Morecambe Offshore Windfarm: Generation Assets

Environmental Statement

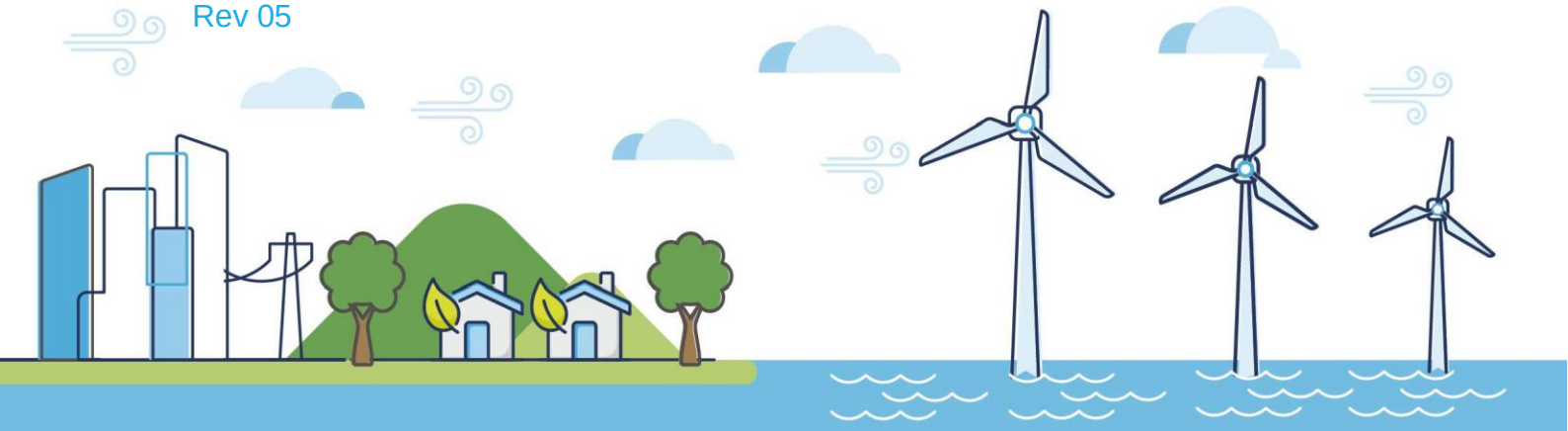
Volume 5

Chapter 11 Marine Mammals

PINS Document Reference: 5.1.11

APFP Regulation: 5(2)(a)

Rev 05



Document History

Doc No	MOR001-FLO-CON-ENV-RPT-1110	**Rev**	05
Alt Doc No	PC1165-RHD-ES-XX-RP-Z-0011		
Document Status	Approved for Use	**Doc Date**	8 April 2025
PINS Doc Ref	5.1.11	**APFP Ref**	5(2)(a)

Rev	Date	Doc Status	Originator	Reviewer	Approver	Modifications
01	31 May 2024	Approved for Use	Royal HaskoningDHV	Morecambe Offshore Windfarm Ltd	Morecambe Offshore Windfarm Ltd	n/a
02	26 November 2024	Approved for Use	Royal HaskoningDHV	Morecambe Offshore Windfarm Ltd	Morecambe Offshore Windfarm Ltd	Updates for Deadline 1
03	18 February 2025	Approved for Use	Royal HaskoningDHV	Morecambe Offshore Windfarm Ltd	Morecambe Offshore Windfarm Ltd	Updates for Deadline 4 to incorporate information supplied in technical notes during examination
04	11 March 2025	Approved for Use	Royal HaskoningDHV	Morecambe Offshore Windfarm Ltd	Morecambe Offshore Windfarm Ltd	Updates for Deadline 5 to incorporate information supplied in response to NRW's D4 submission
05	8 April 2025	Approved for Use	Royal HaskoningDHV	Morecambe Offshore Windfarm Ltd	Morecambe Offshore Windfarm Ltd	Updates for Deadline 5a to incorporate information supplied in response to NRW's D5 submission

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Figure 11.1 Morecambe Offshore Windfarm Site location and Agreement for Lease (AfL) boundary

Figure 11.2 Other projects and activities included in the Cumulative Effects Assessment for piling for marine mammals

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
IEMEP	Inis Ealga Marine Energy Park
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
NAS	Noise Abatement System
NCMPA	Nature Conservation Marine Protected Area
NI	Northern Ireland
NISA	North Irish Sea Array
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
UWSMS	Underwater Sound Management Strategy
UXO	Unexploded Ordnance
VHF	Very High Frequency
VTMP	Vessel Traffic Management Plan
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	square kilometre
kV	kilovolt
m	metre
m/s	metres per second
m^2	square metre
m^3	cubic 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. Additionally, comments received during examination have been incorporated into the assessments (as outlined in technical notes (REP1-083 and REP3-060 - Marine Mammal Technical Note 1 (EIA)). This particularly includes additional information in the cumulative effects section, although it is noted that there are no identified changes to overall conclusions.

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.

Impact	Worst-case scenario	Notes and rationale
Impact 4: Barrier effect from underwater noise	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	The maximum spatial area of potential impact, and duration of impacts, are considered to cause the worst-case barrier effect for underwater noise.
Impact 5: Barrier effects from physical presence of windfarm	Fixed foundations. **WTG spacing:** ▪ Minimum in row spacing: 1,060m ▪ Minimum inter row spacing: 1,410m	The maximum spatial area of potential impact is considered to cause the worst-case barrier effect, due to the presence of windfarm infrastructure.
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**: 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.	
	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	The worst-case scenario is based on the maximum area of infrastructure on the seabed.

