment of other industries is included in the CEA for all plans and projects (**Section 11.7.3.2**). Within this section, **Cumulative effect 1c:** includes a precautionary assessment of the combined effects of piling at the Project and two geophysical surveys, two aggregate dredging projects, one seismic survey or two low-order UXO clearances.

11.740 11.741 There is no requirement to assess the Transmission Assets and the Project in addition to what is presented in **Section 11.7.3.2**. If both the Project and Transmission Assets were to conduct piling activities simultaneously, alongside noise generated by other mentioned activities or industries, the resulting impact would likely resemble that of the Project operating alone (refer to **Table 11.107** for assessment results).

Cumulative effect 2: Increased collision risk with vessels

Construction

11.741 11.742 As described in **Section 11.6.3.6**, the very precautionary marine mammal vessel collision risk for the Project was assessed as moderate to minor adverse. Because the vessels within the windfarm would be stationary for much of the time, the actual risk is however likely to be negligible. The additional 385 vessels per year from the Transmission Assets would only represent 15% of the annual construction vessels associated with the Project (2,583 vessels).

11.742 11.743 Despite the different approach to assessments, both projects have assessed the collision risk to be minor adverse, apart from harbour seal at the Project which had a moderate adverse effect due to the extremely small reference population of seven seals. The combined number of vessels from both projects is likely to have the potential to lead to an increase in vessel collisions with marine mammals. As a very precautionary in-combination assessment, the magnitude was defined as high for harbour seal, medium for harbour porpoise and grey seal, and low for the remaining species. The effect significance, based on a low sensitivity, was therefore **moderate adverse** for harbour seal with a low sensitivity, and **minor adverse** for all other species.

11.743 11.744 However, both the Transmission Assets and the Project outline the best practice measures that vessel operators will follow, which will minimise the overall effect significance as low as **minor adverse**.

Operation and maintenance

11.744 11.745 The annual vessels transits required for operation and maintenance activities at the Transmission Assets are 1,155. Combined with the Project, there would be a maximum of 1,987 vessels transiting between the ports and the project sites, approximately 30% less than those planned to be used during construction. These numbers are based on heavy-maintenance years which are anticipated to only occur every 5 years for the Project (**Table 11.1**) and represent the worst-case.

11.745 11.746 As the annual vessel traffic reduces by a third, the collision risk for marine mammals is also likely to reduce. The effect will therefore be slightly less or the same than what has been assessed during construction. Taking a precautionary approach, the magnitude for harbour seal would remain **high** due to the small reference population, and **low** for the remaining species.

~~11.746~~11.747 The impact significance for any potential increased collision risk as a result of operation and maintenance vessels has been assessed as a very precautionary **moderate adverse** for harbour seal and **minor adverse** for all other species.

~~11.747~~11.748 Both projects would adhere to the best practice measures (measures for the Project are provided in the Outline PEMP, see **Section 11.3.3**) that vessel operators have to follow, in order to minimise the overall effect significance as low as minor adverse for all species.

Summary

~~11.748~~11.749 Key interactions and additive effects between the Project and Transmission Assets have been considered with no identification of effects that would result in impacts of greater significance than assessed for either the Project or Transmission Assets (**Table 11.83**).

Table 11.83 Summary of impacts from the Project and Transmission Assets alone and combined[16]

Impact	Residual significance of effect		Combined assessment
	Transmission Assets	Project	
Construction / decommissioning phases			
Auditory injury from piling	Not significant (Minor adverse)	Not Significant (Minor adverse)	Not assessed further. Suitable mitigation to reduce the potential for any PTS (outlined in the MMMP) from any project, would be put in place to reduce any risk to marine mammals.
Disturbance from piling	Not significant (Minor adverse)	Not significant (Minor adverse)	Not Significant (Minor adverse) using CEA iPCoD modelling (**Section 11.7.3.2**)
Auditory injury and disturbance from other construction noise	Not significant (Minor adverse) (incl. vessels)	Not significant (Minor to negligible adverse) (excl. vessels)	Not significant (Minor adverse)
TTS and disturbance through vessels	Assessed under 'other construction noise'	Not significant (Minor adverse)	Not significant (Minor adverse)
Vessel collision risk	Not significant (Minor adverse)	Not Significant (Minor adverse)	Not Significant (Minor adverse)
Injury and disturbance from UXO detonation	Not significant (Minor adverse)	Not Significant (Minor adverse) (**Appendix 11.3**)	Assessed in CEA **Section 11.7.3.2**
Barrier effects as result of UWN	No identified direct impact	Not significant (Minor to negligible adverse)	Effect interactions are limited. While additive in nature across the study

[16] Note: wording of impacts has been summarised to encompass both projects. Where impacts were not considered = n/a

Impact	Residual significance of effect		Combined assessment
	Transmission Assets	Project	
Changes to prey resources/ availability	Not significant (Minor adverse)	Not significant (Minor to negligible adverse)	area, the significance of these impacts is not considered to be elevated beyond those individually assessed in terms of EIA significance.
Changes to water quality	Scoped out	Not significant (Negligible adverse)	
Disturbance of seals at haul-out sites	No identified direct impact	Not significant (Minor to negligible adverse)	
Operation and maintenance phase			
Auditory injury & disturbance from operational WTG	n/a	Not significant (Minor adverse)	Not significant (Minor adverse)
Auditory injury and disturbance from other operational activities	Not significant (Minor adverse) (incl. vessels)	Not significant (Minor to negligible adverse) (excl. vessels)	Not significant (Minor adverse)
TTS and disturbance through vessels	Assessed under 'other operational noise'	Not significant (Minor to negligible adverse)	Not significant (Minor adverse)
Vessel collision risk	Not significant (Minor adverse)	Not significant (Minor to negligible adverse)	Not significant (Minor to negligible adverse)
Barrier effects as result of UWN	Scoped out	Not significant (Minor adverse)	Effect interactions are limited. While additive in nature across the study area, the significance of these impacts is not considered to be elevated beyond those individually assessed in terms of EIA significance.
Changes to prey resources/ availability	Not significant (Minor adverse)	Not significant (Minor to negligible adverse)	
Changes to water quality	Scoped out	Not significant (Negligible adverse)	
Disturbance of seals at haul-out sites	No identified direct impact	Not significant (Minor to negligible adverse)	

11.7.3.2 Cumulative assessment – All plans and projects

~~11.749~~11.750 Based on both the impacts (**Table 11.79**) and plans and projects identified where there is the potential for cumulative effects (**Appendix 11.4**), where required, a detailed cumulative assessment was undertaken considering all relevant information from the Project and the other plans and projects (including the Transmission Assets).

Cumulative effect 1: Disturbance from underwater noise

~~11.750~~11.751 The potential sources of cumulative underwater noise, which could disturb marine mammals, and which were screened into the CEA were:

- Piling activities at OWFs, including the Project
- Other construction activities at OWFs and subsea interconnector cables including at the Project (vessels, cable installation works, dredging, seabed preparation and rock placement)
- ~~Licensed disposal sites~~
- Disturbance from operational windfarms (after the baseline survey in 2021)
- Geophysical and seismic surveys (other than for the Project)
- Aggregate extraction and dredging
- UXO clearance (other than for the Project)

~~11.751~~11.752 The approach to the assessment for cumulative disturbance from underwater noise for harbour porpoise has been based on the approach for the assessment of disturbance set out in **Section 11.6.3.2**, including the most recent advice from the SNCBs (JNCC *et al*., 2020) on the assessment of impacts on SACs.

~~11.752~~11.753 As outlined in **Section 11.7.1** the impacts considered in the CEA have been defined in **Table 11.79** and exclude auditory injury (PTS and TTS).

~~11.753~~11.754 Where a quantitative assessment has been possible, the potential magnitude of disturbance at other projects has been based on the publicly available project-specific density estimates or numbers of animals impacted. Details are found in Section 2.6 of **Appendix 11.4**.

~~11.754~~11.755 Where there is no project specific information or a speculative assessment for a potential activity has been undertaken, the results of potential disturbance are only indicative. These assessments were highly conservative and not based on any project specific information such as densities or impact ranges and have been quantified using known disturbance ranges. As such, the assessment for cumulative disturbance from underwater noise was based on the outcome of the population modelling which took into account projects specific effects and was deemed the most accurate.

Cumulative effect 1a: Indicative assessment of underwater noise impacts from piling at other OWFs

~~11.755~~11.756 Following the initial screening of UK and European OWFs, further screening was undertaken to identify those OWF projects that have the potential for overlapping construction phases with the Project. This screening considered known construction periods of UK and European OWF projects, including known piling activities 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 activities with the Project (see **Appendix 11.4** for further details).

~~11.756~~11.757 Potential disturbance from underwater noise during piling activities has been assessed based on the dose-response curves (Project-alone) which presented the worst-case numbers of animals disturbed (refer to **Section 11.6.3.2** for disturbance assessment).

~~11.757~~11.758 Of the UK and European OWFs screened in as having a construction period that could potentially overlap with the construction of the Project, six OWFs could be undertaking piling activities at the same time as the Project (**Table 11.84**).

Table 11.84 Plans and projects screened in for overlap in piling with piling at the Project

Project	PINS Tier[17]	Distance to Project	Species included in assessment
AyM OWF[18]	1	29km	All species but white-beaked dolphin
Erebus OWF	1	285km	All species but Risso's dolphin and white-beaked dolphin
Mona Offshore Wind Project	2	10km	All species but Risso's dolphin and white-beaked dolphin
Morgan and Morecambe Transmission Assets	2	0km	All species
Morgan Offshore Wind Project Generation Assets	2	17km	All species but Risso's dolphin and white-beaked dolphin

[17] Information on project stages and tiers see **Appendix 11.4**

[18] Site is in the Welsh MU and outside the harbour seal assessed range but due to proximity to the Project it has been included in the CEA for the worst-case

Project	PINS Tier[17]	Distance to Project	Species included in assessment
White Cross OWF	1	306km	All species but Risso's dolphin, white-beaked dolphin and harbour seal

~~11.758~~11.759 Given the stage of these projects, limitations and constraints to project delivery and uncertainty on scheduling, a more realistic short list of OWF projects that could be undertaking piling activities at the same time as the Project will be considered as projects develop, but this is the best available information at the time of writing, taking a precautionary approach.

Sensitivity

~~11.759~~11.760 As outlined in **Section 11.6.2**, harbour porpoise and minke whale were assessed as having **medium** sensitivity to disturbance from underwater noise from piling at OWFs, whilst dolphins and seals had **low** sensitivity.

Magnitude

~~11.760~~11.761 The magnitude of the potential disturbance from Project piling activities has been based on the worst-case disturbance ranges for each marine mammal species that has been assessed in **Section 11.6.3.2**:

- Harbour porpoise (**Table 11.28**)
  - The disturbance range was based on the EDR of 26km (2,123.7km^2) for monopile (as worst-case)
- Bottlenose dolphin, common dolphin, Risso's dolphin and white-beaked dolphin (**Table 11.29**)
  - The number of disturbed animals was based on the dose-response curves (DRC) for harbour porpoise during single pile installation at the Project. This provided an overly precautious number of animals that could be disturbed, as dolphins are known to have less sensitive hearing compared to harbour porpoise
- Minke whale (**Table 11.30**)
  - The potential impact area during single pile installation was based on a 30km precautionary disturbance range (Richardson *et al*., 1999) from each piling location (2,827.4km^2 per project)
- Grey seal and harbour seal (**Table 11.31**)
  - The disturbance range was based on a strong behavioural response of 25km (1,963.5km^2) (Russell *et al.,* 2016) during pile driving

~~11.761~~11.762 For all other projects, the worst-case disturbance numbers were taken from the relevant PEIRs and ESs for the cumulative assessment.

~~11.762~~11.763 It should be noted that the potential areas of disturbance assumed that there would be no spatial overlap in the areas of disturbance between different projects and were therefore highly conservative.

~~11.763~~11.764 Piling of all WTG/OSP foundations at the Project windfarm site has been included in the CEA as a worst-case scenario. It was also assumed that all OWF projects would be 100% piled, as a worst-case, if piled foundations was an option for WTGs or OSP(s).

~~11.764~~11.765 The approach to the CEA for piling at OWFs was based on the potential for single piling activity at each windfarm at the same time as single piling activity at the Project windfarm site. This approach allowed for some of the OWFs to not be undertaking piling activities at the same time, while others could be simultaneously undertaking piling activities (further information is available in **Appendix 11.4**). This was considered to be the most realistic worst-case scenario, as it is highly unlikely that all other windfarms would be simultaneously undertaking piling activities at exactly the same time as piling activity at the Project, especially given the limited active piling time.

~~11.765~~11.766 It is important to note the actual duration for active piling (based on 4.5hrs per pile for the Project) which could disturb marine mammals is only a very small proportion of the potential construction period, based on the estimated maximum duration to install individual piles (**Table 11.1**). This means that there would be a limited window for any cumulative impact to occur.

~~11.766~~11.767 The cumulative impact for common dolphin and Risso's dolphin for OWFs that could be undertaking piling activities at the same time as Project piling is provided in **Table 11.85**. The potential magnitude for the cumulative impacts of piling activities was assessed as low for Risso's dolphin and common dolphin.

Table 11.85 Quantified CEA for the potential disturbance for common and Risso's dolphin species during single piling at the OWF projects which could be piling at the same time as the Project

Common dolphin			
Project	**Common dolphin density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed during single piling**
The Project	0.028	DRC	127.6
AyM	0.0081	DRC	17
Mona	0.018	DRC	80
Morgan Generation Assets	0.018	DRC	72
Morgan and Morecambe Transmission Assets	0.047	DRC	151
Erebus	1.61	DRC	2,067
White Cross	5.23	TTS <50m	0.040
Total number of Common dolphin			2,514.6
(*without the Project*)			*2,387*
Percentage of CGNS MU			2.5%
(*without the Project*)			*2.3%*
Magnitude of cumulative effect			Low
(*without the Project*)			*Low*
Risso's Dolphin			
Project	**Risso's Dolphin density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed during single piling**
The Project	0.0006	DRC	2.4
AyM	0.031	DRC	65
Mona	0.031	DRC	139
Morgan Generation Assets	0.031	DRC	125
Morgan and Morecambe Transmission Assets	0.0034	DRC	4
Erebus	*n/a*	*n/a*	-
White Cross	*n/a*	*n/a*	-
Total number of Risso's Dolphin			335.4
(without Morecambe OWFs)			*333*
Percentage of CGNS MU			2.74%
(without the Project)			*2.72%*
Magnitude of cumulative effect			Low
(without the Project)			*Low*

Population modelling for cumulative disturbance from OWF projects

~~11.767~~11.768 The method for determining the magnitude of a disturbance impact is detailed in **Section 11.6.3.2.** To show if the results indicated a significantly disturbed population, the population would have to have experienced an additional 1% annual population decline per year, compared to the modelled unimpacted reference population.

~~11.768~~11.769 The following piling schedules have been included in the population modelling (more details to be found in Section 7.1 of **Appendix 11.2**):

- Morgan Offshore Wind Project Generation Assets: 2026/2027
- Mona Offshore Wind Project : 2026/2027
- Morgan and Morecambe Offshore Wind Farms: Transmission Assets: 2026/2027
- AyM Offshore Wind Farm: Q1 Year 2 – Q4 Year 4 2027 – 2029
- Erebus: Q4 2024 – Q4 2026
- White Cross OSP: Q2 2025 - Q3 2027
- White Cross Seabed Anchors: Q2 2025 -Q3 2027

Harbour porpoise

~~11.769~~11.770 It is important to note that the harbour porpoise density used for the Project was derived from two years of site-specific survey. The resulting density used was much higher than what was known for the surrounding area. As discussed in **Appendix 11.2**, this density of 1.621 animals per km^2 was not representative of the wider area when comparing it to other OWFs in the area, and other scientific data sources such as Waggitt *et al.* (2019), or Evans and Waggitt (2023).

~~11.770~~11.771 In practice, the potential temporary effects 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. In addition, not all individuals would be displaced over the entire potential disturbance range (26km EDR) used within the assessments. For example, the study of harbour porpoise at Horns Rev (Brandt *et al*., 2011), indicated that, at closer distances (2.5 to 4.8km), there was 100% avoidance, however, this proportion decreased significantly moving away from the pile driving activity and at distances of 10km to 18km avoidance was 32% to 49%, and at 21km the abundance was reduced by just 2%.

~~11.771~~11.772 For the cumulative scenario assessed within the CIS MU (see **Appendix 11.2** Section 7.1 for details of the projects considered, and their parameters), the iPCoD model predicts a slight decrease in harbour porpoise population size over time (**Plate 11.10** and **Table 11.86**).

~~11.772~~11.773 At the end of 2027, one year after piling has commenced in the wider area, the median population size was predicted to be 100% of the un-impacted population size. By the end of 2028 (the year piling ends), the median population size for the impacted population was predicted to be 99.78% of the un-impacted population size. Beyond 2028, the impacted population was expected to maintain the same stable trajectory as the un-impacted population (as far as 2051 which was the end point of the modelling, at which point the median impacted to un-impacted ratio was 99.26%; **Table 11.91**).