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	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.
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		

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 and Underwater Sound Management Strategy (UWSMS) 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.
Under Water Sound Management Strategy (UWSMS)	The UWSMS 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 aim of the UWSMS strategy is to reduce residual effects on sensitive marine mammal (and fish) receptors. The UWSMS is an overarching document that secures any further mitigation measures necessary to reduce the risk of both injury and disturbance to marine mammals and fish receptors due to elevated underwater sound from those activities assessed within the EIA including piling. The UWSMS would be developed in consultation with the relevant Statutory Nature Conservation Bodies (SNCBs) and the MMO, detailing the proposed measures to reduce the risk of Project alone and cumulative noise and disturbance.
PEMP Vessel Traffic Management Plan (VTMP) (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
<u>Impacts</u> 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. **Appendix 11.1** provides information on baseline ambient noise
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 and Outline UWSMS the required mitigation and management measures would be further developed in the pre-construction period. This would be based upon the best information, up to date guidance 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
<u>Secretary of State decision making</u> 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*., 2010)
- 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 unexploded ordnance clearance in the marine environment (JNCC, 2025)
- Statutory Nature Conservation Agency Protocol for Minimising the Risk of Injury to Marine Mammals from Piling Noise (JNCC, 2010)

- 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)
- JNCC, Natural England and Cefas. (JNCC *et al.,* 2025) JNCC, Natural England and Cefas position on the use of quieter piling methods and noise abatement systems when installing offshore wind turbine foundations.

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*. (2010) 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*. (2010) EPS draft guidance suggests definitions for a 'significant group' of individuals, or proportion of the population, for EPS species. As such, this guidance has been considered in defining the thresholds for magnitude of impacts (**Table 11.10**).

11.55 The JNCC *et al*. (2010) draft guidance provides some indication on how many animals may be 'removed' from a population without causing detrimental effects to the population at 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*. (2010) 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*. (2010) draft guidance considered 4% as the maximum potential growth rate in harbour porpoise, and the 'default' rate for cetaceans. Therefore, beyond natural mortality, up to 4% of the population could theoretically be permanently removed before population growth could be halted. In assigning 5% 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. Each impact has been considered using a range of assessment methods, including quantitative and qualitative methods, and has taken into account the effects of each impact over the Project lifetime. Consequently, the overall significance has regard to the full evidence base.

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

Sensitivity	Adverse Magnitude				Beneficial Magnitude			
	High	Medium	Low	Negligible	Negligible	Low	Medium	High
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.

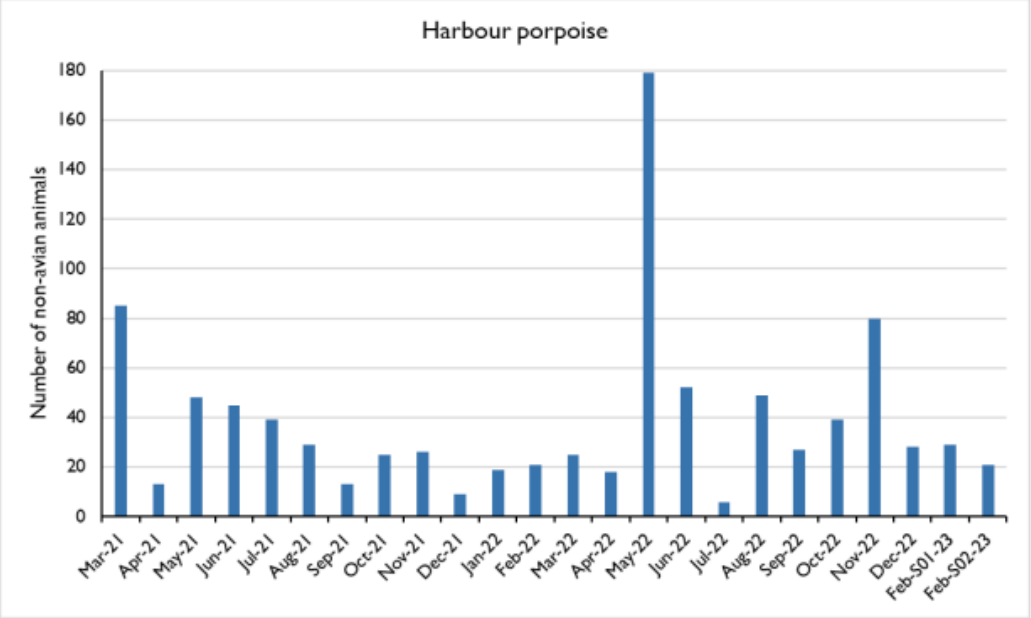

*Plate 11.1 Abundance of harbour porpoise recorded between March 2021 and February 2023 in the survey area (see **Appendix 12.1**).*

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)

Species	Reference population extent	Population	Source
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 Numerous research has found that marine mammal different hearing groups will have different sensitivity to noise; for example a range of TTS experiments suggest that harbour porpoises are more sensitive to sound than bottlenose dolphins (Tougaard *et al.,* 2015). Graham *et al.* (2017) studied the responses of bottlenose dolphins due to both impact and vibration pile driving noise and found that bottlenose dolphin were not excluded from sites in the vicinity of piling; however, on occasions bottlenose dolphins spent a reduced period of time in the vicinity of construction works. But overall, Graham *et al.* (2017) documented that dolphins showed a weak behavioural response to impact piling. Looking at harbour porpoise response to piling at the Beatrice OWF, showed clear signs of displacement. These two examples show evidence that species groups have different level of sensitivities to underwater noise. It has been documented that seals are at their highest sensitivity in the reproduction and/or pupping stage of the life (Harwood and King, 2014), and during this time, the seals tend to be close to shore staying relatively close to breeding haul-out sites, giving them a lower level of sensitivity.

11.193 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.

11.194 The sensitivity of marine mammals to disturbance was considered to be medium for all marine mammal receptors using a precautionary approach (**Table 11.16**).

11.195 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	Medium
Common dolphin	High	Medium	Medium
Risso's dolphin	High	Medium	Medium
White-beaked dolphin	High	Medium	Medium
Minke whale	High	Medium	Medium
Grey seal	High	Medium	Medium
Harbour seal	High	Medium	Medium

11.6.3 Potential effects during construction

11.196 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

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

11.198 Assessments have been presented for each individual impact for the Project alone during the construction phase. However, there is the potential for interactions of multiple impacts during this phase. Further information on these interactions is presented in **Section 11.10**. Additionally, disturbance effects from various impacts may occur simultaneously and throughout the duration of the construction phase, leading to additive effects. These have been assessed in **Section 11.10.1.** A lifetime assessment for all phases of the Project has also been presented in **Section 11.10.1**.

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

11.199 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.

11.200 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.

11.201 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.

11.202 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

11.203 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.

11.204 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).

11.205 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

11.206 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

11.207 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

11.208 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.

11.209 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

11.210 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.

11.211 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

11.212 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**).

11.213 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.

11.214 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

11.215 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).

11.216 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

11.217 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)).

11.218 **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

11.219 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).

11.220 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.

11.221 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.

11.222 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**).

11.223 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.

11.224 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**.

11.225 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**).

11.226 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.

11.227 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	50Hz to 86kHz

Species hearing group	Generalised hearing range
Phocid carnivores in water (PCW)	

11.228 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.

11.229 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.

11.230 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 μPa^2s)	
				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

11.231 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).

11.232 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.

11.233 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

11.234 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

11.235 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

11.236 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).

11.237 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.

11.238 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.

11.239 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).

11.240 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.

11.241 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.

11.242 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

11.243 **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

11.244 **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

11.245 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

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

11.247 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

11.248 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**).

11.249 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.

11.250 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 at a single point in time) 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 at a single point in time (**Table 11.23**).

Table 11.23 Maximum number of individuals (and % of reference population) that could be at risk of PTS at a single point in time from a 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) at a single point in time	Magnitude (permanent effect)	Maximum number of individuals (% of reference population) at a single point in time	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) at a single point in time	Magnitude (permanent effect)	Maximum number of individuals (% of reference population) at a single point in time	Magnitude (permanent effect)
Minke whale	SEL_{ss} Weighted (219 dB re 1µPa^{2}s) 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

11.251 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.

11.252 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**).

11.253 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**).

11.254 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).

11.255 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.

11.256 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**).

11.257 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**).

11.258 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 at a single point in time 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) at a single point in time	Magnitude (permanent effect)	Maximum number of individuals (% of reference population) at a single point in time	Magnitude (permanent effect)
Harbour porpoise	SEL_{cum} Weighted (155 dB re 1µPa²s) Impulsive	243 (0.4% of CIS MU)	Medium	98.9 (0.2% of CIS MU)	Medium
Bottlenose dolphin	SEL_{cum} Weighted (185 dB re 1µPa²s) 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 1µPa²s) 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 1µPa²s) 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 1µPa²s) Impulsive	0.001 (0.000002% of CGNS MU)	Negligible	0.0007 (0.000002% of CGNS MU)	Negligible
Minke whale	SELcum Weighted (183 dB re 1µPa2s)	2.9 (0.01% of CGNS MU)	Medium	1.3	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) at a single point in time	Magnitude (permanent effect)	Maximum number of individuals (% of reference population) at a single point in time	Magnitude (permanent effect)
	Impulsive			(0.007% of CGNS MU)	
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

11.259 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}).

11.260 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

11.261 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**).

11.262 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.

11.263 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 at a single point in time (**Table 11.25**).

Table 11.25 Maximum number of individuals (and % of reference population) that could be at risk of TTS at a single point in time 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) at a single point in time	Magnitude (permanent effect)	Maximum number of individuals (% of reference population) at a single point in time	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) at a single point in time	Magnitude (permanent effect)	Maximum number of individuals (% of reference population) at a single point in time	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

11.264 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**).

11.265 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**).

11.266 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.

11.267 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 at a single point in time 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) at a single point in time	Magnitude (permanent effect)	Maximum number of individuals (% of reference population) at a single point in time	Magnitude (permanent effect)
Harbour porpoise	SEL_{cum} Weighted (140 dB re 1 μPa^2s) 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^2s) 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^2s) 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^2s) 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^2s) 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

11.268 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**.

11.269 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**).

11.270 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**).

11.271 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**.

11.272 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**).

11.273 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

11.274 The development and implementation of a MMMP for piling and UWSMS (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.

11.275 The MMMP for piling and UWSMS 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 and UWSMS would be based on the Draft MMMP and Outline UWSMS which has been included with the DCO Application. The Draft MMMP and Outline UWSMS include further details of the embedded mitigations and the potential additional mitigation measures to be adopted by the Project.

11.276 Mitigation to reduce the risk of PTS would include establishing a monitoring zone and ADD activation prior to the soft-start commencing, as required to be agreed through the MMMP.

11.277 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.

11.278 The Project is committed to additional mitigation to ensure that if the Project worst case was to be implemented (the high strike rate scenario with the maximum hammer energy) the potential PTS effects would be fully mitigated by using noise reduction methods such as Noise Abatement Systems (NAS). Measures have been included in the Draft MMMP and Outline UWSMS, considering both design refinement and noise reduction methods as appropriate and in consideration of latest guidance (JNCC *et al*., 2025).

11.279 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.

11.280 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

11.281 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**).

11.282 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 and UWSMS (**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 and UWSMS (**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 and UWSMS (**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 and UWSMS (**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 and UWSMS (**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 and UWSMS (**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 and UWSMS (**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 and UWSMS (**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

11.283 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.

11.284 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**).

11.285 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.

11.286 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.

11.287 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.

11.288 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).

11.289 Effective Deterrence Radius (EDR) and disturbance assessments based on known impact ranges assume a uniform species density across the effect area. This assumption may not reflect actual variations in distribution and

could lead to an under- or over-estimation of disturbance effects. While some animals would flee, others might remain in the area of effect from piling but additionally (or again) be disturbed by other noise sources. The recommended EDRs were based on empirically-derived ranges *"where the bulk of the effect (reduction in porpoise vocal activity or sightings) had been detected*" (Brown *et al.,* 2023) noting that:

- The EDRs do not represent 100% disturbance in an associated area, nor do they represent the maximum range at which disturbance effects can be detected;
- Only the most detectable effects on the animals are observed by those studies informing the EDRs;
- The observed disturbance effects reported in the different studies were not derived in a comparable way (Brown *et al.,* 2023).