~~11.773~~11.774 For harbour porpoise, the potential magnitude of the cumulative impact for disturbance from underwater noise from piling was 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 11.86 Results of the iPCoD modelling for the cumulative assessment, giving the mean population size of the harbour porpoise population (CIS MU) for years up to 2052 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	62,516	62,516	100.00%
End 2027	62,574	62,569	100.00%
End 2028	62,509	62,278	99.78%
End 2031	62,389	61,703	99.22%
End 2036	62,482	61,818	99.26%
End 2046	62,436	61,770	99.27%
End 2051	62,564	61,897	99.26%

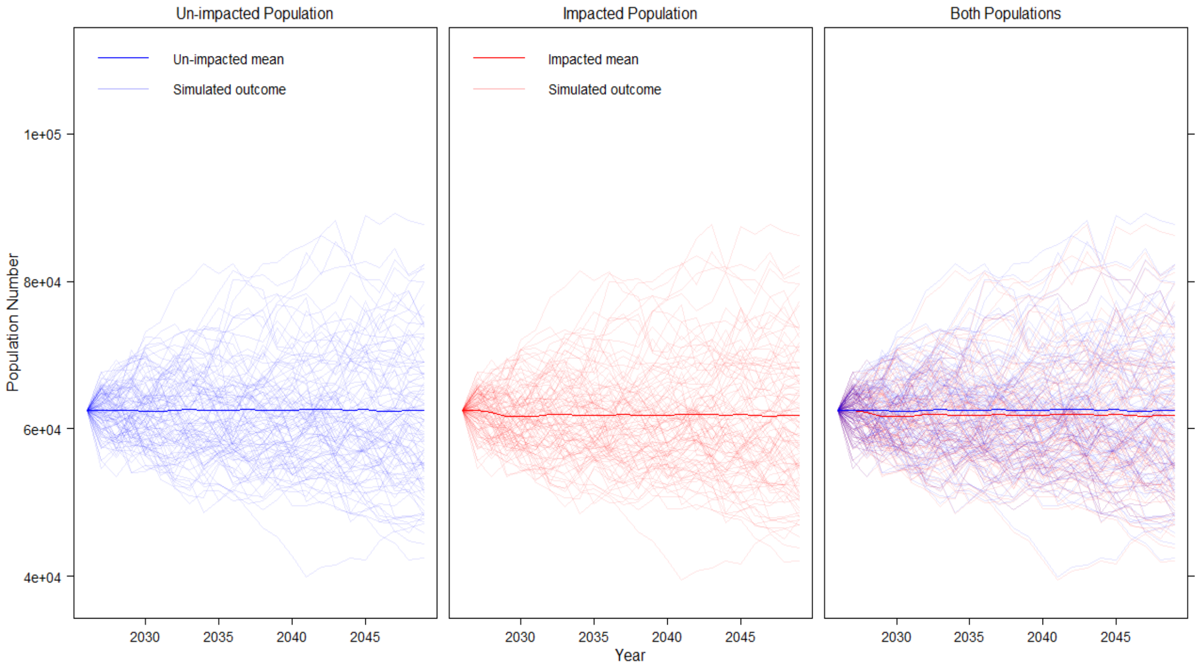

Plate 11.10 Simulated worst-case harbour porpoise population sizes for both the un-impacted and the impacted populations for the cumulative assessment (scientific notation used in these charts, e.g. 4e+04 = 40,000)

Bottlenose dolphin

~~11.774~~11.775 For the cumulative scenario assessed within the IS MU (see **Appendix 11.2** Section 7.1 for details of projects considered, and their parameters), the iPCoD model predicted a slight decrease in bottlenose dolphin population size over time (**Table 11.87** and **Plate 11.11**).

~~11.775~~11.776 At the end of 2027, one year after piling commenced in the wider area, the median population size was predicted to be 100% of the un-impacted population size. By the end of 2028 (the year piling ends) the median population size for the impacted population was predicted to be 98.61% of the un-impacted population size. The impacted population size further reduced to 97.80% of the un-impacted population size by the end of 2046. From this time point onwards, the impacted population size began to recover, reaching 97.97% of the un-impacted population size by the end of 2051 (which was the end point of the modelling).

~~11.776~~11.777 For bottlenose dolphin, the potential magnitude of the cumulative impact for disturbance from underwater noise from piling was assessed as **low** as a conservative approach due to a 1.39% decrease in one year. Overall, the yearly average was less than a 1% population level effect over both the first six years and 25-year modelled periods.

Table 11.87 Results of the iPCoD modelling for the cumulative assessment, giving the mean population size of the bottlenose dolphin population (IS MU) for years up to 2052 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	296	296	100.00%
End 2027	295	289	100.00%
End 2028	292	281	98.61%
End 2031	286	271	97.71%
End 2036	277	264	97.87%
End 2046	261	249	97.80%
End 2051	254	242	97.97%

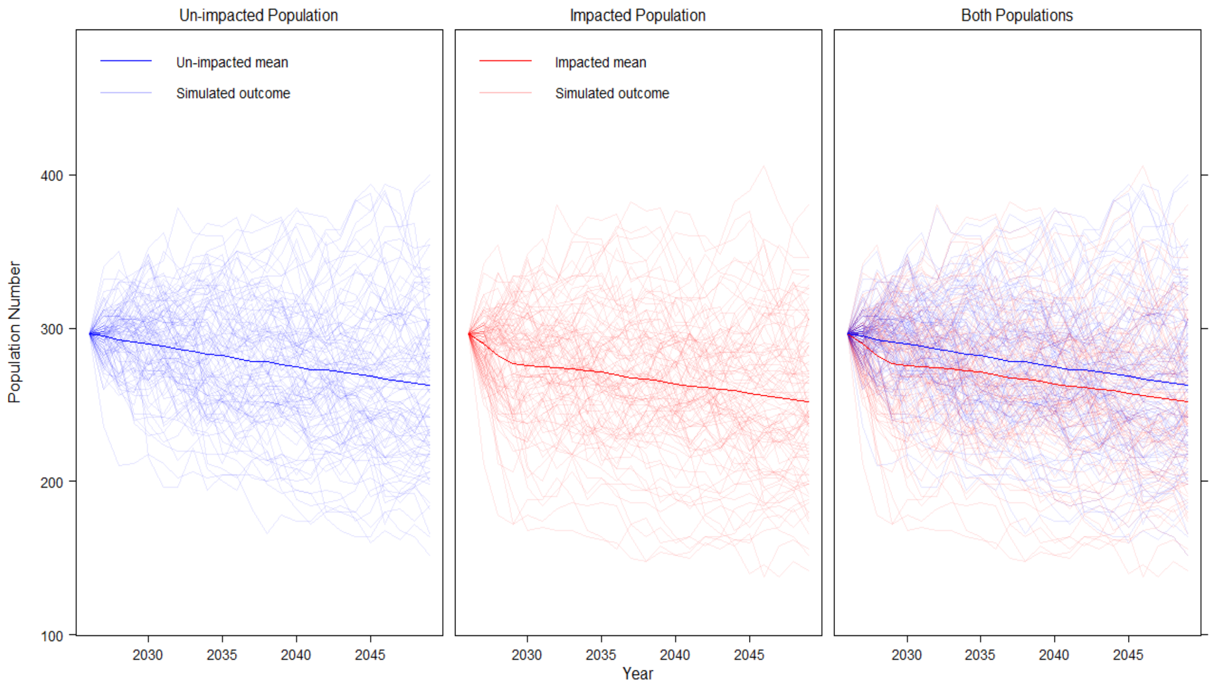

Plate 11.11 Simulated worst-case bottlenose dolphin population sizes for both the un-impacted and the impacted populations for the cumulative assessment

Minke whale

~~11.777~~11.778 For the cumulative scenario assessed within the CGNS MU (see **Appendix 11.2** Section 7.1 for details of projects considered, and their parameters), the iPCoD model predicted a slight decrease in minke whale population size over time (**Table 11.88** and **Plate 11.12**).

~~11.778~~11.779 At the end of 2027, one year after piling commenced in the wider area, the median population size was predicted to be 100% of the un-impacted population size. By the end of 2028 (the year piling ends) the median population size for the impacted population was predicted to be 99.87% of the un-impacted population size. The impacted population at the end of 2046 (20 years after piling commences) was expected to be 96.88% of un-impacted population, and at the end of 2051, which was the end point of the modelling, the impacted population was predicted to be 96.80% of the unimpacted population.

11.77911.780 For minke whale, the potential magnitude of the cumulative impact for disturbance from underwater noise from piling was 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 11.88 Results of the iPCoD modelling for the cumulative assessment, giving the mean population size of the minke whale population (CGNS MU) for years up to 2052 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	20,118	20,118	100.00%
End 2027	20,125	20,123	100.00%
End 2028	20,185	20,140	99.87%
End 2031	20,226	19,885	98.75%
End 2036	20,270	19,691	97.63%
End 2046	20,472	19,724	96.88%
End 2051	20,525	19,757	96.80%

Plate 11.12 Simulated worst-case minke whale population sizes for both the un-impacted and the impacted populations for the cumulative assessment

Grey seal

~~11.780~~11.781 For the cumulative scenario assessed for the wider reference population (see **Appendix 11.2** Section 7.1 for details of projects considered, and their parameters) the iPCoD model predicted no discernible decrease in grey seal population size over time (**Table 11.89** and **Plate 11.13**).

~~11.781~~11.782 At the end of 2027, one year after piling commenced in the wider area, the median population size was predicted to be 100% of the un-impacted population size. This lack of discernible effect on the impacted population was maintained until 2051, which was the end point of the modelling.

~~11.782~~11.783 For grey seal, the potential magnitude of the cumulative impact for disturbance from underwater noise from piling was 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 11.89 Results of the iPCoD modelling for the cumulative assessment, giving the mean population size of the grey seal population (wider reference population (see **Section 11.5.9**) for years up to 2052 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	13,288	13,288	100.00%
End 2027	13,393	13,393	100.00%
End 2028	13,473	13,475	100.01%
End 2031	13,727	13,732	100.04%
End 2036	14,192	14,197	100.04%
End 2046	15,049	15,054	100.03%
End 2051	15,557	15,563	100.03%

* Note that the marginal increase in the impacted population in comparison to the un-impacted population is a result of the environmental stochasticity built into the model

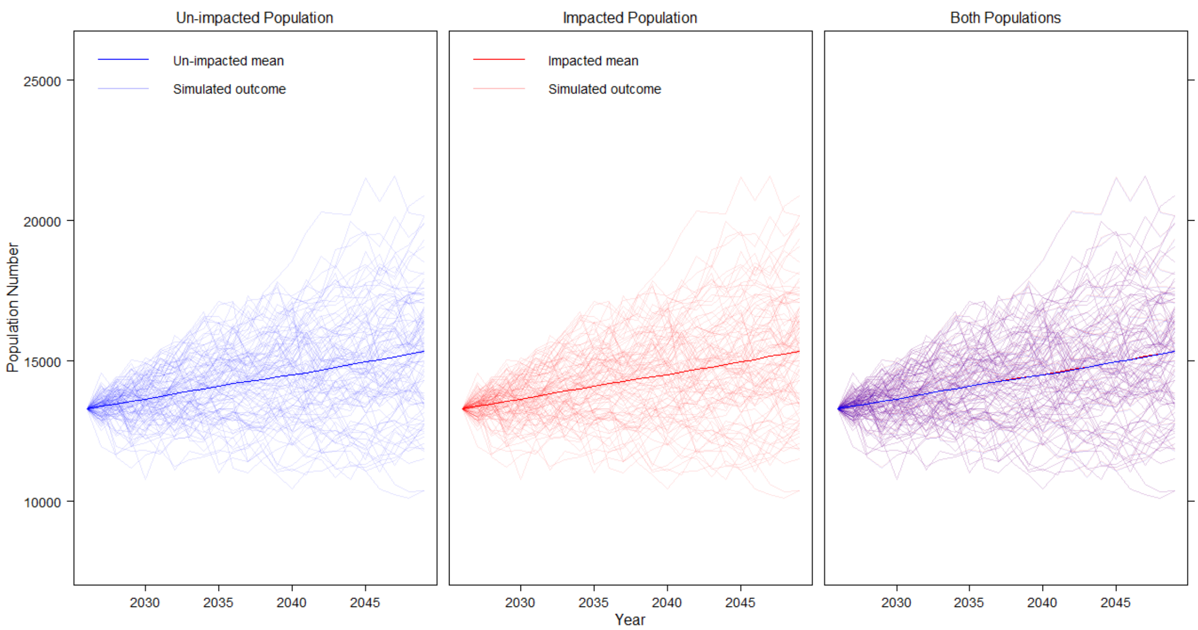

Plate 11.13 Simulated worst-case grey seal population sizes for both the un-impacted and the impacted populations for the cumulative assessment of the wider reference population.

~~11.783~~11.784 In addition to the wider reference population, the model was also run for the smaller 'Combined population' (NW England MU and IoM population, see **Section 11.5.9**), the iPCoD model predicted no discernible effect to the Combined population (**Table 11.90** and **Plate 11.14**).

*Table 11.90 Results of the iPCoD modelling for the cumulative assessment, giving the mean population size of the grey seal combined population (NW England MU and IoM population (see **Section 11.5.9**) for years up to 2052 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	1,592	1,592	100.00%
End 2028	1,603	1,603	100.00%
End 2029	1,612	1,611	100.00%
End 2032	1,645	1,642	99.88%
End 2037	1,711	1,708	99.86%
End 2047	1,834	1,830	99.96%
End 2052	1,896	1,892	100.00%

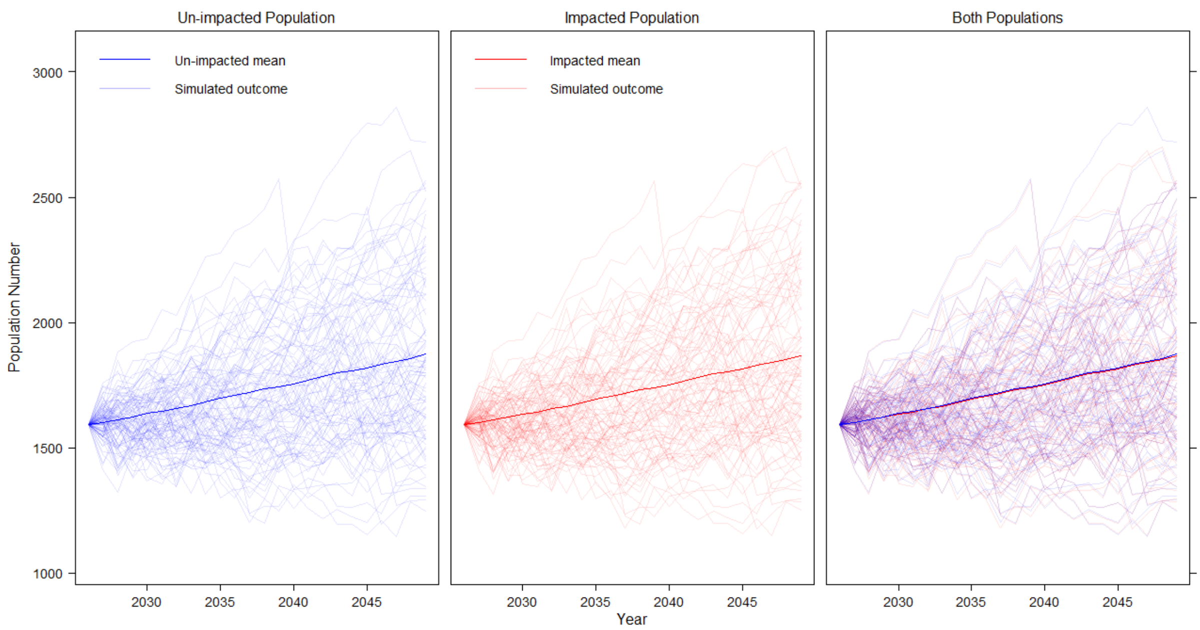

Plate 11.14 Simulated worst-case grey seal population sizes for both the un-impacted and the impacted populations for the cumulative assessment

Harbour seal

~~11.784~~11.785 For the cumulative scenario assessed for the wider reference population (NW England MU and NI MU) (see **Appendix 11.2** Section 7.1 for details of projects considered, and their parameters), the iPCoD model predicted no discernible decrease in harbour seal population size over time (**Table 11.91** and **Plate 11.15**).

~~11.785~~11.786 At the end of 2027, one year after piling commenced in the wider area, the median population size was predicted to be 100% of the un-impacted population. This lack of discernible effect on the impacted population was maintained until 2051, which was the end point of the modelling.