11.290 There is a potential for additive effects (see **Section 11.10.1.3**), however noting activities such as piling can disturb and displace animals, reducing their exposure to other noisy activities from the Project.

11.291 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).

11.292 While a precise measurement of repeated disturbances is not available, the numbers of animals predicted to be disturbed represent a single point in time.

Sensitivity

11.293 All marine mammal species are assessed as having medium sensitivity to disturbance from underwater noise as a precautional approach (**Table 11.16**).

Magnitude

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

- 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) (used to inform significance of effect)
- Consideration of the duration of activites and repeat disturbances

11.295 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 assessment of disturbance has then been based on the population modelling (where available) and consideration of the full evidence base to assess the significance of effect for disturbance from piling.

11.296 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

11.297 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, 2023b). 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.

11.298 Brown *et al*. (2023) highlight that the approach used to produce the current 26km EDR likely overestimates the response because it does not account for underlying seasonal variation during baseline and piling periods. Additionally, findings in the latest PrePared reported on harbour porpoise response to piling at Ocean Winds Moray West OWF providing evidence of an EDR of 10km, making a strong case for reducing the current 26 km EDR for unabated impact piling of monopiles (Benhemma-Le Gall *et al.,* 2024). These observations were based on a single project and were specific to the Moray Firth Offshore Windfarm, consequently posing limitations to applying this EDR.This EDR has not been reviewed nor approved by the regulators, and as such, has not been applied in the assessments of disturbance. Furthermore, it is expected that updates with regard to revised EDR distances will be published by JNCC in 2025.

11.299 As a worst-case scenario, 100% disturbance of harbour porpoise in the areas has been assumed in the EDR assessment.

11.300 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 based on the EDR approach, is presented in **Table 11.28**.

11.301 The magnitude of the potential impact is assessed as **medium** for the 26km EDR, with >5% of CIS MU anticipated to be temporarily disturbed at a single point in time, 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 at a single point in time 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) at a single point in time	Magnitude (temporary effect)	Maximum number of individuals (% of reference population) at a single point in time	Magnitude (temporary effect)
Harbour porpoise	3,443 (5.5% of CIS MU)	Medium	1,146 (1.8% of CIS MU)	Low

Dolphin species

11.302 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 at a single point in time as a result of underwater noise during Project piling, has been estimated by using the worst-case TTS impact ranges in **Table 11.29**.

11.303 The magnitude of the potential impact was assessed as **negligible** for all dolphin species across the relevant MUs, anticipated to be temporarily disturbed at a single point in time (**Table 11.29**).

Table 11.29 Maximum number of dolphin spp. (and % of reference population) that could be disturbed at a single point in time 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) at a single point in time	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

11.304 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**.

11.305 The magnitude of the potential impact was assessed as **negligible** with <1% of the CGNS MU anticipated to be temporarily disturbed at a single point in time (**Table 11.30**).

Table 11.30 Maximum number of minke whale (and % of reference population) that could be at disturbed at a single point in time 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) at a single point in time	Magnitude (temporary effect)
Minke whale	24.9 (0.12% of CGNS MU)	Negligible

Seal species

11.306 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 at a single point in time as a result of underwater noise during piling at the Project, is presented in **Table 11.31.**

11.307 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 at a single point in time. 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 at a single point in time. 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 at a single point in time 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) at a single point in time	**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

11.308 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).

11.309 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.

11.310 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).

11.311 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.

11.312 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.

11.313 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.

11.314 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.

11.315 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.

11.316 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.

11.317 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 at a single point in time as a result of underwater noise during piling, based on the worst-case foundation and location, are presented in **Table 11.32**.

11.318 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 at a single point in time (**Table 11.32**).

11.319 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 at a single point in time during piling based on the dose-response approach

Species	Number of individuals disturbed (% of reference population) at a single point in time	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	Negligible

Species	Number of individuals disturbed (% of reference population) at a single point in time	Magnitude (temporary effect)
	(0.009% of the combined MU; 0.00001% of the wider reference population)	
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

11.320 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.

11.321 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.

11.322 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.

11.323 **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.

11.324 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.

11.325 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

11.326 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.

11.327 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 at a single point in time 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 at a single point in time(**Table 11.34**).

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

Species	Maximum number of individuals (% of reference population) during one ADD activation	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

11.328 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.

11.329 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. However, it is noted that other construction activities could be undertaken at the same time as piling events and during breaks in piling.

11.330 **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					

11.331 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.

11.332 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).

11.333 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.

11.334 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.

11.335 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).

11.336 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

11.337 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.

11.338 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**.

11.339 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). NRW have acknowledged that this threshold could be used as one possible method to determine the significance of behavioural disturbance on a population, based on the iPCoD outputs. However, this guidance is intended for consideration of PTS and remains under development. In absence of other guidance, the 1% threshold remains a valid way to review results of population modelling to inform overall assessment conclusions.

11.340 It should also be noted that the results of the population modelling inform the significance of effect at a population level, rather than a magnitude.

11.341 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.

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

11.342 For harbour porpoise, iPCoD results have been presented with both median and mean population sizes, and the mean and median ratios of impacted: unimpacted population sizes displayed (**Table 11.38**). The results show a less than 1% average[4] annual decline over the first six years and over the 25 year period for both the mean and median, and therefore a **minor adverse** effect, and **not significant in EIA terms**.

11.343 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

[4] This was determined by dividing the overall percentage change for the 6 and 25 year timepoints by 6 and 25, respectively, to obtain an annual average change.

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.

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	Mean impacted as % of un-impacted	Un-impacted population median	Impacted population median	Median impacted as % of un-impacted
Start	62,516	62,516	100.00%	62,516	62,516	100.00%
End 2028	62,451	62,451	100.00%	62,590	62,590	100.00%
End 2029	62,424	62,268	99.75%	62,431	62,304	99.89%
End 2032	62,524	62,403	99.81%	62,317	62,191	99.89%
End 2037	62,307	62,180	99.80%	61,858	61,698	99.89%
End 2047	62,036	61,908	99.80%	61,274	61,197	99.89%
End 2052	61,876	61,750	99.80%	60,910	60,745	99.89%

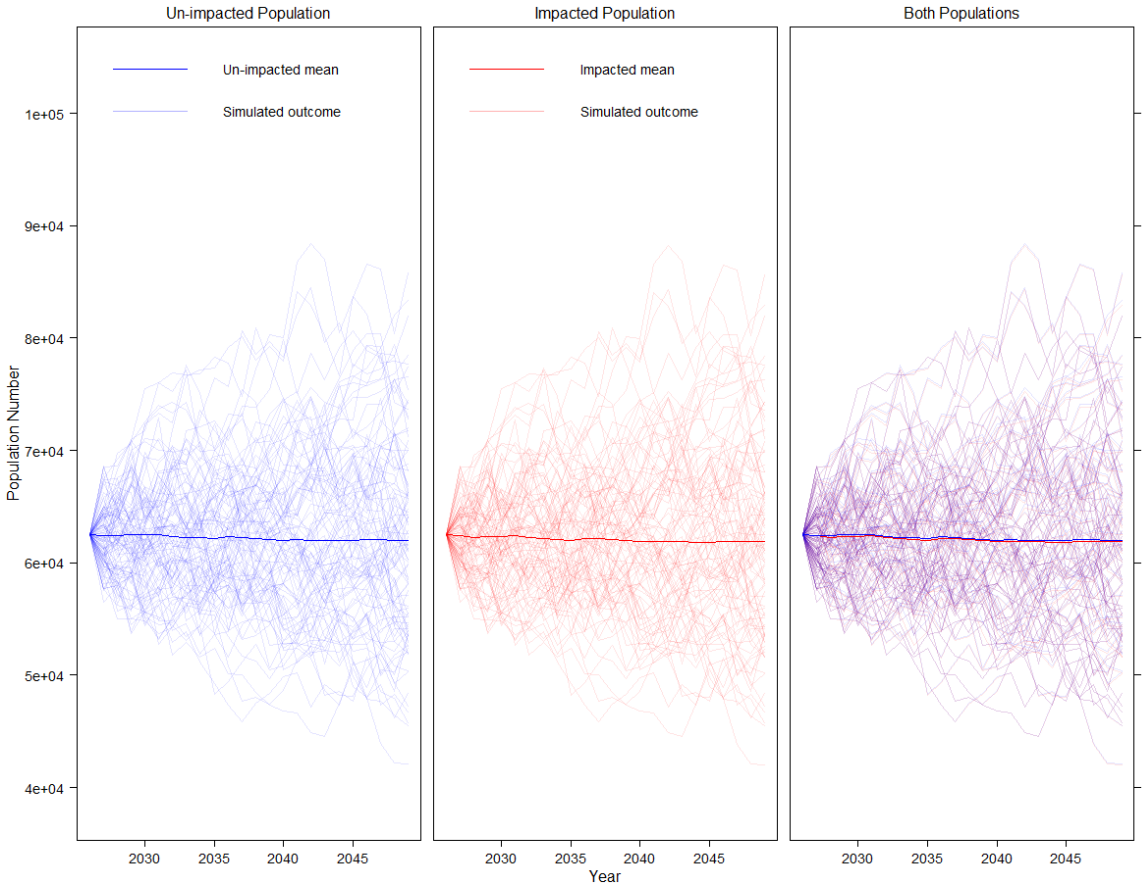

Plate 11.2 Simulated worst-case harbour porpoise population sizes for both the un-impacted and the impacted populations (scientific notation used in these charts, e.g. 4e+04 = 40,000)

Bottlenose dolphin

11.344 For bottlenose dolphin, iPCoD results are presented with both median and mean population sizes, and the mean and median ratios of impacted: unimpacted population sizes displayed (**Table 11.39**). The results show a less than 1% average annual decline over the first six years and over the 25 year period for both mean and median, and therefore a **minor adverse** effect, and **not significant in EIA terms**. .

11.345 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**).

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	Mean impacted as % of un-impacted	Un-impacted population median	Impacted population median	Median impacted as % of un-impacted
Start	296	296	100.00%	296	296	100.00%
End 2028	295	295	100.00%	296	296	100.00%
End 2029	293	288	98.30%	294	290	100.00%
End 2032	287	283	98.69%	288	284	100.00%
End 2037	278	275	98.85%	278	274	100.00%
End 2047	262	259	98.75%	258	256	100.00%
End 2052	255	252	98.73%	252	250	100.00%

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

Minke whale

11.346 For minke whale, iPCoD results have been presented with both median and mean population sizes, and the mean and median ratios of impacted: unimpacted population sizes displayed (**Table 11.40**). The results show a less than 1% average annual decline over the first six years and over the 25 years period for both the mean and median, and therefore a **minor adverse** effect, and **not significant in EIA terms**. .

11.347 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**).