~~11.786~~11.787 For harbour seal, the potential magnitude of the cumulative impact for disturbance from underwater noise from piling was 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 11.91 Results of the iPCoD modelling for the cumulative assessment, giving the mean population size of the harbour seal population (North West MU and NI MU) for years up to 2052 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	1,412	1,412	100.00%
End 2027	1,415	1,415	100.00%
End 2028	1,413	1,413	100.00%
End 2031	1,416	1,416	100.00%
End 2036	1,420	1,420	100.00%
End 2046	1,430	1,430	100.00%
End 2051	1,436	1,436	100.00%

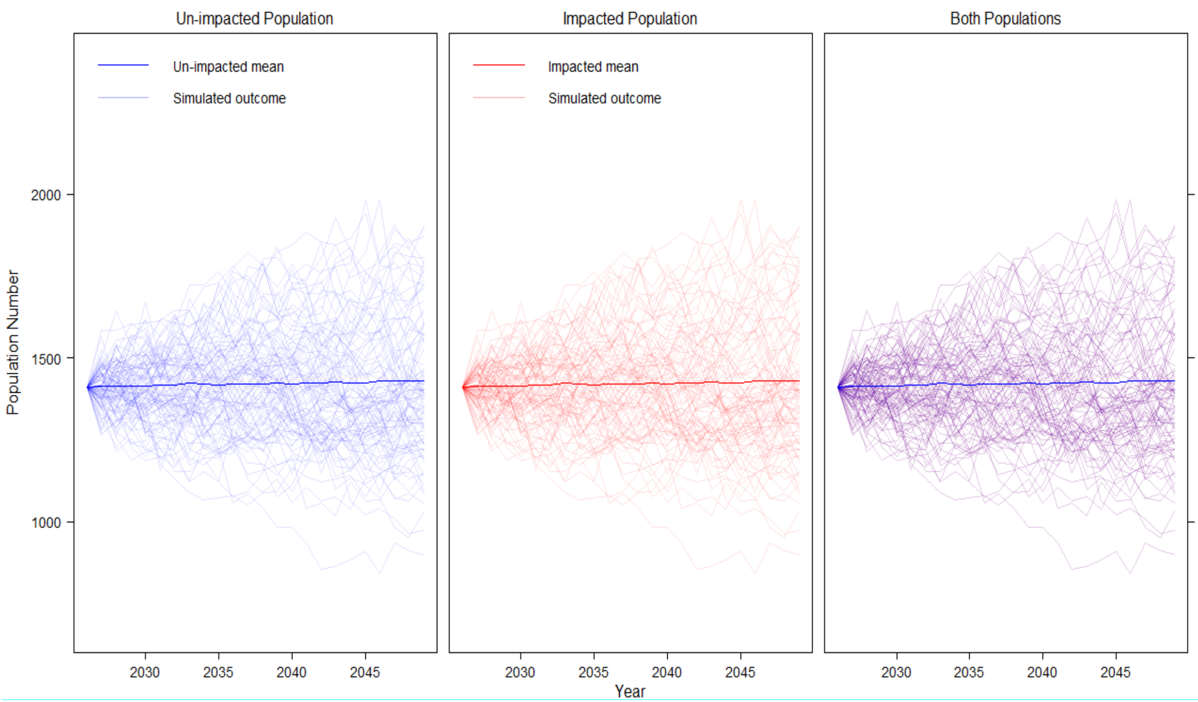

Plate 11.15 Simulated worst-case harbour seal population sizes for both the un-impacted and the impacted populations for the cumulative assessment

11.78711.788 In addition to the wider reference population the model was also run cumulatively for the smaller NW England MU (7 individuals), the iPCoD modelling predicted no discernible cumulative effect to the NW England MU population (**Table 11.92**).

11.78811.789 As previously described for population modelling for Project-alone in **Section 11.6.3.2**, it should be noted that the model predicted extinction of the population in the majority of cases for both the impacted and un-impacted population scenarios. However, the Section further explains that due to the connectivity to the wider Irish Sea, the seven seals are most likely to be part wider regional population. Thus, using the assessment including the wider reference population is much more appropriate.

Table 11.92 Results of the iPCoD modelling for the Project, giving the mean population size of the harbour seal population (North West MU) for years up to 2052 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	4	100.00%
End 2028	3	3	100.00%
End 2029	3	3	100.00%
End 2032	3	3	100.00%
End 2037	3	3	100.00%
End 2047	3	3	100.00%
End 2052	3	3	100.00%

Summary of magnitude of cumulative population level consequences due to disturbance

11.78911.790 For all species assessed, the modelled impact of piling from the Project fell below the threshold of a 1% annual decline in population which was considered insignificant. The greatest impact of cumulative disturbance occurred for minke whale, with a predicted 3.2% decline in population size over a 25-year period but fell below the 1% annual decline mark.

11.79011.791 The population consequences of disturbance for bottlenose dolphin were assessed as **low** and all other species were assessed as **negligible**.

Significance of effect

11.79111.792 If all included OWFs were undertaking piling activities at the same time as the Project, there is the potential for a low to negligible magnitude of impact (dependent on species), however, as outlined above, it is highly unlikely that all OWFs would be simultaneously undertaking piling activities at exactly the same time as the short duration of piling activity in the Project windfarm site.

11.79211.793 Taking into account the low and medium receptor sensitivity for the relevant marine mammal species, the overall cumulative impact assessment for disturbance to marine mammals from piling activities at OWFs, including the Project was **minor adverse** (not significant in EIA terms) for harbour porpoise, bottlenose dolphin, and minke whale and **negligible**

adverse (not significant in EIA terms) for all other species modelled. This was deemed to be a conservative assessment based on the worst-case scenario for OWFs undertaking piling activities at the same time as the Project.

~~11.793~~11.794 Upon application of the Marine Wildlife Licence in the Project pre-construction phase, an updated assessment would confirm any further mitigation measures such as noise abatement measures and/or management measures, such as scheduling and timing of piling, may need to be considered if the piling schedules for all the OWFs were to overlap. It is noted that the Project has already committed to no concurrent Project piling as embedded mitigation.

~~11.794~~11.795 The confidence in this impact assessment was medium, as it was deemed precautionary enough to comfortably encompass the likely uncertainty and variability. Throughout the assessment, it has been made clear where multiple and compounding precautionary assumptions have been made. Where possible, project specific species data has been used for the quantification of impacts (when based on published PEIRs and ESs).

Cumulative effect 1b: Indicative assessment of underwater noise impacts from construction activities (other than piling) at other OWFs

~~11.795~~11.796 All OWFs with construction dates that have the potential to overlap with the construction window for the Project have the potential for cumulative effects.

~~11.796~~11.797 Construction activities (such as seabed preparation, cable installation and vessel activities) could occur at the same time as piling activities at the Project. Projects where piling overlap was considered have not been included in regard to other construction noise.

~~11.797~~11.798 OWFs screened in for other construction activities that could have potential cumulative impacts with piling at the Project were (**Appendix 11.4**):

- Codling Wind Park (for all species except harbour seal) (PINS Tier 2)
- Dublin Array (for all species except harbour seal) (PINS Tier 2)
- North Irish Sea Array (for all species except harbour seal) (PINS Tier 2)
- Sceirde Rocks (for all species except bottlenose dolphin, Risso's dolphin, grey and harbour seal) (PINS Tier 2).

Sensitivity

~~11.798~~11.799 As outlined in **Section 11.6.2**, all harbour porpoise and minke whale were assessed as having **medium** sensitivity to disturbance from underwater noise sources, whilst dolphins and seals were assessed as having **low** sensitivity.

Magnitude

~~11.799~~11.800 During the construction of the Project, there is the potential for overlap with impacts from non-piling construction activities at other OWFs. Noise sources which could cause potential disturbance impacts during OWF construction activities, other than pile driving, can include vessels, mooring installation, seabed preparation, cable installation works and rock placement.

~~11.800~~11.801 The CEA included all projects that could have non-piling construction activities during the Project construction period. It is noted that these are all Tier 2 projects and the certainty on scheduling, and thus temporal overlap, is low.

~~11.801~~11.802 The potential impact area for harbour porpoise was based on the worst-case disturbance range of 4km (50.27km^2), which was based on a study where various construction activities occurred simultaneously at different locations within the windfarm study area (Benhemma-Le Gall *et al*., 2021) (see **Section 11.6.3.3**).

~~11.802~~11.803 For harbour porpoise, based on the worst-case scenario, for all OWFs that could be constructing at the same time as piling at the Project, the potential magnitude of the temporary effect was assessed as **medium**, with >5% of the reference population potentially temporarily disturbed (**Table 11.93**). This was considered precautionary given the limited and intermittent duration of piling activities at the Project.

Table 11.93 Quantified CEA for the potential disturbance of harbour porpoise during construction activities (other than piling) at OWF projects at the same time as piling at the Project

Harbour porpoise			
Project	**Harbour porpoise density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	1.621	2123.7	3,442.5
Codling	0.942	50.27	47.4
Dublin Array	0.942	50.27	47.4
North Irish Sea Array	0.942	50.27	47.4
Sceirde Rocks	0.092	50.27	4.6
Total number of harbour porpoise			3,589.2
(without the Project)			*146.7*
Percentage of CIS MU			5.7%
(without the Project)			*0.2%*
Magnitude of cumulative effect			Medium
(without the Project)			*Negligible*

~~11.803~~11.804 For all bottlenose dolphins, based on the worst-case scenario, for all OWFs that could be constructing at the same time as piling at the Project, the potential magnitude of the temporary effect was assessed as **high**. For all other dolphins and minke whale the magnitude was **negligible** (**Table 11.94**).

~~11.804~~11.805 This was considered precautionary given the limited and intermittent duration of piling activities at the Project. Noted should be also the rather cautious estimation of disturbed animals as the dose-response curves are based on harbour porpoise.

~~11.805~~11.806 Grey seal was assessed using the MUs from the wider reference population in which the projects are situated. The magnitude was assessed as **low** for piling at the Project and the activities at each of the four Tier 2 OWF in combination.

Table 11.94 Quantified CEA for the potential disturbance of other marine mammals during the construction activities (other than piling) at OWF projects at the same time as piling at the Project

Bottlenose dolphin			
Project	**Bottlenose dolphin density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	0.001	DRC	56.3
Codling	0.2352	50.27	11.82
Dublin Array	0.2352	50.27	11.82
North Irish Sea Array	0.2352	50.27	11.82
Sceirde Rocks	*Not included as outside the grey seal CEA area*		
Total number of bottlenose dolphin			91.7
(without the Project)			*35.5*
Percentage of IS MU			31.3%
(without the Project)			*12.1%*
Magnitude of cumulative effect			High
(without the Project)			*High*
Common dolphin			
Project	**Common dolphin density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	0.00014	DRC	127.6
Codling	0.03	50.27	1.4
Dublin Array	0.03	50.27	1.4
North Irish Sea Array	0.03	50.27	1.4
Sceirde Rocks	0.23	50.27	11.7
Total number of Common dolphin			143.4
(without the Project)			*15.8*

Percentage of CGNS MU *(without the Project)*			0.001 *0.0002%*
Magnitude of cumulative effect *(without the Project)*			Negligible *Negligible*
Risso's dolphin			
Project	**Risso's dolphin density (/km²)**	**Impact area (km²)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	0.0006	DRC	2.4
Codling	0.0032	50.27	0.2
Dublin Array	0.0032	50.27	0.2
North Irish Sea Array	0.0032	50.27	0.2
Sceirde Rocks	*Not included as there is no species density data available for this region*		
Total number of Risso's dolphin *(without the Project)*			3.0 *0.6*
Percentage of CGNS MU *(without the Project)*			0.0002% *0.00004%*
Magnitude of cumulative effect *(without the Project)*			Negligible *Negligible*
White-beaked dolphin			
Project	**White-beaked dolphin density (/km²)**	**Impact area (km²)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	0.007	DRC	17.9
Codling	*Not included as there is no species density data available for this region*		
Dublin Array			
North Irish Sea Array			
Sceirde Rocks	0.048	50.27	2.4
Total number of White-beaked Dolphin *(without the Project)*			20.3 *2.4*
Percentage of CGNS MU *(without the Project)*			0.05% *0.005%*
Magnitude of cumulative effect *(without the Project)*			Negligible *Negligible*
Minke whale			
Project	**Minke whale density (/km²)**	**Impact area (km²)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	0.0088	2827.43	24.9
Codling	0.014	50.27	2.8
Dublin Array	0.014	50.27	2.8

North Irish Sea Array	0.014	50.27	2.8
Sceirde Rocks	0.03	50.27	6.0
Total number of minke whale			39.4
(without the Project)			*14.5*
Percentage of CGNS MU			0.2%
(without the Project)			*0.07%*
Magnitude of cumulative effect			Negligible
(without the Project)			*Negligible*
Grey seal			
Project	**Grey seal density (/km²)**	**Impact area (km²)**	**Maximum number of individuals potentially disturbed during single piling**
The Project (piling)	0.104	1963.5	204.2
Codling	0.269	50.27	13.5
Dublin Array	0.269	50.27	13.5
North Irish Sea Array	0.269	50.27	13.5
Sceirde Rocks	*Not included as outside the grey seal CEA area*		
Total number of grey seal in wider reference population range			244.7
(without the Project)			*40.5*
Percentage of wider reference population			1.8%
(without the Project)			*0.3%*
Magnitude of cumulative effect			Low
(without the Project)			*Negligible*

Significance of effect

~~11.806~~11.807 If all included OWFs were constructing at the same time as the Project, there was the potential for a medium magnitude of impact for harbour porpoise, low for grey seal and negligible magnitude of impact for all other marine mammal species.

~~11.807~~11.808 Taking into account the medium and low receptor sensitivity for the relevant marine mammal species, the overall cumulative effect for disturbance to marine mammals from construction activities at other OWF (at same time as Project piling activities) was **moderate adverse** for harbour porpoise and bottlenose dolphin, **minor adverse** for minke whale and grey seal, and **negligible adverse** for the remaining dolphin species (**Table 11.94**).

~~11.808~~11.809 As stated previously, it is important to highlight that the harbour porpoise density used in these assessments was much higher than what was known for the surrounding area and was not representative of the wider area when comparing it to other OWFs in the area and other data sources. Furthermore, it should be noted that the bottlenose dolphin density was based on the dose-response curves for harbour porpoise, and thus was overly precautious and in reality, numbers of disturbed animals would be expected to be less as this species is less sensitive to noise (**Appendix 11.2**).

~~11.809~~11.810 Emphasis should be given to a more realistic worst-case if the dose-response curves, instead of the EDR and disturbance range, were to be applied for harbour porpoise and both seal species.

~~11.810~~11.811 It should be noted that the projects included within the cumulative assessment for disturbance from other OWFs constructing at the same time were done so based on the current knowledge of their possible construction or activity windows. Additionally, it is very unlikely that all activities would be taking place on the same day, or in the same season. The cumulative assessment therefore likely represented an over-precautionary, and worst-case, estimate of the marine mammals that could be at risk of disturbance during the 2.5 year offshore construction period of the Project.

~~11.811~~11.812 The confidence in this effect assessment was low, as it was deemed overly precautionary as there were no prospective construction periods for the developments listed. Where possible, the uncertainty in the data which is typically used to inform CEAs, as well as the quantification of impacts (when based on published ESs), have been removed. Instead, a standard impact range for disturbance and the same source for density estimates (e.g. ObSERVE, SCANS-IV and Carter *et al*. (2022)) for all OWF sites has been used.

Cumulative effect 1c: Indicative assessment of underwater noise impacts from other industries and activities

~~11.812~~11.813 The cumulative assessment considered effects from geophysical surveys and seismic surveys associated with other projects, and the potential for UXO clearances occurring at the same time as Project construction. It is noted that there was low certainty on the schedule of these activities, but the assessment has been based on the most up to date information available in terms of predicted temporal overlap.

~~11.813~~11.814 The cumulative disturbance assessment considered the following activities occurring at the same time as piling for the Project:

- Geophysical surveys associated with other developments
- Aggregate extraction and dredging
- Seismic surveys
- UXO clearance

Sensitivity

~~11.814~~11.815 As outlined in **Section 11.6.2**, all harbour porpoise and minke whale were assessed as having **medium** sensitivity to disturbance from underwater noise sources, whilst dolphins and seals were assessed to have **low** sensitivity.

Magnitude

Potential for disturbance from geophysical surveys

~~11.815~~11.816 As outlined in **Appendix 11.4**, OWF geophysical surveys, using Acoustic Sub-bottom Profilers (SBPs) and Ultra-Short Base Line (USBL) systems, have the potential to disturb marine mammals and were therefore screened into the CEA as a precautionary approach.

~~11.816~~11.817 It was 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 the Project. The potential for disturbance due to the use of a SBP has, however, been modelled and results indicated that there was the potential for a possible behavioural response in marine mammals at up to 4.22km (55.95km^2) from the source (Scottish and Southern Energy, 2020). It was assumed, as a worst-case scenario, that there could potentially be up to two geophysical surveys in the IS at any one time, during construction (piling) of the Project.

~~11.817~~11.818 The potential disturbance ranges used in the cumulative assessment were based on the SNCB guidance for assessment for harbour porpoise. Assessments for the Review of Consents (RoC) HRA for the Southern North Sea SAC[19] (BEIS, 2020), modelled the potential for disturbance due to the use of a SBP, and results indicated that there was the potential for a possible behavioural response in harbour porpoise at up to 3.77km from the source. The most recent guidance for assessing the significance of noise disturbance for harbour porpoise SACs (JNCC *et al.,* 2020; JNCC, 2023) recommended the use of an EDR of 5km for geophysical surveys.

~~11.818~~11.819 Geophysical surveys are a moving source of noise, rather than a stationary one (i.e. the distance at which a survey vessel could travel in one day, with the species relevant buffer area).

~~11.819~~11.820 It is difficult to determine what the potential area of effect would be when taking into account it is a moving source (as it is difficult to predict

[19] 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 (BEIS, 2020).

how far a vessel may survey in a day). Based on survey vessels travelling at a speed of 4.5 to 5 knots, up to 199km could be surveyed in one day. This however does not take into account the survey downtime for line changes, weather, or other technical reasons. Approximately only 52% of the surveying time was spent surveying, as per review of seismic surveys within the UK (BEIS, 2020).

~~11.820~~11.821 These assumptions have been applied to geophysical surveys due to their similarity in approach. Taking these into account, then up to 103.5km could be surveyed in one day by one geophysical survey vessel. **Table 11.95** summarises the total impact area for each marine mammal species, taking into account the recommended disturbance ranges as discussed separately for each species below.

~~11.821~~11.822 It must be noted that this approach was highly precautionary as it is unlikely that the whole geophysical survey transect area would cause disturbance to marine mammal species, as animals would return once the vessel had passed, and the disturbance had ceased.

Table 11.95 Impact area of geophysical surveys calculated for the marine mammal species in the study area based on a 103.5 km survey length

Species	Survey length	Disturbance buffer (km)	Total geophysical survey area including turning area (km^2)	
			One survey	Two surveys
Harbour porpoise	103.5km	5	596.04	1192.1
Seals		1	210.1	420.2
Dolphins and minke whale		3.12	353.5	707

~~11.822~~11.823 As the locations of the potential geophysical surveys were unknown, the following assessments were based on the density estimates summarised in **Table 11.15** and discussed in **Section 11.1**.

Harbour porpoise

~~11.823~~11.824 The potential impact area, using a 5km EDR and based on the worst-case scenario of two geophysical surveys occurring at the same time as piling activities on the Project, the potential magnitude of the temporary impact has been assessed as **medium**, with 6.5% of the reference population potentially temporarily disturbed (**Table 11.96**).

Table 11.96 Quantified CEA for the potential disturbance of harbour porpoise during geophysical surveys at OWF projects

Harbour porpoise			
Project	**Harbour porpoise density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	1.621	2123.7	3,442.5
Disturbance from two geophysical surveys	0.515	1192.1	613.9
Total number of harbour porpoise			4,056.4
(without the Project)			*613.9*
Percentage of CIS MU			6.5%
(without the Project)			*0.99%*
Magnitude of cumulative effect			Medium
(without the Project)			*Negligible*

Dolphins and minke whale

~~11.824~~11.825 Assessments for the EPS Protected Sites and Species Risk Assessment (Scottish and Southern Energy, 2020) modelled the potential for a possible behavioural response in marine mammals up to 3.12km from the source in water depths at 10m, and 4.22km in water depths at 100m.

~~11.825~~11.826 Given the shallow water depths in the Project area (18-40m below LAT), the disturbance distance of 3.12km was taken forward and applied to the approach described above (**Table 11.95**), resulting in an impact area of 707km^2 for marine mammals.

~~11.826~~11.827 The potential impact area, based on the worst-case scenario, of two geophysical surveys occurring at the same time as piling activities on the Project, the potential magnitude of the temporary effect has been assessed **high** for bottlenose dolphin with just over 20% of the reference population potentially temporarily disturbed, and **negligible** for the remaining dolphins and minke whale (**Table 11.97**).

Table 11.97 Quantified CEA for the potential disturbance of dolphins and minke whale during the geophysical surveys at OWF projects

Bottlenose dolphin			
Project	**Bottlenose dolphin density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	0.0104	DRC	56.3
Disturbance from two geophysical surveys	0.0104	707	7.4
Total number of bottlenose dolphin			63.7
(without the Project)			*7.35*
Percentage of IS MU			21.7%
(without the Project)			*2.5%*
Magnitude of cumulative effect			High
(*without the Project*)			*Low*
White-beaked dolphin			
Project	**White-beaked dolphin density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	0.007	DRC	17.9
Disturbance from two geophysical surveys	0.007	707	4.95
Total number of white-beaked dolphin			22.9
(without the Project)			*5.0*
Percentage of CGNS MU			0.05%
(*without the Project*)			*0.01%*
Magnitude of cumulative effect			Negligible
(*without the Project*)			*Negligible*

Common dolphin			
Project	**Common dolphin density (/km²)**	**Impact area (km²)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	0.028	DRC	127.6
Disturbance from two geophysical surveys	0.028	707	19.8
Total number of Common dolphin *(without the Project)*			147.4 *19.8*
Percentage of CGNS MU *(without the Project)*			0.1% *0.02%*
Magnitude of cumulative effect (*without the Project*)			Negligible *Negligible*
Risso's Dolphin			
Project	**Risso's dolphin density (/km²)**	**Impact area (km²)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	0.0006	DRC	2.4
Disturbance from two geophysical surveys	0.0006	707	0.42
Total number of Risso's dolphin *(without the Project)*			2.8 *0.42*
Percentage of CGNS MU *(without the Project)*			0.02% *0.004%*
Magnitude of cumulative effect *(without the Project)*			Negligible *Negligible*
Minke whale			
Project	**Minke whale density (/km²)**	**Impact area (km²)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	0.0088	2827.4	24.9
Disturbance from two geophysical surveys	0.0088	707	6.2
Total number of minke whale *(without the Project)*			31.1 *6.2*
Percentage of CGNS MU *(without the Project)*			0.16% *0.03%*
Magnitude of cumulative effect *(without the Project)*			Negligible *Negligible*

Seals

~~11.827~~11.828 As a worst-case for geophysical surveys, it has been assumed that seals within 1km (a total area of 3.1km^2) could be disturbed for each geophysical survey (BEIS, 2020), and would result in a disturbance area of 420.2km^2 over the whole transit area for two surveys (**Table 11.95**).

~~11.828~~11.829 Based on the worst-case scenario of two geophysical surveys occurring at the same time as piling activities on the Project, the potential magnitude of the temporary impact has been assessed as **low** for grey seal, with over 2% of the wider reference population potentially temporarily disturbed, and **negligible** for harbour seal, with 0.2% of the wider reference population disturbed (**Table 11.98**).

Table 11.98 Quantified CEA for the potential disturbance of seals during the geophysical surveys at OWF projects

Grey seal			
Project	**Grey seal density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	0.1	1963.5	204.2
Disturbance from two geophysical surveys	0.152	420.2	64.5
Total number of grey seal *(without the Project)*			268.7 *64.5*
Percentage of wider reference population *(without the Project)*			2.0% *0.5%*
Magnitude of cumulative effect *(without the Project)*			Low *Negligible*
Harbour seal			
Project	**Harbour seal density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	0.00011	1963.5	0.2
Disturbance from two geophysical surveys	0.00012	420.2	0.05
Total number of harbour seal *(without the Project)*			0.3 *0.05*
Percentage of wider reference population *(without the Project)*			0.02% *0.004%*
Magnitude of cumulative effect *(without the Project)*			Negligible *Negligible*

Potential for disturbance from aggregate extraction and dredging

~~11.829~~11.830 Taking into account the small potential impact ranges and the distances of the aggregate extraction and dredging projects from the Project, 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.

~~11.830~~11.831 Two aggregate/dredging projects have been screened in that could have potential cumulative disturbance impacts with piling taking place at the Project (see **Appendix 11.4**):

- North Bristol Deep 1601 (all species but white-beaked dolphin, bottlenose dolphin, grey and harbour seal)
- North Bristol Deep 1602 (all species but white-beaked dolphin, bottlenose dolphin, grey and harbour seal)

~~11.831~~11.832 As outlined in the BEIS (2020) Review of Consents (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). This would result in a potential disturbance area of 1.13km^2 for each project, or up to 2.26km^2 for two aggregate projects.

~~11.832~~11.833 The aggregate/dredging projects lie beside each other within the Bristol Channel, approximately 11km southeast of Cardiff. To represent the animals disturbed, the densities from SCANS-IV block CS-C block were used. The caveat was that the Channel itself was not covered in the surveys but a large area of the Celtic Deep beyond Pembrokeshire and Cornwall (Gilles *et al.,* 2023). This was the best available data for this area. For grey seal, the Carter *et al*. (2022) density of MU 12 Wales has been used.

~~11.833~~11.834 The cumulative effect of piling at the Project in combination with two aggregate projects in the Bristol Channel resulted in a magnitude of **medium** for harbour porpoise with just over 5% of the reference population affected. For grey seal the magnitude was assessed as **low,** but **negligible** for all Dolphins and minke whale (**Table 11.99**).

~~11.834~~11.835 As the aggregate project lies in the Bristol Channel and therefore outside the IS MU for bottlenose dolphin and the wider area for harbour seal, the magnitude of the impact would be **negligible** as animals form the relevant MUs would not be affected.

Table 11.99 Quantified CEA for the potential disturbance of harbour porpoise, delphinids, minke whale and grey seal during extraction and dredging activities

Harbour porpoise			
Project	**Harbour porpoise density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	1.621	2123.7	3,442.5
North Bristol Deep 1601 & 1602	0.0157	2.26	0.04
Total number of harbour porpoise *(without the Project)*			3,442.6 *0.04*
Percentage of CIS MU *(without the Project)*			5.51% *0.0001%*
Magnitude of cumulative effect *(without the Project)*			Medium *Negligible*
Common dolphin			
Project	**Common dolphin density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	0.028	DRC	127.6
North Bristol Deep 1601 & 1602	0.841	2.26	1.9
Total number of common dolphin *(without the Project)*			129.5 *1.9*
Percentage of CGNS MU *(without the Project)*			0.1% *0.002%*
Magnitude of cumulative effect *(without the Project)*			Negligible *Negligible*
Risso's Dolphin			
Project	**Risso's dolphin density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	0.0006	DRC	2.4
North Bristol Deep 1601 & 1602	0.0057	2.26	0.01
Total number of Risso's dolphin *(without the Project)*			2.4 *0.01*
Percentage of CGNS MU *(without the Project)*			0.02% *0.0001%*
Magnitude of cumulative effect *(without the Project)*			Negligible *Negligible*

Minke whale			
Project	**Minke whale density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	0.0018	2827.43	5.1
North Bristol Deep 1601 & 1602	0.0079	2.26	0.02
Total number of minke whale *(without the Project)*			5.1 *0.02*
Percentage of CGNS MU *(without the Project)*			0.03% *0.00009%*
Magnitude of cumulative effect *(without the Project)*			Negligible *Negligible*
Grey seal			
Project	**Grey seal density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	0.1	1963.5	196.4
North Bristol Deep 1601 & 1602	0.07	2.26	0.16
Total number of grey seal *(without the Project)*			196.5 *0.16*
Percentage of wider reference population *(without the Project)*			1.5% *0.001%*
Magnitude of cumulative effect *(without the Project)*			Low *Negligible*

Potential for disturbance from seismic surveys

~~11.835~~11.836 It was not possible to estimate the location, or number, of potential seismic surveys that could be undertaken at the same time as construction and potential piling activity for the Project.

~~11.836~~11.837 As a precautionary approach, the potential for cumulative impacts from oil and gas seismic surveys has been screened into the CEA for further consideration. It was assumed, as a worst-case scenario, that there could potentially be one seismic survey in the IS at any one time during construction (piling) of the Project. One seismic survey for Spirit Energy is scheduled to take place in 2024 as part of the carbon capture exploration. To date, no other licences or licence applications with an overlapping time period with Project construction was available at the time of writing. Therefore, the following assessment for one seismic survey has been included for information at this stage.

~~11.837~~11.838 Seismic surveys are a moving source, travelling up to 199km in one day (based on a speed of 4.5 knots), of which 52% (103.5km) is active survey time. **Table 11.100** summarises the total impact area for each marine mammal species, taking into account the recommended disturbance ranges, and which are discussed in the relevant species assessment section below.

~~11.838~~11.839 It must be noted that this approach was highly precautionary as it is unlikely that the whole seismic survey transect area would cause disturbance to marine mammal species, as animals would return once the vessel had passed, and the disturbance had ceased.

Table 11.100 Impact area of seismic surveys calculated for the marine mammal species in the study area based on a 103.5km survey length

Species	Survey length	Disturbance buffer (km)	Total area of one seismic survey including turning area (km^2)
Harbour porpoise	103.5km	12	1,694.4
Delphinids	103.5km	11	1,518.6
Minke whale	103.5km	10	1,349.2
Seals	103.5km	17	2,667.4

Harbour porpoise

~~11.839~~11.840 The potential impact area during seismic surveys, was based on a buffer of 12km, following the current JNCC disturbance guidance (JNCC, 2023) (**Table 11.101**).

Table 11.101 Quantified CEA for the potential disturbance of harbour porpoise during seismic surveys

Harbour porpoise			
Project	**Harbour porpoise density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	1.621	2123.7	3,442.5
Disturbance from one seismic survey	0.515	1,694.39	872.6
Total number of harbour porpoise			4,315.1
(*without the Project*)			*872.6*
Percentage of CIS MU			6.9%
(*without the Project*)			*1.4%*
Magnitude of cumulative effect			Medium
(*without the Project*)			*Low*

Dolphins

~~11.840~~11.841 Strong avoidance of bottlenose dolphin from a 2D seismic survey (with 470 cubic inch airguns, and a peak sound source level of 243dB re 1 µPa @1m) was modelled at between 1.8km and 11km (based on site-specific underwater noise modelling using the dB*ht* method) (DECC, 2011). Assuming the largest potential disturbance range of 11km and a survey length of 103.5km, the impact area for one seismic survey was suggested to be 1,518.63km^2.

Table 11.102 Quantified CEA for the potential disturbance of Dolphins during seismic surveys

Bottlenose dolphin			
Project	**Bottlenose dolphin density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	0.0104	DRC	56.3
Disturbance from one seismic survey	0.0104	1,518.63	15.8
Total number of bottlenose dolphin *(without the Project)*			72.1 *15.8*
Percentage of IS MU *(without the Project)*			32.2% *5.4%*
Magnitude of cumulative effect *(without the Project)*			High *Medium*
White-beaked dolphin			
Project	**White-beaked dolphin density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	0.007	DRC	17.9
Disturbance from one seismic survey	0.007	1,518.63	10.6
Total number of white-beaked dolphin *(without the Project)*			28.5 *10.6*
Percentage of CGNS MU *(without the Project)*			0.07% *0.02%*
Magnitude of cumulative effect *(without the Project)*			Negligible *Negligible*

Common dolphin			
Project	**Common dolphin density (/km²)**	**Impact area (km²)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	0.028	DRC	127.6
Disturbance from one seismic survey	0.028	1,518.63	42.5
Total number of Common dolphin			170.1
(without the Project)			*42.5*
Percentage of CGNS MU			0.17%
(without the Project)			*0.04%*
Magnitude of cumulative effect			Negligible
(without the Project)			*Negligible*
Risso's Dolphin			
Project	**Risso's Dolphin density (/km²)**	**Impact area (km²)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	0.0006	DRC	2.4
Disturbance from one seismic survey	0.0006	1,518.63	0.9
Total number of Risso's Dolphin			3.31
(without the Project)			*0.9*
Percentage of CGNS MU			0.03%
(without the Project)			*0.01%*
Magnitude of cumulative effect			Negligible
(without the Project)			*Negligible*

Minke whale

~~11.841~~11.842 There was little available information on the potential for disturbance to minke whales from seismic surveys, however, based on a radius of 10km (Macdonald *et al.*, 1995) and a survey length of 103.5km, the impact area for one seismic survey was suggested to be 1,349.16km².

Table 11.103 Quantified CEA for the potential disturbance of minke whale during seismic surveys

Minke whale			
Project	**Minke whale density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	0.0088	2827.4	24.9
Disturbance from one seismic survey	0.0088	1,349.2	11.9
Total number of minke whale			36.8
(*without the Project*)			*11.9*
Percentage of CGNS MU			0.2%
(*without the Project*)			*0.06%*
Magnitude of cumulative effect			Negligible
(*without the Project*)			*Negligible*

Seals

~~11.842~~11.843 There was little 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, showed potential disturbance ranges from 13.3km to 17.0km from the source (BEIS, 2020). These ranges were 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.

~~11.843~~11.844 A potential disturbance range of 17km (or impact area of 2,667.4km^2 for one survey) was therefore applied to both grey seal and harbour seal, due to a lack of species-specific information.

Table 11.104 Quantified CEA for the potential disturbance of grey seal and harbour seal during seismic surveys

Grey seal			
Project	**Grey seal density (/km²)**	**Impact area (km²)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	0.1	1,963.5	196.3
Disturbance from one seismic survey	0.152	2,667.4	405.4
Total number of grey seal *(without the Project)*			601.8 *405.4*
Percentage of wider reference population *(without the Project)*			4.5% *3.1%*
Magnitude of cumulative effect *(without the Project)*			Medium *Medium*
Harbour seal			
Project	**Harbour seal density (/km²)**	**Impact area (km²)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	0.00011	1,963.5	0.2
Disturbance from one seismic survey	0.00012	2,667.4	0.3
Total number of harbour seal *(without the Project)*			0.5 *0.3*
Percentage of wider reference population *(without the Project)*			*0.05%* *0.03%*
Magnitude of cumulative effect *(without the Project)*			Negligible *Negligible*

~~11.844~~11.845 For seismic surveys, if undertaken at the same time as piling for the Project, with no other cumulative activities, the magnitude of impact would be **high** for bottlenose dolphin, **medium** for harbour porpoise and grey seal, and **negligible** for minke whale and remaining dolphin species.

Potential for disturbance from UXO clearance

~~11.845~~11.846 It was 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 the Project.

~~11.846~~11.847 A more detailed and indicative assessment of potential injury and disturbance arising from UXO clearances at the Project can be found in **Appendix 11.3**. A separate Marine Licence application for any required UXO clearance for the Project would be submitted prior to any planned activities and would consider any potential cumulative effects.

~~11.847~~11.848 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 assessment is therefore based on potential for disturbance from one UXO high-order detonation (worst-case), as well as one low-order clearance event. However, the likelihood of this and temporal overlap with piling for the Project is low.

~~11.848~~11.849 JNCC guidance refers to the preference of using low-order deflagration, thus this is carried forward in the assessment below, in combination with piling at the Project.

~~11.849~~11.850 The magnitude of the potential disturbance from UXO clearance has been estimated based on the following:

Harbour porpoise

~~11.850~~11.851 The potential impact area of 2,123.7km^2 per project for harbour porpoises, 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 following the current JNCC (2023) guidance.