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	Mean impacted as % of un-impacted	Un-impacted population median	Impacted population median	Median impacted as % of un-impacted
Start	20,120	20,120	100.00%	20,120	20,120	100.00%
End 2028	20,188	20,188	100.00%	20,256	20,256	100.00%
End 2029	20,222	20,203	99.91%	20,236	20,217	99.94%
End 2032	20,193	20,145	99.76%	20,148	20,078	99.81%
End 2037	20,189	20,114	99.63%	20,032	19,944	99.70%
End 2047	20,115	20,026	99.56%	19,857	19,784	99.63%
End 2052	19,976	19,887	99.56%	19,407	19,320	99.63%

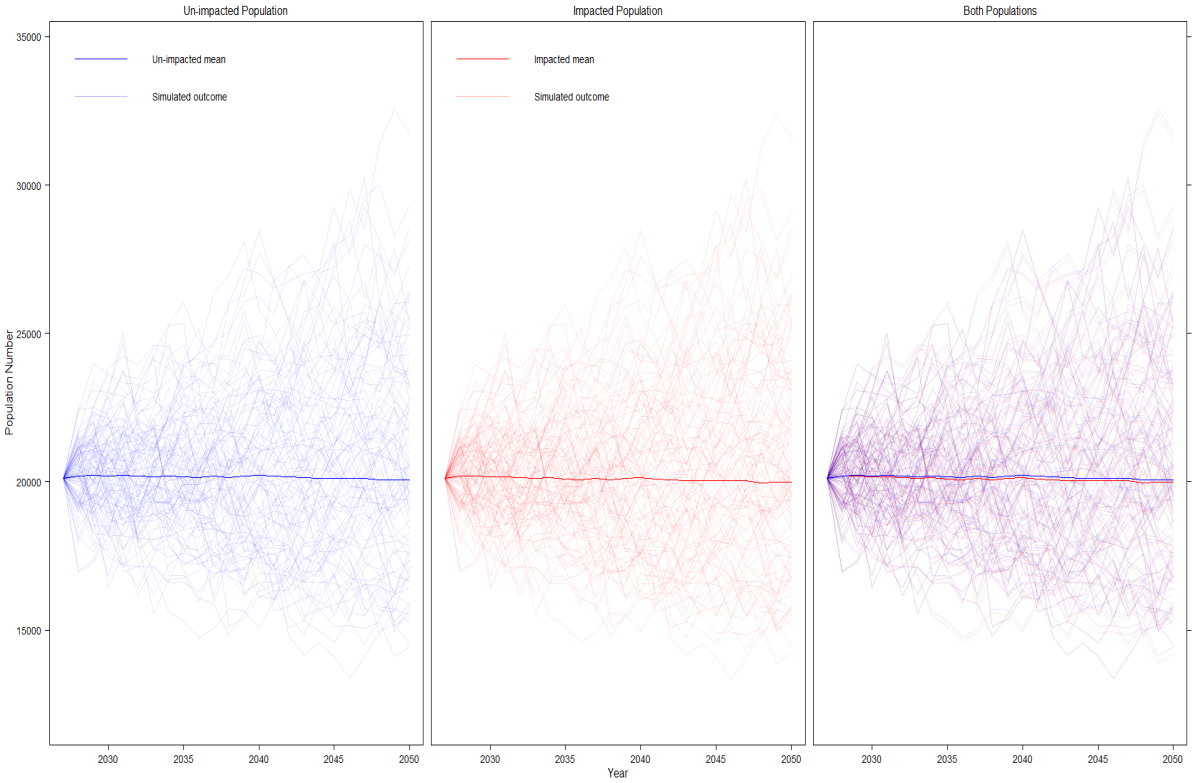

Plate 11.4 Simulated worst-case minke whale population sizes for both the un-impacted and the impacted populations

Grey seal

11.348 For grey seal, iPCoD results were presented for both the wider reference population (**Table 11.41**) and the smaller 'combined population' (North-West (NW) England MU and Isle of Man (IoM) population, (see **Section 11.5.9**)) **Table 11.42**), with both median and mean population sizes, and the mean and median ratios of impacted: unimpacted population sizes. The results show no annual decline over the first six years and over the 25 years period for both the mean and median, and therefore a **minor adverse** effect, and **not significant in EIA terms**. .

11.349 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**).

*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 mean and median ratio between their population sizes*

Year	Un-impacted population mean	Impacted population mean	Mean impacted as % of un-impacted	Un-impacted population median	Impacted population median	Median impacted as % of un-impacted
Start	13,288	13,288	100.00%	13,288	13,288	100.00%
End 2028	13,388	13,388	100.00%	13,454	13,454	100.00%
End 2029	13,443	13,444	100.00%	13,501	13,501	100.00%
End 2032	13,735	13,736	100.00%	13,811	13,811	100.00%
End 2037	14,202	14,203	100.00%	14,243	14,244	100.00%
End 2047	15,116	15,118	100.00%	15,011	15,015	100.00%
End 2052	15,583	15,585	100.00%	15,431	15,434	100.00%