Table 11.105 Quantified CEA for the potential disturbance of harbour porpoises during low-order UXO clearance at OWF projects

Harbour porpoise			
Project	**Harbour porpoise density (/km²)**	**Impact area (km²)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	1.621	2,123.7	3,442.5
Disturbance from high-order UXO clearance	0.515	2,123.7	1,093.7
Disturbance from low-order UXO clearance	0.515	78.5	40.4
Total number of harbour porpoise			4,576.7
(without the Project)			*1,134.2*
Percentage of CIS MU			7.3%
(without the Project)			*1.8%*
Magnitude of cumulative effect			Medium
(without the Project)			*Low*

Dolphins, minke whale and seals

~~11.851~~11.852 The worst-case modelled impact ranges for dolphins spp. at the Project for TTS/fleeing response (using the impulsive unweighted SPL_{peak}) of 1.1km (3.8km²) for high-order clearance, and 0.13km (0.053km²) for low-order clearance. So as the worst case, to represent the wider potential impact area for two low-order UXO clearance events for all dolphin species was based on the 5km disturbance range for harbour porpoise, as a precautionary measure.

~~11.852~~11.853 The potential impact area during a single UXO clearance event, based on the modelled worst-case impact range at the Project for TTS/fleeing response (using the impulsive weighted SELs) of 89km (24,884.56km²) for high-order clearance, and 4.5km (63.62km²) for low-order clearance.

~~11.853~~11.854 The potential impact area during a single UXO clearance event on grey and harbour seals, based on the modelled worst-case impact range at the Project for TTS/fleeing response (using the impulsive weighted SELs) of 16km (804.25km²) for high-order clearance, and 0.8km (2.01km²) for low-order clearance.

Table 11.106 Quantified CEA for the potential disturbance of Dolphins during low-order UXO clearance at OWF projects

Bottlenose dolphin			
Project	**Bottlenose dolphin density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	0.0104	DRC	56.3
EDR from two low-order UXO clearances	0.0104	157	1.6
Total number of bottlenose dolphin			57.9
(without the Project)			*1.6*
Percentage of IS MU			25.9%
(without the Project)			*0.6%*
Magnitude of cumulative effect			High
(without the Project)			*Negligible*
White-beaked dolphin			
Project	**White-beaked dolphin density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	0.007	DRC	17.9
EDR from two low-order UXO clearances	0.007	157	1.1
Total number of white-beaked dolphin			19
(without the Project)			*1.1*
Percentage of CGNS MU			0.04%
(without the Project)			*0.003%*
Magnitude of cumulative effect			Negligible
(without the Project)			*Negligible*

Common dolphin			
Project	**Common dolphin density (/km²)**	**Impact area (km²)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	0.028	DRC	127.6
EDR from two low-order UXO clearances	0.028	157	4.4
Total number of Common dolphin			132
(without the Project)			*4.4*
Percentage of CGNS MU			0.13%
(without the Project)			*0.004%*
Magnitude of cumulative effect			Negligible
(without the Project)			*Negligible*
Risso's dolphin			
Project	**Risso's dolphin density (/km²)**	**Impact area (km²)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	0.0006	DRC	2.4
EDR from two low-order UXO clearances	0.0006	157	0.1
Total number of Risso's Dolphin			2.5
(without the Project)			*0.09*
Percentage of CGNS MU			0.02%
(without the Project)			*0.001%*
Magnitude of cumulative effect			Negligible
(without the Project)			*Negligible*

Minke whale			
Project	**Minke whale density (/km²)**	**Impact area (km²)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	0.0088	2,827.43	24.9
Disturbance from high-order UXO clearances	0.0088	24,884.60	218.98
Disturbance from low-order UXO clearances	0.0088	63.62	0.56
Total number of minke whale			244.43
(without the Project)			*219.54*
Percentage of CGNS MU			1.21%
(without the Project)			*1.09%*
Magnitude of cumulative effect			Low
(without the Project)			*Low*

Grey seal			
Project	**Grey seal density (/km²)**	**Impact area (km²)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	0.1	1963.5	196.4
Disturbance from high-order UXO clearances	0.152	804.25	122.25
Disturbance from low-order UXO clearances	0.152	2.01	0.31
Total number of grey seal			318.90
(without the Project)			*122.55*
Percentage of wider reference population			2.4%
(without the Project)			*0.9%*
Magnitude of cumulative effect			Low
(without the Project)			*Negligible*

Harbour seal			
Project	**Harbour seal density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed**
The Project (piling)	0.00011	1963.5	0.22
Disturbance from high-order UXO clearances	0.00012	804.25	0.097
Disturbance from low-order UXO clearances	0.00012	2.01	0.00024
Total number of harbour seal *(without the Project)*			0.31 *0.097*
Percentage of wider reference population *(without the Project)*			0.03% *0.008%*
Magnitude of cumulative effect *(without the Project)*			Negligible *Negligible*

~~11.854~~11.855 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, were 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 suggested that disturbance behaviour was not predicted to occur from UXO clearance, if undertaken over a short period of time (JNCC, 2010b[4]).

~~11.855~~11.856 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. There is also the potential for any high-order clearance to use noise abatement measures such as bubble curtains which would further reduce the impact.

~~11.856~~11.857 For UXO clearance (two clearance events) occurring at the same time as piling on the Project, with no other cumulative activities, the magnitude of impact would be **high** for bottlenose dolphin, **medium** for harbour porpoise, **low** for minke whale and grey seal and **negligible** for harbour seal, and the remaining delphinids.

Combined disturbance from other industries and activities (other than OWF)

~~11.857~~11.858 The magnitude of disturbance from all underwater noise sources of industries and activities (other than OWF), as described above, have been quantitively assessed together in **Table 11.107**.

~~11.858~~11.859 As highlighted in **Appendix 11.4** the certainty of these activities taking place together and at the same time as piling on the Project was low (for example there were no known licences or licence applications for seismic surveys).

~~11.859~~11.860 For harbour porpoise and grey seal, the magnitude of impact was **medium**, with less than 10% of the reference population at risk from noisy activities, with the potential for cumulative disturbance effects together with piling at the Project. Minke whale are at risk from noisy activities with the potential for cumulative disturbance effects together with piling at the project, for which the magnitude of impact was **low**, with less than 5% of the respective populations at risk of disturbance.

~~11.860~~11.861 Common dolphin, Risso's dolphin, white-beaked dolphin and harbour seal are at risk from noisy activities with the potential for cumulative disturbance effects together with piling at the project, for which the magnitude of impact was **negligible**, with less than 1% of the respective populations at risk of disturbance.

~~11.861~~11.862 For bottlenose dolphin, up to 27.7% of the reference population was at risk from noisy activities with a **high** magnitude of impact (**Table 11.107**).

*Table 11.107 Quantitative assessment for all other industry 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 11.10**)*

Impact	Number of individuals							
	Harbour porpoise	**Bottlenose dolphin**	**White-beaked dolphin**	**Common dolphin**	**Risso's dolphin**	**Minke whale**	**Grey seal**	**Harbour seal**
Worst-case disturbance from the Project (piling)	3,442.5	56.3	17.9	127.6	2.4	24.9	196.4	0.2
Geophysical surveys	613.9	7.4	4.9	19.8	0.4	6.2	64.5	0.05
Aggregates and dredging	0.035	-	-	1.9	0.01	0.02	0.2	-
Seismic surveys	872.6	15.8	10.6	42.5	3.3	11.9	405.4	0.3
UXO clearance	1,134.2	1.6	1.1	4.4	0.1	219.54	122.55	0.097
Total number of individuals	6,063.2	81.05	34.58	196.21	6.24	262.54	788.91	0.68
(without the Project)	2,620.7	24.75	16.68	68.61	3.84	237.66	592.56	0.47
Percentage of MU	9.70%	27.7%	0.08%	0.2%	0.05%	1.30%	5.94%	0.06%
(without the Project)	4.19%	*8.5%*	*0.04%*	*0.07%*	*0.03%*	1.18%	4.46%	0.04%
Magnitude of cumulative effect	Medium	High	Negligible	Negligible	Negligible	Low	Medium	Negligible
(without the Project)	*Low*	*Medium*	*Negligible*	*Negligible*	*Negligible*	*Low*	*Low*	*Negligible*

Significance of effect

~~11.862~~11.863 If all other industry noisy activities were taking place at the same time as piling at the Project, there would be the potential for a high magnitude of impact for bottlenose dolphin, medium for harbour porpoise and grey seal, and a negligible magnitude of impact for all other marine mammal species.

~~11.863~~11.864 Therefore, taking into account the medium and low receptor sensitivity, the overall cumulative effect for disturbance to marine mammals from other industries and activities was assessed to be **moderate adverse** (significant in EIA terms) for harbour porpoise and bottlenose dolphin, and **minor adverse** (not significant in EIA terms) for all other species.

~~11.864~~11.865 It should be noted that a more realistic assessment would be produced if results from the dose-response curves, instead of the EDR and disturbance ranges, were used for harbour porpoise and seal species. This would lower the magnitude appropriately.

~~11.865~~11.866 Furthermore, projects/activities included within the cumulative assessment for disturbance from other activities and industries were selected based on speculative assessments as there were no current licences or applications pending to confirm timing or specifics. The likelihood however of these activities being undertaken and for them to overlap with the Project piling is low (for example there were no current licences or licence applications for seismic surveys and therefore seismic surveys have been presented for information at this stage). It is very unlikely that all activities would be taking place on the same day or in the same season, therefore the assessment likely represents an over-precautionary and worst-case estimate of the marine mammals that could be at risk of disturbance during the 2.5 year offshore construction period of the Project.

~~11.866~~11.867 The confidence in this cumulative effect assessment is considered medium, as it was deemed precautionary enough to comfortably encompass the likely uncertainty and variability. Throughout the assessment, it has been made clear where multiple and compounding precautionary assumptions have been made. Where possible, the uncertainty in the data which is typically used to inform CEAs, as well as the quantification of impacts (when based on published ESs) have been removed. Instead, a standard impact range for disturbance and the same source for density estimates (e.g. SCANS-IV (2023) and Carter *et al*. (2022) seal-at sea density estimates) has been used when calculating effects for each given impact. However, consideration has been given to a number of plans or projects/activities and the likelihood of temporal overlap of all these activities is low.

Summary of cumulative effect 1: Disturbance from underwater noise

~~11.867~~11.868 Each of the above-described noise sources were quantitively assessed assuming they all occur at same time as piling activities on the Project. This is a highly unlikely scenario; even the likelihood of piling at six additional developments alongside the Project in the 2.5 years of scheduled construction is highly unlikely, as well as the construction of other projects.

~~11.868~~11.869 For bottlenose dolphin, for any noisy activities with the potential for cumulative disturbance effects, the magnitude of impact was **high** alongside the Project piling due to the number of animals predicted to be affected by the application of the harbour porpoise dose-response curve, which was a highly conservative worst case.

~~11.869~~11.870 For harbour porpoise and grey seal for all noisy activity alongside piling at the Project, the overall magnitude of impact was **medium**, and **negligible** for all other species.

~~11.870~~11.871 As previously stated, the magnitude of disturbance for cumulative effects from piling has been based on the population modelling (where available) to assess the significance.

Significance of effect

~~11.871~~11.872 If all included noisy activities were to occur at the same time as piling at the Project, there was the potential for a high to negligible magnitude of impact (dependant on species). However, as outlined above, the activities assessed in sections Cumulative effects 1b and 1c were only presented as possible activities that could occur during construction at the Project. These assessments were speculative as no licences or applications had been submitted at that time. The disturbance activities included within sections Cumulative effects 1b and 1c were assessed with no current knowledge of their possible construction or activity windows. It is very unlikely that all activities would be taking place on the same day or in the same season, therefore this likely represents an over-precautionary and worst-case estimate of the marine mammals that could be at risk of disturbance during the offshore construction period of the Project.

~~11.872~~11.873 The significance of effect for potential disturbance from cumulative effects of underwater noise has therefore been based on the assessment presented in section Cumulative effects 1a where known variables have been applied to quantify the impacts.

~~11.873~~11.874 Based on the population modelling for disturbance due to underwater noise from concurrent piling at multiple projects and taking into account the individual receptor sensitivity for the marine mammal species, the overall impact significance for disturbance from cumulative underwater noise, was **minor** to **negligible adverse** (not significant in EIA terms) depending on the marine mammal species modelled.

~~11.874~~11.875 Population modelling for those projects with the loudest noise and largest impact ranges (piling) showed a low magnitude for bottlenose dolphin and negligible magnitude for harbour porpoise, minke whale and both seal species populations over 25 years, despite the number of developments in the area.

~~11.875~~11.876 For common dolphin, Risso's dolphin and white-beaked dolphin the dose-response curve assessments from the relevant projects have been examined cumulatively. The overall impact significance for disturbance from cumulative underwater noise ranged from **minor adverse** for common dolphin and Risso's dolphin to **negligible adverse** (not significant in EIA terms) for white-beaked dolphin.

~~11.876~~11.877 The confidence in this cumulative effect assessment was high for underwater noise as it was deemed precautionary enough to comfortably encompass the likely uncertainty and variability. Throughout the assessment it has been made clear where multiple and compounding precautionary assumptions have been made.

~~11.877~~11.878 No additional mitigation is proposed due to the potential cumulative effects at this time above the embedded mitigation (noting the Project commitment for no concurrent Project piling) and the additional mitigation considered (MMMP, see **Section 11.3.3.1**) for the Project. However, further consideration would be given to additional requirements if deemed applicable, as more detailed information becomes available regarding potential effects and timing of other projects.

Table 11.108 Assessment of effect significance for the potential of a cumulative disturbance effect due to other noisy projects and activities[20]

Marine mammal species/receptor	Sensitivity	Magnitude	Significance of effect	Additional mitigation measures proposed	Residual effect
Harbour porpoise	Medium	Negligible	Not Significant (Minor adverse)	No additional mitigation required for cumulative disturbance	Not Significant (Minor adverse)
Bottlenose dolphin	Low	Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Risso's dolphin	Low	Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Common dolphin	Low	Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)
White-beaked dolphin	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)
Minke Whale	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Grey seal	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)
Harbour seal	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)

[20] The table reflects the assessments of concurrent piling at multiple projects alongside piling at the Project.

Cumulative effect 2: Barrier effects

Cumulative effect 2a: Barrier effects from underwater noise

~~11.878~~11.879 The sensitivity of marine mammals with regard to barrier effect due to underwater noise was medium for harbour porpoise and minke whale, and low for all other species.

~~11.879~~11.880 The assessment of the potential for barrier effects due to Project construction underwater noise concluded the effect to marine mammal species would be **minor adverse** (not significant in EIA terms) (**Section 11.6.3.5**).

~~11.880~~11.881 Given the presence of other proposed OWF projects within the IS, including AyM, Mona, Morgan Generation Assets, and the Morgan and Morecambe Transmission Assets, which have similar construction timelines, there is potential for disturbance impact ranges to overlap. It is important to note that the OWFs, and other noise sources also included within the CEA, are spread over the wider area of the IS.

~~11.881~~11.882 The project-alone assessments for Mona ES and Morgan PEIR stated that although animals could experience mild disturbance, they were not going to be excluded from the coastal area, thus unlikely to lead to barrier effects. Similarly, ES assessments in AyM showed that barrier effects from noise during operation would be of negligible adverse significance. The potential magnitude of cumulative impact for a barrier effect to marine mammals as a result of cumulative underwater noise impacts was assessed to be **low** given the short-term nature of the impact and the geographical spread of the OWFs and activities.

~~11.882~~11.883 The potential for a barrier effect due to underwater noise during operation of the Project was assessed as **minor adverse** (not significant in EIA terms) (**Section 11.6.4.4**). Given the separation of projects the magnitude of effects was not considered greater than Project-alone.

~~11.883~~11.884 No additional mitigation was identified to be required for the potential for cumulative barrier effects from underwater noise impacts.

Cumulative effect 2b: Physical barrier effects

~~11.884~~11.885 The potential for barrier effects due to the physical presence of the Project, as discussed in **Section 11.6.4.5** showed that marine mammal species were not anticipated to be deterred from transiting through the Project site, based on current information.

~~11.885~~11.886 Given the presence of other proposed OWF projects within the IS, developments including AyM, Mona, Morgan, and the Transmission Assets, the potential for cumulative barrier effects from physical presence has been identified. However, evidence indicates that marine mammals are known to still use, be present and move through OWFs with fixed foundations whilst operational.

~~11.886~~11.887 Research by Fernandez-Betelu *et al*. (2022) found that the investigated offshore structures (oil and gas platforms and Beatrice Demonstrator platform) attracted harbour porpoises and therefore played an important role as foraging areas. It was unclear if the turbines were operational, but nonetheless, the structure itself was not hindering animals to travel. Scheidat *et al*. (2011) inferred similar findings from increased acoustic activities of harbour porpoise between pre-construction and operational phase of the Egmond aan Zee OWF.

~~11.887~~11.888 Taking into account the spacing between each WTG at the Project (approximately 1km in-rows), the distance to Morgan (16.7km) and Mona (10.0km) OWF, and other OWFs even further away, marine mammals would be able to move freely between each project site and in between structures of the Project. Therefore, it is not expected that there would be any potential for a cumulative barrier effect across different projects, with the resulting potential for any cumulative barrier effects from physical presence assessed as having a **negligible** magnitude for marine mammals.

~~11.888~~11.889 At the time of this ES report, there was limited information on the layout of the WTGs of the neighbouring developments and thus, the assessment has been based on the information presented; the final layout of WTGs would only be confirmed in the pre-construction period.