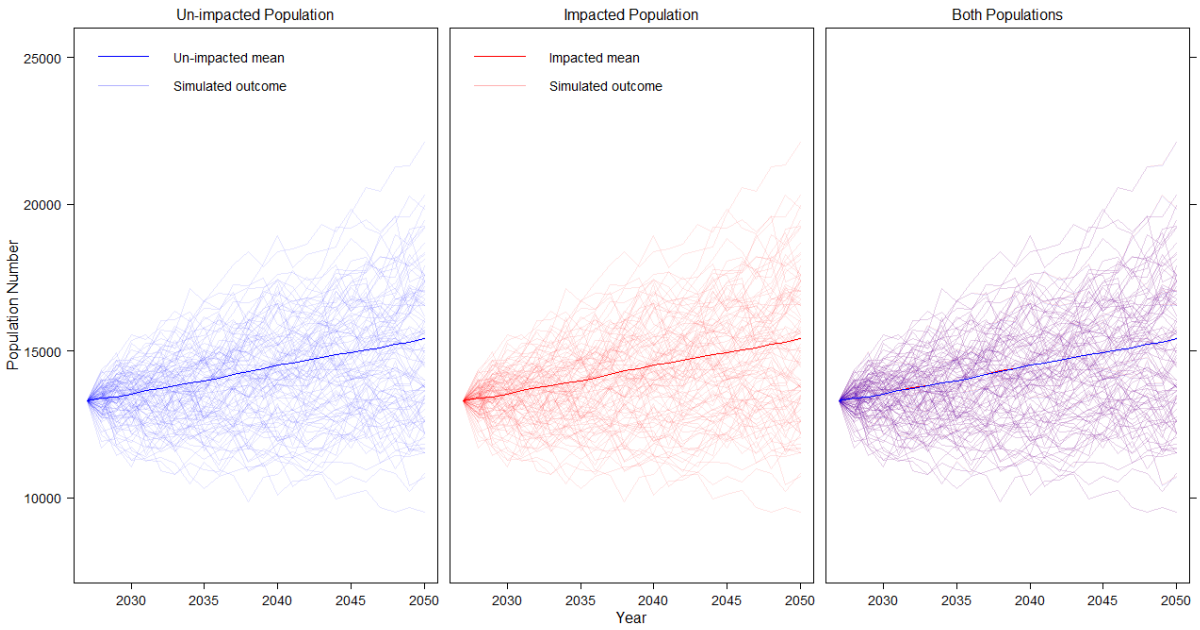

Plate 11.5 Simulated worst-case grey seal population sizes for both the un-impacted and the impacted populations

11.350 The model run for the smaller 'combined population' assumed a worst-case of 196 disturbed and 0.2 estimated animals with PTS on every piling day (**Plate 11.6** and **Table 11.42**).

11.351 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 mean and median ratio between their population sizes

Year	Un-impacted population mean	Impacted population mean	Mean impacted as % of un-impacted	Un-impacted population median	Impacted population median	Median impacted as % of un-impacted
Start	1,592	1,592	100.00%	1,592	1,592	100.00%
End 2028	1,605	1,605	100.00%	1,612	1,605	100.00%
End 2029	1,617	1,617	100.00%	1,620	1,617	100.00%
End 2032	1,650	1,649	100.00%	1,654	1,649	100.00%
End 2037	1,701	1,701	100.00%	1,692	1,701	100.00%
End 2047	1,814	1,814	100.00%	1,806	1,814	100.00%
End 2052	1,876	1,876	100.00%	1,868	1,876	100.00%

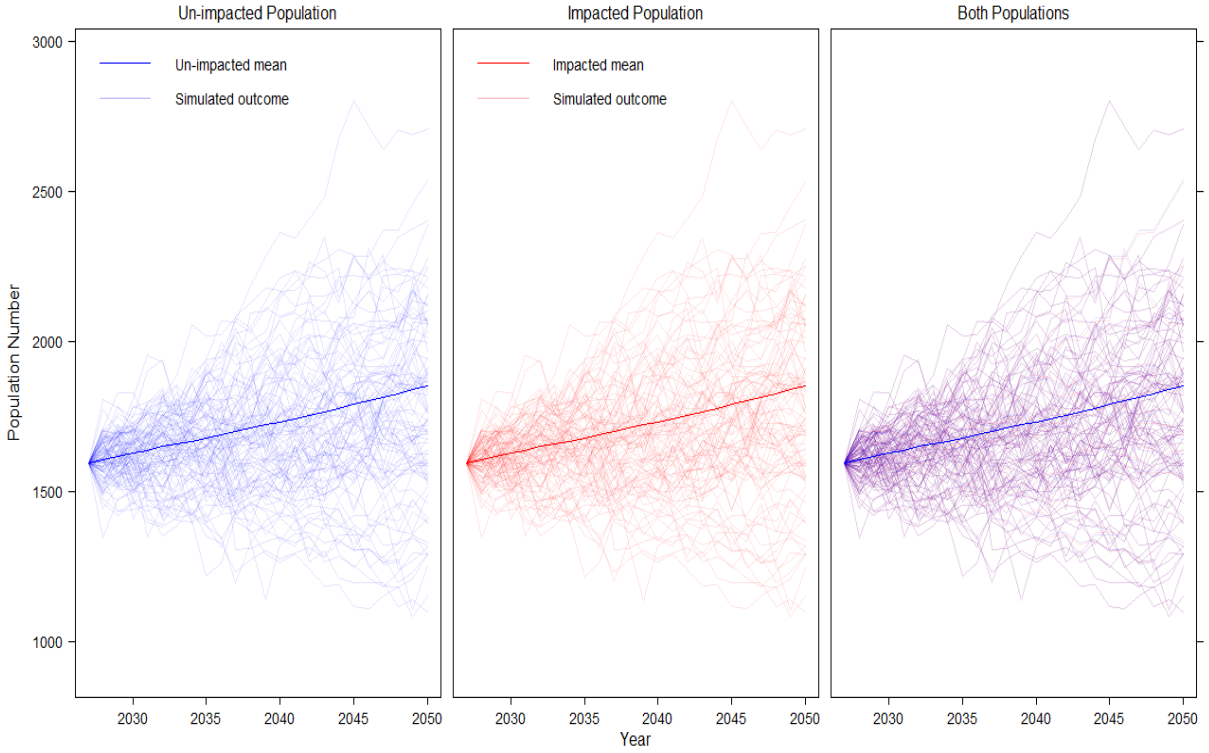

Plate 11.6 Simulated worst-case grey seal population sizes for both the un-impacted and the impacted populations

Harbour seal

11.352 For harbour seal, iPCoD results have been presented for both the NW and Northern Ireland (NI) MU (**Table 11.43**); and the NW MU (**Table 11.44**) with both median and mean population sizes, and the mean and median ratios of impacted: unimpacted population sizes displayed. The results show no annual decline in the first six years and over the 25 years period for both the mean and median, and therefore a **minor adverse** effect, and **not significant in EIA terms.**

11.353 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**).