~~11.889~~11.890 With the sensitivity of medium and low, and the expected magnitude level of negligible (at worst), the impact significance for minke whale and harbour porpoise would be **minor adverse** (not significant in EIA terms) and for all other marine mammal species it would be **negligible adverse** (not significant in EIA terms).

~~11.890~~11.891 No additional mitigation has been identified to be required for the potential for cumulative physical barrier effects.

Cumulative effect 3: Increased collision risk with vessels

~~11.891~~11.892 As outlined in **Section 11.6.3.6**, the increased collision risk due to construction related Project vessels had an effect significance of moderate to minor adverse, although best practice measures to reduce the risk of collision with vessels were identified to reduce the residual significance of effect to minor adverse (not significant in EIA terms) for all species.

~~11.892~~11.893 During construction for the Project-alone, the greatest numbers of animals during this construction period were identified for harbour porpoise, grey seal, and common dolphin, with eight, five and two animals, respectively, facing this risk. For all other species had fewer than one animal were at risk (see **Table 11.56**).

~~11.893~~11.894 The risk of collision was reduced for some species (see **Table 11.74**) during the operation and maintenance phase, when vessel numbers would be significantly less than during the construction phase.

~~11.894~~11.895 Furthermore, a review on vessel disturbance in **Section 8** in **Appendix 11.2,** and the collision risk assessment in **Section 11.6.3.6** (Project-alone), indicated that the assessment was precautionary and the actual risk would be negligible.

~~11.895~~11.896 To reduce any marine mammal collision risk, vessel movements, where possible, would be incorporated into recognised vessel routes and hence to areas where marine mammal species are accustomed to vessels. All vessel movements would be kept to the minimum number that is required to reduce any potential for collision risk, and vessel speeds will be minimised, where practicable, whilst transiting. Additionally, vessel operators would use best practice to reduce any risk of collisions with marine mammals. Such best practice measures are set out in the Outline PEMP, included with the DCO Application. It is expected that other offshore projects and industries would follow similar measures in order to reduce the potential for collision risk of marine mammals with vessels (Mona, Morgan and AyM have committed to similar best practice measures).

~~11.896~~11.897 As vessel movements to and from any port would be incorporated within existing vessel routes as far as possible, 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. Once on-site, OWF vessels and other construction related 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 cumulative projects for marine mammals would be negligible.

~~11.897~~11.898 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 was considered to be extremely low or negligible. Increased collision risk from aggregate extraction and dredging has therefore been screened out from further consideration in the CEA.

~~11.898~~11.899 Considering the above, the expected cumulative magnitude level of effect during the construction phase was identified as negligible (at worst) with best practice measures being applied. Taking into account the **low** sensitivity for harbour porpoise, dolphins, and seals, and **medium** sensitivity for minke whale, the residual effect significance would therefore be **minor adverse** (not significant in EIA term) for all marine mammals. The significance of effect would be the same or less during the operation and maintenance phase.

~~11.899~~11.900 Best practice measures, as implemented for the Project, would ensure that any risk of vessels colliding with marine mammals is avoided as far as practicable.

~~11.900~~11.901 No additional mitigation has been identified as being required for the potential for cumulative collision risk due to the offshore construction activities associated with other OWFs at the same time as the Project.

Cumulative effect 4: Disturbance at seal haul-out sites

~~11.901~~11.902 The sensitivity of grey seal and harbour seal to disturbance at haul-out sites was **low** (see **Section 11.6.2**).

~~11.902~~11.903 Due to baseline vessel traffic being relatively high, and the closest distance of the Project to any seal haul-out site being over 30km, it was not expected that the Project would have any significant effect to seal at haul-out sites, with an effect significance of minor adverse. In addition, best practice measures would be implemented by the Project, such as reducing vessel transit speeds, wherever possible, and the avoidance of transiting within 1km (outside of established navigation routes) of any seal haul-out site.

~~11.903~~11.904 It has been assumed that all other projects would follow the similar best practice measures with regards to avoiding disturbance at haul-out sites if deemed required, unless within an established navigation route where seal haul-out sites are near to a vessel corridor (where seals present in that area would be used to vessels transiting past the area). It was therefore assessed that there would be limited potential for any cumulative disturbance effect at any seal haul-out site, and the cumulative effect magnitude would be **low.**

~~11.904~~11.905 Considering the sensitivity of low for both seal species, and the expected magnitude level of low, the effect significance for cumulative disturbance at seal haul-out sites would therefore be **minor adverse** (not significant in EIA terms).

~~11.905~~11.906 No additional mitigation has been identified as being required for the potential for cumulative disturbance at seal haul-out sites.

Cumulative effect 5: Changes to prey resources

~~11.906~~11.907 As per **Chapter 10 Fish and Shellfish Ecology**, the cumulative effects of piling noise are deemed not to be greater than the Project-alone effects (minor adverse). For any potential changes to prey resources, it has been assumed that any potential effects 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 effects other than those assessed for marine mammals, i.e. if prey are disturbed from an area as a result of underwater noise, marine mammals would 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 have been disturbed from the area.

~~11.907~~11.908 Any effects to prey species (such as seabed disturbance and associated SSCs) 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 would typically represent a small percentage of the potential habitat for prey species in the surrounding area.

~~11.908~~11.909 Taking into account the assessment for the Project-alone, and assuming similar effects for other projects and activities (assessed as minor adverse effect in the Mona ES and Morgan PEIR and a a negligible adverse effect for AyM ES), 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 effect on marine mammal populations as a result of changes to prey resources. Therefore, the cumulative magnitude was considered to be **negligible**.

~~11.909~~11.910 With the sensitivity of **low** to **medium**, and the magnitude level of **negligible** (at worst), for minke whale and harbour porpoise, the effect significance would be **minor adverse** (not significant in EIA term), and for all other marine mammals would be **negligible** (not significant in EIA terms).

~~11.910~~11.911 No additional mitigation has been identified as being required for the potential for cumulative effects to prey species.

Cumulative effect 6: Assessment of disturbance from operational offshore turbines generators

~~11.911~~11.912 The cumulative assessment considered disturbance effects from operational turbine generators associated with wind, wave or tidal projects in the CEA area. Plans and projects that have already been assessed in phases other than operation were not repeated here.

~~11.912~~11.913 The screened in projects (**Table 11.109**) have either become operational since the Project site-specific baseline surveys commenced in March 2021 or would become operational during the construction phase of the Project (**Appendix 11.4**).

Table 11.109 All plans and projects screened in for operational overlap with piling at the Project

Project	Structure	PINS Tier	Distance to Project	Species included in assessment
Saint- Brieuc OWF, France	Fixed	1	546km	All species but bottlenose dolphin, grey and harbour seal
Twin-Hub	Floating	1	399km	All species but bottlenose dolphin, grey and harbour seal
Morlais	Tidal	1	83km	All species
Llŷr 1	Floating	2	287km	All species but bottlenose dolphin, grey and harbour seal
Llŷr 2	Floating	2	287km	All species but bottlenose dolphin, grey and harbour seal
FloWatt Tidal Pilot, France	Tidal	2	464km	All species but bottlenose dolphin, grey and harbour seal

~~11.913~~11.914 This section assessed the potential for cumulative impact arising from the piling noise at the Project, in conjunction with operational turbine noise generated by the screened in projects. As disturbance ranges to operational turbines were not known, a qualitative approach has been taken to assess this cumulative impact.

~~11.914~~11.915 For Project-alone, the disturbance effect of the operational WTGs was assessed as having a minor adverse effect. Initial literary evidence (in **Section 11.6.4.1**) focused on specific noise level measurements at different OWFs and predictions regarding the impact area and potential responses of marine mammals.

~~11.915~~11.916 Following this, more evidence has been laid out below, emphasizing the low noise levels emitted during WTG operation, highlighting the absence of expected physiological injury to marine mammals but potential behavioural reactions if they are in close proximity to the WTGs.

Fixed foundation windfarms

~~11.916~~11.917 The main sources of sound generated during the operation of wind turbines are aerodynamic and mechanical. The mechanical noise is from the nacelle at the top of the wind turbine tower. As the wind turbine blades rotate, vibrations are generated that travel down the turbine tower and radiate into the surrounding water column and seabed (Tougaard *et al*., 2009; 2020; Nedwell *et al*., 2003).

~~11.917~~11.918 Noise levels associated with operational OWFs are relatively low, with recorded levels between 141 and 146 dB re 1µPs-m (RMS SPL) at four UK OWFs (MMO, 2015; Cheesman *et al*., 2016), and levels of 106 and 126 dB re 1µPa-m (RMS SPL) at three operational OWFs in Sweden and Denmark, which could not be audible for harbour porpoise at a distance of 70m from the wind turbine location (Tougaard *et al*., 2009). It has also been predicted that within a few hundred metres of a wind turbine, noise would be comparable to background noise levels (MMO, 2015; Cheesman, 2016).

~~11.918~~11.919 If the ambient background noise was masking the sound of operational turbines, then it is not expected for an animal to change their behaviour. In Marmo *et al*. (2013) the results showed that neither seals nor bottlenose dolphin were predicted to exhibit a behavioural response. Only 10% of harbour porpoise encountering the noise of an operational OWF can detect jacket foundation turbines at 4km and 11km (at windspeeds of 10 and 15ms^2, respectively) and monopiles out to 18km. Only 10% of minke whales are predicted to react to operational monopile WTGs between around 5km and 13km (at windspeeds of 10 and 15ms^2, respectively). However, the majority (50% and 90%) of minke whale and harbour porpoise would not respond to operational noise (Marmo *et al*., 2013).

~~11.919~~11.920 In fact, there was an overall increase in acoustic activity of harbour porpoise inside the operating wind farm, compared to pre-construction surveys at the Egmond aan Zee OWF (Scheidat *et al.,* 2011). The reason for this may have been the reef effect, attracting more prey species, and/or the sheltering effect of the turbines from heavy ship traffic.

~~11.920~~11.921 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 wind turbine (Tougaard *et al*., 2009; Sigray and Andersson, 2011).

~~11.921~~11.922 Measurements made at three different wind turbines in Denmark and Sweden at ranges between 14m and 40m from the turbine foundations found that the sound generated due to turbine operation was only detectable over underwater ambient noise at frequencies below 500Hz (Tougaard *et al*., 2009).

~~11.922~~11.923 Tougaard *et al*. (2020), reviewed the available measurements of underwater noise from different wind turbines 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 turbines in locations with high ambient noise from shipping or high wind speeds (Tougaard *et al*., 2020).

~~11.923~~11.924 An underwater noise study from a Chinese OWF in Shanghai found that the noise of ebb and flow around the windfarm was louder than the turbines (Yang *et al*., 2018). It must be noted that the capacity of the OWFs in this study are between 3 - 6MW only, whereas the Project's turbine capacity is expected to be at least three to fourfold higher.

~~11.924~~11.925 The trend of larger turbines sizes leads to the projection of elevated source levels. In particular, this extrapolation suggested a modelled source level of 177dB re 1µPa for a 10MW turbine and the subsequent increase in impact areas for behavioural disruption in marine mammals (Stöber and Thomsen, 2021). Larger turbine sizes have been modelled for the Project (see **Appendix 11.1**). While there are limitations in extrapolation for larger turbines, it is also important to note that larger turbines are spaced further apart than smaller ones.

~~11.925~~11.926 In a separate study envisioning the deployment of large-scale turbine arrays across the North Sea using 5MW turbines with source levels reaching 167.6dB re 1µPa, predictions were made (Molen *et al*., 2014). Within this hypothetical OWF array comprising 60 no. 5MW turbines, the anticipated noise levels were estimated to range between 113–115 dB re 1 mPa (RMS) within 400m of a turbine. The expected noise levels would diminish below 102dB re 1µPa (RMS) in the spaces between two such farms with a 5km separation. It was noted that under specific sea-states, the noise levels might decrease even further, potentially falling below the typical ambient noise. This scenario would enable animals to travel through quieter corridors.

Floating windfarms

~~11.926~~11.927 The aerodynamically produced noise generally does not influence underwater noise levels due to the reflection off the water surface (Marmo *et al*. 2013, Tougaard *et al*. 2020), but the partially submerged turbine tower may radiate noise into the water column.

~~11.927~~11.928 Operational noise levels that were measured from fixed offshore wind turbines were comparable to noise emissions from floating offshore wind turbines at Kincardine and Hywind Scotland at comparable distances (Risch *et al*., 2023). Noise emissions were concentrated in the frequencies below 200Hz and showed distinct tonal features, likely related to rotational speed, between 50 and 80Hz at Kincardine and 25 and 75Hz at Hywind Scotland.

~~11.928~~11.929 The report further highlighted that the overall effect of the operational noise and the ability of marine mammals to perceive this noise would be largely dependent on ambient noise levels and wind speed. As opposed to fixed structures, the mooring structures generated noise too, particularly during higher wind speeds when impulsive 'snaps' were perceived more often than usual. Measurements of noise levels above the median (median = 100dB noise contour) were recorded at distances up to 4km from the turbine array (Risch *et al*., 2023).

~~11.929~~11.930 Harbour porpoise click detection reduced at the sites closest to the turbine compared to the site furthest away, the report, however, indicated the preliminary nature of this particular result and highlighted that behavioural effects need to be studied in more detail whilst this industry is growing (Risch *et al.,* 2023).

Wave and tidal projects

~~11.930~~11.931 The noise that is generated from devices harvesting wave energy, derives from the moving parts in the wave energy convertors and the hydraulic pumps. In an underwater noise study by Tougaard (2015), the noise recorded from the Wavestar converter was barely detectable above the ambient nearshore noise, which was relatively high compared to offshore noise), although the hydraulic pumps caused noise of 20–25dB above ambient. Based on marine mammal audiogram, harbour porpoise should not hear any noise, whereas seals would hear the hydraulic pump clearly.

~~11.931~~11.932 Extensive wildlife observations around the European Marine Energy Centre (EMEC) wave and tidal energy test sites in Orkney have found little evidence of any long-term effects such as avoidance. There was no clear relationship between harbour porpoise, harbour seal and grey seal abundance and the operational sites (Long, 2017).

~~11.932~~11.933 The same report found the influence of the test site on other cetacean species difficult to assess due to the varying sizes (i.e., unusually large pods) and sporadic sightings in and around the site during the surveys. However, a slight reduction in density was modelled when the site became operational.

~~11.933~~11.934 It was suggested that vessel movement could be influencing marine mammal abundance, rather than the test site itself and Long (2017) stated that for seals beyond 1km there appeared to be little change from baseline abundances.

Magnitude

~~11.934~~11.935 If all noise from the operational turbine projects were taking place at the same time as piling at the Project, the potential for overlap with the operational noise from other turbine-generated projects which could cause potential disturbance impacts was identified.

~~11.935~~11.936 Considering the aforementioned evidence, the geographical spread of the projects in the wider IS region and the short impact ranges arising from operational turbines (determined through the Project's underwater noise modelling), the magnitude of the impact would be temporary and limited to the Project's timeframe. Consequently, it was assessed as **low** for all marine mammal species.

Significance of effect

~~11.936~~11.937 Taking into account the low sensitivity for dolphins and seals, and the medium receptor sensitivity for harbour porpoise and minke whale, the overall cumulative effect for disturbance from noise from operational offshore turbine generators and wave sites when Project piling activities are ongoing, was determined as **minor adverse** (not significant in EIA terms) (**Table 11.110**).

Table 11.110 Assessment of effect significance for the potential for cumulative disturbance due to operational offshore turbines generators

Marine mammal species/receptors	Sensitivity	Magnitude	Significance of effect	Additional mitigation measures proposed	Residual effect
Harbour porpoise and minke whale	Medium	Negligible	Not Significant (Minor adverse)	None identified	Not Significant (Minor adverse)
Dolphins and seals	Low		Not significant (Negligible)		

11.8 Transboundary effects

~~11.937~~11.938 The highly mobile nature of marine mammals included within this assessment means that there is the potential for transboundary effects. This has been taken into account throughout the assessments as the study area for each species was based on their relevant MU (or area within which the same individuals were considered to be part of one larger overall population). The MUs (and therefore reference populations) for each species covered an area wider than the UK (**Table 11.111**). This approach has been taken through the assessments.

Table 11.111 Countries and areas considered in the marine mammal assessments through the relevant MU reference populations

Species/receptor	Countries/areas	Inclusion within assessments
Harbour porpoise	▪ NW and SW England ▪ Wales ▪ IoM ▪ East and South ROI ▪ NI ▪ SW Scotland ▪ NW France	CIS MU (IAMMWG, 2023; see **Appendix 11.2**) CEA screening area (see **Appendix 11.4**)
Bottlenose dolphin	▪ NW England ▪ Wales ▪ IoM ▪ East and South ROI ▪ NI ▪ SW Scotland	IS MU (IAMMWG, 2023; see **Appendix 11.2**) CEA screening area (see **Appendix 11.4**)
Common dolphin Risso's dolphin White-beaked dolphin Minke whale	▪ NW England ▪ Wales ▪ IoM ▪ East and South ROI ▪ NI ▪ SW Scotland	CGNS MU (IAMMWG, 2023; see **Appendix 11.2**) CEA screening area (see **Appendix 11.4**)
Grey seal	▪ NW England ▪ Wales ▪ IoM ▪ East and South ROI ▪ NI	NW England MU and IoM for combined MUs NW England MU; IoM population; Wales MU; NI MU; E RoI; SE RoI population for wider reference population (SCOS, 2020; see **Appendix 11.2**) CEA screening area (see **Appendix 11.4**)

Species/receptor	Countries/areas	Inclusion within assessments
Harbour seal	▪ NW England ▪ NI	NW England MU and NI MU (SCOS, 2020; see **Appendix 11.2**) CEA screening area (see **Appendix 11.4**)

11.8.1 Transboundary effects with the Isle of Man

~~11.938~~11.939 MNRs at the IoM concerning marine mammals are not covered as part of the RIAA. Since the Isle of Man territory is not bound by the regulations outlined in the Habitats Directive (the IoM is not a European Economic Area (EEA) state, but a self-governing British Crown Dependency), the protected areas within the IoM are not applicable to the scope of the RIAA. The potential transboundary effects between the Project and relevant IoM MNRs have therefore been considered here. The assessment involved the examination of how activities or changes at the Project windfarm site might impact marine mammal populations or habitats within the protected areas around the IoM. The species for which the IoM MNRs are designated for are harbour porpoise, bottlenose dolphin, Risso's dolphin, grey seal, harbour seal and minke whale (**Appendix 11.2**; Table 2.2).

~~11.939~~11.940 Unlike for designated sites in the EU and UK, the IoM does not have specific conservation objectives set out for the MNRs, but refer to more general objectives such as those of the conservation of specific species or habitats, enabling their recovery and the exclusion of damaging activities and impacts.

Harbour porpoise

~~11.940~~11.941 While both in the Project-alone and CEAs for harbour porpoise the worst-case effect significance was of moderate adverse, the long-term population consequences (iPCoD) over a 25-year period revealed a negligible impact on the population of the CIS MU.

~~11.941~~11.942 The potential for adverse effects on the integrity of the conservation objectives for SACs designated for harbour porpoises have been thoroughly examined in the RIAA. No adverse effects on the site integrity have been identified in the RIAA assessments for the North Anglesey Marine SAC, the Bristol Channel Approaches SAC, West Wales Marine SAC, Rockabill to Dalkey Island, or the North Channel SAC.

~~11.942~~11.943 The SAC-specific assessments were derived from the reference population of the CIS MU. As no adverse effects have been identified on the closest SAC, the North Anglesey Marine SAC, it was expected that the effects on any MNR site (such as Baie ny Carrickey, Calf and Wart Bank, Langness, Laxey, Niarbyl, Port Erin, West Coast) at the IoM would be comparable. This was because these protected sites are situated within the same sea region, and consequently, the animals within them belonged to the same population.

Bottlenose dolphin

~~11.943~~11.944 The Project-alone assessments for bottlenose dolphins indicated low levels of effect significance. The modelled population consequences (iPCoD) of cumulative disturbance over a 25-year span have shown a minor adverse effect on the small bottlenose population of the IS MU, and an insignificant effect of the even smaller Cardigan Bay SAC population (147 bottlenose dolphin).

~~11.944~~11.945 The RIAA investigated potential adverse effects on the integrity of conservation objectives for the relevant bottlenose dolphin SAC. It was determined that no adverse effects were identified in the Cardigan Bay SAC, nor in the Pen Llŷn a'r Sarnau SAC. During half of the year, specifically in summer, bottlenose dolphins reside in Cardigan Bay, whilst in winter, they migrate north and spend time around the IoM. As no adverse effects were observed on the Cardigan Bay SAC population, it is unlikely that dolphins connected with the Baie ny Carrickey, Douglas or Laxey MNRs would be significantly affected, considering there was connectivity between individuals from the SAC and the MNRs and the wider IS population.

Risso's Dolphin

~~11.945~~11.946 The MNRs that encompass habitats for this species included Baie ny Carrickey, Calf and Wart Bank, Douglas, and Langness. These sites are positioned along the southeast to east coast of the IoM. Both the effects from the Project-alone and the cumulative effects reviewed in **Section 11.7.3.2**. indicated that Risso's dolphin demonstrated a minor adverse to negligible effect significance.

~~11.946~~11.947 Looking at the entire population, it was estimated that 2.7% of Risso's dolphin would experience cumulative disturbance during piling if all other OWFs, alongside piling at the Project, were to occur simultaneously. In contrast, the Project-alone contributed only 0.02% to the disturbed reference population of Risso's dolphin. The number of disturbed animals for all assessed projects was based on the very precautionary approach of using the harbour porpoise dose-response curves and presented unrealistic numbers of disturbed animals.

~~11.947~~11.948 Furthermore, the numbers of disturbed animals are based on the unmitigated noise effect of piling and as such the effect of piling on Risso's dolphin would not cause a significant population level effect or impact on the conservation status of the individuals supported by the MNRs.

Grey seal

~~11.948~~11.949 Although both the Project-alone and CEAs for grey seals resulted in minor to negligible adverse levels, the population consequences (iPCoD) over a 25-year period have indicated a negligible impact on the combined NW MU and IoM population and the wider reference population. An evaluation of potential adverse effects on the integrity of conservation objectives for relevant SACs designated for grey seal was conducted in the RIAA. No adverse effects were identified in the assessment for the Pen Llŷn a'r Sarnau SAC, nor the Pembrokeshire Marine SAC.

~~11.949~~11.950 As the IoM MNRs (including Langness, Niarbyl, Ramsey, and West Coast) would support the same reference population (Wales MU and SW England MU) associated with the Welsh SACs, then the effect on the MNR conservation objectives would be comparable to those assessed in the RIAA.

Harbour seal

~~11.950~~11.951 While both the assessments for harbour seal (conducted separately for Project-alone and cumulative effects) yielded results indicating moderate to negligible levels of adversity, the overall population consequences (iPCoD) over a 25-year span showed a negligible impact on the wider reference population. Additional modelling was conducted on the small population from the Strangford Lough SAC (106 harbour seal), which returned to have no discernible impact on the population. The RIAA was conducted to evaluate potential adverse effects on the integrity of conservation objectives specifically for the Strangford Lough SAC, and no adverse effects were identified.

~~11.951~~11.952 The absence of adverse effects identified in the assessment for the Strangford Lough SAC implied that the impact effects were unlikely to significantly influence the conservation objectives of the relevant IoM MNR sites (including Langness, Ramsey, and West Coast). Harbour seals from the wider population associated with the Strangford Lough SAC are most likely to also be utilising the MNR sites at the IoM. In the assessments in the RIAA, there were no adverse effects on site integrity identified and the same would apply to the MNR site given the distance from the Project.

Minke whale

~~11.952~~11.953 Only one MNR, Laxey, situated on the east coast of the island has been specifically designated for minke whale. The impacts arising from the Project-alone (**Section 11.1**) exhibited mostly minor adverse effects. The cumulative effect of sequential piling identified a significant impact, but this would be reduced to minor adverse once mitigation had been applied.

~~11.953~~11.954 When assessing cumulative effects detailed in **Section 11.7.3.2**, the impact on minke whale was assessed as minor in terms of adverse effect significance. Considering the entire population level (CGNS MU), the cumulative disturbance for this species was estimated to affect less than 0.3% if all disturbances were to occur simultaneously. Regarding long-term predictions concerning population consequences (iPCoD) over a span of 25 years, the effect was also deemed negligible.

~~11.954~~11.955 Given the minimal impact observed from the Project-alone, as well as when considering cumulative effects, the probability of any significant transboundary effects with Laxey MNR would be exceedingly low.

Summary

~~11.955~~11.956 Considering the minimal impact evident from the Project-alone, along with the assessment of cumulative effects, the likelihood of significant transboundary effects with the IoM MNRs was determined to be low for all species given mitigations required by all projects.

11.9 Inter-relationships

~~11.956~~11.957 There are clear inter-relationships between the marine mammal ecology topic and several other topics that have been considered within this ES. For marine mammals, potential inter-relationships are already covered as part of the marine mammal assessments within this ES. **Table 11.112** provides a summary of the principal inter-relationships and signposts to where those issues have been addressed in the relevant chapters.

Table 11.112 Marine mammal inter-relationships

Topic and description	Related chapter	Where addressed in this chapter	Rationale
Construction phase			
Underwater noise from vessels	**Chapter 14 Shipping and Navigation**	**Section 11.6.3.4**	Increased vessel traffic could affect the level of disturbance for marine mammals.
Increased collision risk with vessels	**Chapter 14 Shipping and Navigation**	**Section 11.6.3.6**	Increased vessel traffic could affect the level of collision risk for marine mammals.
Changes to prey resources	**Chapter 10 Fish and Shellfish Ecology** **Chapter 9 Benthic Ecology** **Chapter 13 Commercial Fisheries**	**Section 11.6.3.7**	Potential impacts on fish species could affect the prey resource available for marine mammals.

Topic and description	Related chapter	Where addressed in this chapter	Rationale
Changes to water quality	**Chapter 8 Marine Sediment and Water Quality**	**Section 11.6.3.8**	Changes in water quality could affect marine mammals and prey
Operation and maintenance phase			
Underwater noise from vessels	**Chapter 14 Shipping and Navigation**	**Section 11.6.4.3**	Increased vessel traffic could affect the level of disturbance for marine mammals.
Increased collision risk with vessels	**Chapter 14 Shipping and Navigation**	**Section 11.6.4.6**	Increased vessel traffic could affect the level of collision risk for marine mammals.
Changes to prey resources	**Chapter 10 Fish and Shellfish Ecology** **Chapter 9 Benthic Ecology** **Chapter 13 Commercial Fisheries**	**Section 11.6.4.7**	Potential impacts on fish species could affect the prey resource available for marine mammals.
Changes to water quality	**Chapter 8 Marine Sediment and Water Quality**	**Section 11.6.4.8**	Changes in water quality could affect marine mammals and prey
Decommissioning phase			
Inter-relationships for impacts during the decommissioning phase would be the same as those outlined above for the construction phase.			

11.10 Interactions

~~11.957~~11.958 The impacts identified and assessed in this chapter have the potential to interact with each other. The areas of potential interaction between impacts are presented in **Table 11.113** and **Table 11.114**. This provides a screening tool for which impacts have the potential to interact.

~~11.958~~11.959 The worst-case impacts assessed within the chapter took these interactions into account and therefore the impact assessments were considered conservative and robust. For example, 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.

~~11.959~~11.960 The potential combined effects of disturbance from piling, other construction activities and vessels at the Project (Impacts 2, 3 and 4; **Table 11.113** may cause an additive disturbance pathway. The piling was assessed assuming a hammer energy of 120%, although it is improbable that this energy level would be consistently used throughout the entire piling duration. Furthermore, the modelled ranges and assessment outcome do not include any additional mitigation. The potential number of animals disturbed during piling at the Project and the level of effect were therefore highly conservative. Recent research indicated that harbour porpoise can leave the area a few days before piling begins, coinciding with increased vessel traffic near the windfarm site (Benhemma-Le Gall *et al*., 2023). This suggested that the potential effect of piling had also been overestimated due to some animals potentially vacating the area prior to the start. Therefore, any additive effect of these impacts would have already been accounted for within the piling assessment.

11.96011.961 The impacts were assessed relative to each development phase (i.e. construction, operation and maintenance, or decommissioning) to see if (for example) multiple construction impacts affecting the same receptor could increase the level of impact upon that receptor.

11.96111.962 Following this, a lifetime assessment was undertaken, which considered the impact interactions identified, and the potential for impacts to affect receptors across all development phases (**Table 11.113** - **Table 11.115**).

Table 11.113 Interactions between impacts – screening (construction and decommissioning phases)

	Potential interaction between construction and decommissioning phase impacts								
	Impact 1: PTS & TTS from underwater noise during piling	Impact 2: Disturbance from underwater noise during piling	Impact 3: TTS and disturbance from underwater noise during other construction activities	Impact 4: TTS and disturbance from underwater noise and presence of vessels	Impact 5: Barrier effects as a result of underwater noise during construction	Impact 6: Increased collision risk with vessels	Impact 7: Changes to prey resources	Impact 8: Changes to water quality	Impact 9: Disturbance of seals at haul-out sites
Impact 1: PTS & TTS from underwater noise during piling		No	Yes	Yes	Yes	No	No	No	No
Impact 2: Disturbance from underwater noise during piling	No		Yes	Yes	Yes	No	No	No	No
Impact 3: TTS and disturbance from underwater noise during other construction activities	Yes	Yes		Yes	Yes	No	No	No	No
Impact 4: TTS and disturbance from underwater noise and presence of vessels	Yes	Yes	Yes		Yes	No	No	No	No

	Potential interaction between construction and decommissioning phase impacts								
	Impact 1: PTS & TTS from underwater noise during piling	Impact 2: Disturbance from underwater noise during piling	Impact 3: TTS and disturbance from underwater noise during other construction activities	Impact 4: TTS and disturbance from underwater noise and presence of vessels	Impact 5: Barrier effects as a result of underwater noise during construction	Impact 6: Increased collision risk with vessels	Impact 7: Changes to prey resources	Impact 8: Changes to water quality	Impact 9: Disturbance of seals at haul-out sites
Impact 5: Barrier effects as a result of underwater noise during construction	Yes	Yes	Yes	Yes		No	No	No	No
Impact 6: Increased collision risk with vessels	No	No	No	No	No		No	No	No
Impact 7: Changes to prey resources	Yes	Yes	Yes	Yes	No	No		Yes	No
Impact 8: Changes to water quality	No	No	No	No	No	No	No		No
Impact 9: Disturbance of seals at haul-out sites	No	No	No	Yes	No	No	No	No	
Decommissioning phase									
It is anticipated that the decommissioning impacts would be no greater than construction (with no piling)									

Table 11.114 Interactions between impacts – screening (operation and maintenance phase)

	Potential interaction between operation and maintenance phase impacts								
	Impact 1: TTS and disturbance from underwater noise of operational WTGs	Impact 2: TTS and disturbance from underwater noise during maintenance activities	Impact 3: TTS and disturbance from underwater noise and presence of vessels	Impact 4: Barrier effects from underwater noise during operation and maintenance	Impact 5: Barrier effects from physical presence of windfarm infrastructure	Impact 6: Increased collision risk with vessels during operation and maintenance	Impact 7: Changes to prey resources	Impact 8: Changes to water quality	Impact 9: Disturbance of seals at haul-out sites
Impact 1: TTS and disturbance from underwater noise of operational WTGs		Yes	Yes	Yes	No	No	No	No	No
Impact 2: TTS and disturbance from underwater noise during maintenance activities	Yes		Yes	Yes	No	No	No	No	No
Impact 3: TTS and disturbance from underwater noise and presence of vessels	Yes	Yes		Yes	No	No	No	No	No
Impact 4: Barrier effects from underwater noise during operation and maintenance	Yes	Yes	Yes		Yes	No	No	No	No

	Potential interaction between operation and maintenance phase impacts								
	Impact 1: TTS and disturbance from underwater noise of operational WTGs	Impact 2: TTS and disturbance from underwater noise during maintenance activities	Impact 3: TTS and disturbance from underwater noise and presence of vessels	Impact 4: Barrier effects from underwater noise during operation and maintenance	Impact 5: Barrier effects from physical presence of windfarm infrastructure	Impact 6: Increased collision risk with vessels during operation and maintenance	Impact 7: Changes to prey resources	Impact 8: Changes to water quality	Impact 9: Disturbance of seals at haul-out sites
Impact 5: Barrier effects from physical presence of windfarm infrastructure	No	No	No	Yes		No	No	No	No
Impact 6: Increased collision risk with vessels during operation and maintenance	No	No	No	No	No		No	No	No
Impact 7: Changes to prey resources	Yes	Yes	Yes	Yes	No	No		Yes	No
Impact 8: Changes to water quality	No	No	No	No	No	No	No		No
Impact 9: Disturbance of seals at haul-out sites	No	No	Yes	No	No	No	No	No	

Table 11.115 Interaction between impacts – phase and lifetime assessment for marine mammals

Receptor	Highest residual significance level: Construction	Operation and maintenance	Decommissioning	Phase assessment	Lifetime assessment
Harbour porpoise	Minor adverse	Minor adverse	Minor adverse	**<u>Construction</u>** The MMMP would reduce the risk of injury (PTS) for marine mammals, and therefore during UXO clearance or piling there would be no pathway for interaction of potential injury (PTS) with disturbance effects (i.e. all individuals are assumed to be disturbed if within range and excluded from the injury footprint). The assessment of disturbance to marine mammals during piling represented the worst-case scenario for underwater noise, based on the maximum potential disturbance 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. There is no pathway for vessel interaction, or effects on prey resource to interact with noise impacts, as it is assumed that individuals would be excluded from the	**No greater than individually assessed impact.** The greatest magnitude of impact would be the spatial footprint of construction noise (i.e. piling). Once this disturbance impact has ceased all further impact during construction and operation and maintenance would be small scale, highly localised and episodic. There is no evidence of long-term displacement of marine mammals from operational windfarms. It was therefore considered that over the Project lifetime these impacts would not combine and represent an increase in the significance level.
Bottlenose dolphin	Minor adverse	Minor adverse	Minor adverse		
Common dolphin	Minor adverse	Minor adverse	Minor adverse		

	Highest residual significance level				
Receptor	**Construction**	**Operation and maintenance**	**Decommissioning**	**Phase assessment**	**Lifetime assessment**
Risso's dolphin	Minor adverse	Minor adverse	Minor adverse	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 would be highly localised. It was therefore considered that the interaction of these impacts would not represent an increase in the significance level. **Operation and maintenance** Operational noise impacts from WTGs would be highly localised for each WTG. Any changes to habitat for prey species would also be confined to the immediate footprint of WTG. The magnitude of impact was negligible and relates to largely the same spatial footprint. Therefore, there was no greater impact from any interaction between these impacts. There is potential for interaction with noise from maintenance activities and vessels interaction but given the negligible magnitude of impacts and episodic nature of these impacts it was not considered that the interaction of these impacts would	
White-beaked dolphin	Minor adverse	Minor adverse	Minor adverse		
Minke whale	Minor adverse	Minor adverse	Minor adverse		
Grey seal	Minor adverse	Minor adverse	Minor adverse		
Harbour seal	Minor adverse	Minor adverse	Minor adverse		

Receptor	Highest residual significance level Construction	Operation and maintenance	Decommissioning	Phase assessment	Lifetime assessment
				represent an increase in the significance level. Any potential effects during operation and maintenance from underwater noise, changes in prey resources or water quality would be localised, temporary and negligible. **Decommissioning** Same or less than for construction (except for pile driving noise, which would not occur)	

11.11 Marine wildlife licence application

~~11.962~~11.963 A Marine Wildlife Licence application would 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 (if required)
- Piling

~~11.963~~11.964 Prior to these activities taking place, an EPS risk assessment would be undertaken, following the staged approach as outlined in 'The protection of Marine European Protected Species from injury and disturbance' (JNCC *et al*., 2010). If it is deemed that an EPS licence is required for any activity, an EPS Risk Assessment document would be produced, and a Marine Wildlife Licence applied for.

~~11.964~~11.965 Mitigation would be put in place for UXO clearance, and piling, as per the JNCC guidelines. Where ADDs are required, these would also be considered within the risk assessments.

11.12 Summary of mitigation and monitoring requirements

~~11.965~~11.966 Mitigation (see **Section 11.3.3**) would be required for the following activities, and would use the guidance and advice relevant at the time (current guidelines are noted below):

- UXO clearance (see **Appendix 11.3**)
  - Following the JNCC guidelines for minimising the risk of injury to marine mammals from using explosives (JNCC, 2010b[4])
- Piling
  - Following the statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise (JNCC, 2010c)
  - Following the Statutory nature conservation agency guidance for the use of Passive Acoustic Monitoring in UK waters for minimising the risk of injury to marine mammals from offshore activities (JNCC, 2023b)

~~11.966~~11.967 The relevant guidelines would be used as a standard, however, if required, they may be adapted to ensure that any predicted impact ranges are effectively mitigated for all marine mammal species. It is expected that ADDs would be used as part of the mitigation for both UXO clearance and piling.

11.96711.968 Mitigation protocols (MMMPs) would be developed for UXO clearance and piling as outlined in the Draft MMMP. These would be presented as part of the licence conditions prior to construction.

11.96811.969 In addition to the mitigation above, the following measures would also be put in place to reduce vessel collision risk and disturbance from vessels at seal haul-out sites:

- Best practice measures and requirements would be fully detailed in the PEMP and Vessel Traffic Management Plan (in line with the Outline Plans provided with this DCO Application).

11.96911.970 Monitoring requirements are described in the In-Principle Monitoring Plan (IPMP) (Document Reference 6.4) included with the DCO Application and would be further developed and agreed with stakeholders prior to construction taking account of the final detailed design of the Project.

11.97011.971 The IPMP identifies relevant offshore monitoring, as required by the Deemed Marine Licence (DML) conditions, establishes the objectives of such monitoring and sets out the guiding principles for delivering any monitoring measures, as required.

11.97111.972 It should be noted that any monitoring of wide-ranging species, such as marine mammals, is best undertaken at a regional level with a strategic approach.

11.97211.973 Any further monitoring requirements of marine mammals for the Project would be agreed with MMO and Natural England, prior to construction.

11.13 Assessment summary

~~11.973~~11.974 A summary of the potential effects on marine mammals during the construction, operation and maintenance, and decommissioning phases of the Project are summarised in **Table 11.116** and for cumulative effects in **Table 11.117**.

~~11.974~~11.975 Taking into account the proposed mitigation measures, where required, the residual significance of effect during the construction, operation and maintenance and decommissioning phases of the Project were assessed as **minor adverse** (and not significant in EIA terms).

~~11.975~~11.976 For cumulative effects, negligible to minor adverse effects have been identified, based on the noise sources where detailed variables were known (piling at other OWFs), in conjunction with Project piling for all marine mammal receptors.

~~11.976~~11.977 It is noted for the CEA that:

- The assessment assumed the worst case impact range for all projects and activities with no mitigation
- The effect of the Project on harbour porpoise was based on the worst-case density from two years of site-specific survey, in which harbour porpoise sightings were consistenly high and also skewed by a single month with expectionally high numbers. The resulting density used was nearly three times higher than would be expected from use of SCANS-IV (2023)
- The number of bottlenose dolphin potentially disturbed by the Project-alone has been calculated based on the harbour porpoise dose response curve which was a highly conservative approach due to the difference function hearing groups and in the species sensitvitiy and has likely over-estimated the number of individuals affected
- There was no impact overlap with any key areas (e.g. designated sites)
- Not all individuals would be displaced over the entire potential disturbance range used within the assessments
- Behavioural effects from UXO clearance, if they occur, would be an instantaneous response and short-term. Guidance suggested that disturbance behaviour was not predicted to occur from UXO clearance if undertaken over a short period of time (JNCC, 2010b[4])

~~11.977~~11.978 This cumulative assessment has been refined and revised since the PEIR assessment, and has included information from other projects to the best of knowledge up until the agreed six-month cut-off date prior to DCO submission. The final MMMP would more realistically inform the potential requirement for any further mitigation, or need for scheduling of activities across projects.

Table 11.116 Summary of potential effects for marine mammals

Potential impact	Receptor	Sensitivity	Magnitude	Significance of effects	Additional mitigation measures proposed	Residual effect
Construction phase						
Impact 1: PTS from underwater noise during piling	Harbour porpoise	High	Medium	Significant (Major adverse)	MMMP (**Section 11.3.3**)	Not Significant (Minor adverse)
	Dolphins		Negligible	Not significant (Minor adverse)		
	Minke whale		Monopile: Medium Pin-pile: Low	Significant (Major - Moderate adverse)		
	Grey seal		Monopile: Medium Pin-pile: Negligible	Significant (Major adverse) - not Significant (Minor adverse)		
	Harbour seal		Monopile: Low Pin-pile: Negligible	Significant (Moderate adverse) - not Significant (Minor adverse)		
Impact 1: TTS from underwater noise during piling	Harbour porpoise, grey seal	Medium	Low	Not Significant (Minor adverse)	MMMP (**Section 11.3.3**)	Not Significant (Minor adverse)
	Dolphins, minke whale, harbour seal		Negligible			
Impact 2: Disturbance from	Harbour porpoise, minke whale	Medium	Negligible	Not Significant (Minor adverse)	None required or	Not Significant (Minor adverse)

Potential impact	Receptor	Sensitivity	Magnitude	Significance of effects	Additional mitigation measures proposed	Residual effect
underwater noise during piling	Dolphins and seals Spp.	Low			proposed for Project-alone	
Impact 3: TTS from underwater noise during other construction activities	All marine mammal species	Medium	Negligible	Not Significant (Minor adverse)	None required or proposed for Project-alone	Not Significant (Negligible – Minor adverse)
Impact 3: Disturbance from underwater noise during other construction activities	Harbour porpoise, minke whale	Medium	Negligible	Not Significant (Minor adverse)		
	All other species	Low		Not Significant (Negligible adverse)		
Impact 4: TTS from underwater noise and presence of vessels	All marine mammal species	Medium	Negligible	Not Significant (Minor adverse)	None required or proposed for Project-alone	Not Significant (Minor adverse)
Impact 4: Disturbance from underwater noise and presence of vessels	Harbour porpoise, minke whale	Medium	Negligible	Not Significant (Minor adverse)		
	Bottlenose dolphin, grey seal	Low	Low			
	All other dolphins, harbour seal	Low	Negligible	Not Significant (Negligible adverse)		

Potential impact	Receptor	Sensitivity	Magnitude	Significance of effects	Additional mitigation measures proposed	Residual effect
Impact 5: Barrier effects from underwater noise during construction	Harbour porpoise, minke whale	Medium	Negligible	Not Significant (Minor adverse)	None required or proposed for Project-alone	Not Significant (Negligible – Minor adverse)
	Dolphins, seals	Low		Not Significant (Negligible adverse)		
Impact 6: Increased collision risk with vessels	Harbour seal	Low	High	Significant (Moderate adverse)	Best practice measures, as identified in the Outline PEMP (see **Section 11.3.3**).	Not Significant (Minor adverse)
	Harbour porpoise		Medium	Not Significant (Minor adverse)		
	Grey seal		Medium			
	Dolphins		Low			
	Minke whale	Medium	Low			
Impact 7: Changes to prey resources	Harbour porpoise, minke whale	Medium – Low	Negligible	Not Significant (Negligible - Minor adverse)	None required or proposed for Project-alone	Not Significant (Negligible – Minor adverse)
	Dolphins, seals	Low		Not Significant (Negligible adverse)		
	Grey seal	Low	Low	Not Significant (Minor adverse)		
Impact 8: Changes to water quality	All marine mammal species	Negligible	Negligible	Not Significant (Negligible adverse)	Embedded mitigation (see **Section 11.3.3**)	Not Significant (Negligible adverse)

Potential impact	Receptor	Sensitivity	Magnitude	Significance of effects	Additional mitigation measures proposed	Residual effect
Impact 9: Disturbance of seals at haul-out sites	Grey and harbour seal	Low	Low - Negligible	Not Significant (Minor adverse - Negligible)	Best practice measures, including consideration of distances from seal haul-out sites, as provided in the Outline PEMP (see **Section 11.3.3**)	Not Significant (Negligible – Minor adverse)
Operation and maintenance phase						
Impact 1: TTS from underwater noise of operational WTGs	All marine mammal species	Medium	Negligible	Not Significant (Minor adverse)	None required or proposed for Project-alone	Not Significant (Minor adverse)
Impact 1: Disturbance from underwater noise of operational WTGs	Harbour porpoise, minke whale	Medium	Low	Not Significant (Minor adverse)		
	All other species	Low				
Impact 2: TTS from underwater noise during maintenance activities	All marine mammal species	Medium	Negligible	Not Significant (Minor adverse)	None required or proposed for Project-alone	Not Significant (Negligible – Minor adverse)
Impact 2: Disturbance from underwater noise	Harbour porpoise, minke whale	Medium	Negligible	Not Significant (Minor adverse)		

Potential impact	Receptor	Sensitivity	Magnitude	Significance of effects	Additional mitigation measures proposed	Residual effect
during maintenance activities	All other species	Low		Not Significant (Negligible adverse)		
Impact 3: TTS from underwater noise and presence of vessels	All marine mammal species	Medium	Negligible	Not Significant (Minor adverse)	Best practice measures as outlined in **Section 11.3.3**	Not Significant (Negligible – Minor adverse)
Impact 3: Disturbance from underwater noise and presence of vessels	Harbour porpoise	Medium	Low	Not Significant (Minor adverse)		
	Minke whale		Negligible			
	Bottlenose dolphin, seals spp.	Low	Low			
	All other dolphins		Negligible	Not Significant (Negligible adverse)		
Impact 4: Barrier effects from underwater noise during operation and maintenance	All marine mammal species	Not assessed further in the ES; the assessment is linked to **Sections 11.6.4.1 - 11.6.4.3** which were deemed as Not significant (Minor to negligible adverse)			None required or proposed for Project-alone	Not Significant (Minor adverse)
Impact 5: Barrier effects from physical presence of windfarm infrastructure	All marine mammal species	Not assessed further in the ES; based on literature review and link to assessment in **Section 11.6.4.1** barrier effects are deemed as Not Significant (Minor adverse)			None required or proposed for Project-alone	Not Significant (Negligible adverse)

Potential impact	Receptor	Sensitivity	Magnitude	Significance of effects	Additional mitigation measures proposed	Residual effect
Impact 6: Increased collision risk with vessels during operation and maintenance	Harbour seal	Low	High	Significant (Moderate adverse)	Best practice measures as outlined in **Section 11.3.3**	Not Significant (Negligible – Minor adverse)
	Grey seal		Medium	Not Significant (Minor adverse)		
	Harbour porpoise		Low			
	Bottlenose dolphin, Risso's dolphin		Low			
	Common dolphin, white-beaked dolphin		Negligible	Not Significant (Negligible adverse)		
	Minke whale	Medium	Low	Not Significant (Minor adverse)		
Impact 7: Changes to prey resources	Harbour porpoise, minke whale	Low - Medium	Negligible	Not Significant (Negligible – Minor adverse)	None required or proposed for Project-alone	Not Significant (Negligible – Minor adverse)
	Dolphins, seals	Low		Not Significant (Negligible adverse)		
Impact 8: Changes to water quality	All marine mammal species	Negligible	Negligible	Not Significant (Negligible adverse)	Embedded mitigation (see **Section 11.3.3**)	Not Significant (Negligible adverse)
Impact 9: Disturbance of seals at haul-out sites	Grey and harbour seals	Low	Low - Negligible	Not Significant (Negligible – Minor adverse)	Best practice measures, including consideration of distances from seal	Not Significant (Negligible – Minor adverse)

Potential impact	Receptor	Sensitivity	Magnitude	Significance of effects	Additional mitigation measures proposed	Residual effect
					haul-out sites, as provided in the Outline PEMP (see **Section 11.3.3**)	
Decommissioning phase						
Impact 1: PTS or TTS from underwater noise	All marine mammal species	High	Medium - Negligible	Significant (Major adverse) - Not Significant (Minor adverse)	MMMP to reduce risk of PTS	Not Significant (Minor adverse)
Impact 2: Disturbance from underwater noise	All marine mammal species	Medium	Negligible	Not Significant (Minor adverse)	None required	Not Significant (Minor adverse)
Impact 3: Disturbance from underwater noise, presence and movements of vessels	All marine mammal species	Low-Medium	Low - Negligible	Not Significant (Minor - Negligible adverse)	None required	Not Significant (Minor – Negligible adverse)
Impact 4: Barrier effect from underwater noise	All marine mammal species	Low-Medium	Negligible	Not Significant (Negligible - Minor adverse)	None required	Not Significant (Minor adverse)
Impact 5: Increased collision risk with vessels	All marine mammal species	Low-Medium	High - Low	Significant (Moderate - Minor adverse)	Best practice measures (see **Section 11.3.3**).	Not Significant (Minor adverse)
Impact 6: Changes to prey resource	All marine mammal species	Low - Medium	Low - Negligible	Not Significant (Negligible - Minor adverse)	None required	Not Significant (Negligible – Minor adverse)

Potential impact	Receptor	Sensitivity	Magnitude	Significance of effects	Additional mitigation measures proposed	Residual effect
Impact 7: Changes to water quality	All marine mammal species	Negligible	Low - Negligible	Not Significant (Negligible - Minor adverse)	Embedded mitigation (see **Section 11.3.3**)	Not Significant (Negligible adverse)
Impact 8: Disturbance of seals at haul-out sites	Both seal species	Low	Low - Negligible	Not Significant (Minor adverse - Negligible)	Best practice measures, including consideration of distances from seal haul-out sites, as provided in the Outline PEMP (see **Section 11.3.3**).	Not Significant (Negligible – Minor adverse)

Table 11.117 Summary of potential cumulative effects for marine mammals

Potential impact	Receptor	Sensitivity	Magnitude	Significance of effects	Additional mitigation measures proposed	Residual effect
All phases						
CEA 1: Disturbance from underwater noise	Bottlenose dolphin	Low	Low	Not Significant (Minor adverse)	All potential simultaneous noise sources would be considered further, prior to construction and scheduling; if required would be considered as part of the MMMP	Not Significant (Negligible – Minor adverse)
	Dolphins and seals	Low	Negligible - Low	Not Significant (Negligible – Minor adverse)		
	Harbour porpoise, minke whale	Medium	Negligible	Not Significant (Minor adverse)		
CEA 2a: Barrier effects from underwater noise	Harbour porpoise, minke whale	Medium	Low	Not Significant (Minor adverse)	None required	Not Significant (Negligible)
	Dolphins and seals	Low	Low	Not Significant (Minor adverse)		
CEA 2b: Physical barrier effects	Harbour porpoise, minke whale	Medium	Negligible	Not Significant (Minor adverse)	None required	Not Significant (Negligible)
	Dolphins and seals	Low	Negligible	Not Significant (Negligible adverse)		
CEA 3: Increased collision risk with vessels	Harbour seal	Low	High	Significant (Moderate adverse)	Best practice measures, as identified in the Outline PEMP (see **Section 11.3.3**); otherwise, no other mitigation required	Not Significant (Minor adverse)
	Harbour porpoise		Medium	Not Significant (Minor adverse)		

Potential impact	Receptor	Sensitivity	Magnitude	Significance of effects	Additional mitigation measures proposed	Residual effect
	Grey seal		Medium			
	Dolphins		Low			
	Minke whale	Medium	Low			
CEA 4: Disturbance of seals at haul-out sites	Seals	Low	Low	Not Significant (Minor adverse)	None required	Not Significant (Minor adverse)
CEA 5: Changes to prey resources	Harbour porpoise, minke whale	Medium	Negligible	Not Significant (Minor adverse)	None required	Not Significant (Negligible – Minor adverse)
	Dolphins and seals	Low	Negligible	Not Significant (Negligible adverse)		
CEA 6: Disturbance from operational offshore turbines generators	Harbour porpoise, minke whale	Medium	Low	Not Significant (Minor adverse)	None required	Not Significant (Minor adverse)
	Dolphins and seals	Low	Low	Not Significant (Minor adverse)		

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