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 mean and median ratio between their population sizes

Year	Un-impacted population mean	Impacted population mean	Mean impacted as % of un-impacted	Un-impacted population median	Impacted population median	Median impacted as % of un-impacted
Start	1,412	1,412	100.00%	1,412	1,412	100.00%
End 2028	1,413	1,413	100.00%	1,416	1,416	100.00%
End 2029	1,413	1,413	100.00%	1,414	1,414	100.00%
End 2032	1,417	1,417	100.00%	1,412	1,412	100.00%
End 2037	1,425	1,425	100.00%	1,421	1,421	100.00%
End 2047	1,428	1,428	100.00%	1,406	1,406	100.00%
End 2052	1,426	1,426	100.00%	1,406	1,406	100.00%

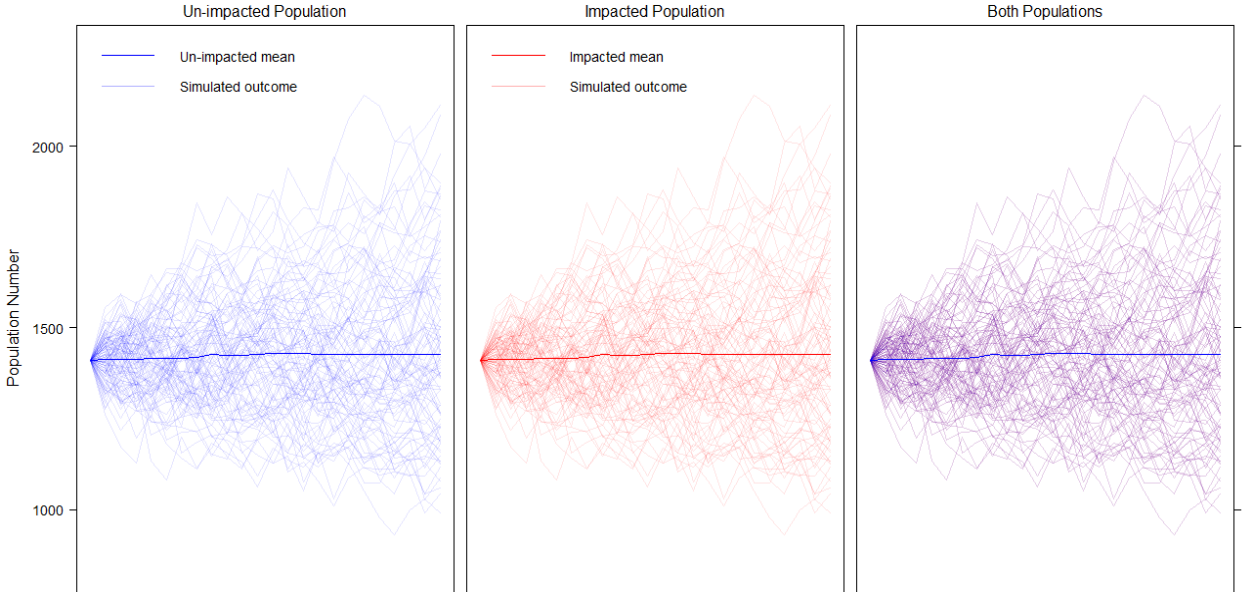

Plate 11.7 Simulated worst-case harbour seal population sizes for both the un-impacted and the impacted populations

11.354 In addition to the wider population, the model was also run for the smaller NW England MU (7 individuals) (**Table 11.44**), 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.

11.355 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 mean and median ratio between their population sizes

Year	Un-impacted population mean	Impacted population mean	Mean impacted as % of un-impacted	Un-impacted population median	Impacted population median	Median impacted as % of un-impacted
Start	4	4	100.00%	4	4	100.00%
End 2028	3	3	100.00%	4	4	100.00%
End 2029	3	3	100.00%	4	4	100.00%
End 2032	3	3	100.00%	4	4	100.00%
End 2037	3	3	100.00%	2	2	100.00%
End 2047	3	3	100.00%	0	0	100.00%
End 2052	3	3	100.00%	0	0	100.00%

Summary of population level consequences due to disturbance

11.356 For all species assessed, the modelled impact of piling from the Project fell below the threshold of a 1% annual average decline in population that would be considered significant. The population consequences of disturbance were therefore assessed as **not significant** (in EIA terms) for all species.

Significance of effect

11.357 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, and includes all quantitative assessment methods (e.g. ERD, DRC and iPCoD modelling).

11.358 The quantitative assessments provide a snapshot of the number of animals disturbed and the percentage of their reference population at a single point in time, which forms the basis for determining the magnitude of effect. Although this assessment quantifies a single event, the duration of effects is also considered. Repeated disturbance events are not expected to have a sustained significant effect on the wider population.. This is shown in the results of the iPCoD modelling that consider piling disturbance over time. However, it is important to note that animals may incur some energetic cost during the construction period (e.g. Williams *et al*., 2006; Hastie *et al*., 2021; Frankish *et al.,* 2023). Considering a professional analysis of the overall evidence base, including the number of animals impacted at any one time and the duration of effects, the magnitude of the effect has been deemed appropriate and proportional to help determine the overall significance of effects.

11.359 Taking into account the sensitivity, and the potential magnitude of the temporary impact, the significance of effect based on the iPCoD modelling (and consideration of all methods presented) for harbour porpoise, bottlenose dolphin and minke whale was assessed as **minor adverse** (not significant in EIA terms), and **minor 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 **minor adverse** (not significant in EIA terms) (**Table 11.45**).

11.360 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 **minor adverse** (not significant in EIA terms) for marine mammal receptor species (**Table 11.45**).

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

11.362 The results of the population modelling have shown that there would be no effect at the population level for any of the modelled species, but measures included in the MMMP and UWSMS would help reduce disturbance.

Mitigation

11.363 The MMMP for piling and the UWSMS 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 and the UWSMS would be based on the Draft MMMP and Outline UWSMS which has been included with the DCO Application. The Draft MMMP and Outline UWSMS include further details of the embedded mitigations and the potential additional mitigation measures to be adopted by the Project.

11.364 The Project is committed to additional mitigation to ensure that if the Project worst case was to be actualised (the high strike rate scenario with the maximum hammer energy) the potential PTS effects would be fully mitigated by using noise reduction methods such as NAS and to ensure there is no residual PTS after ADD use. Measures have been secured in the Draft MMMP and Outline UWSMS, considering both design refinement and noise reduction methods as appropriate. These measures have the potential to further reduce any potential disturbance and in consideration of latest guidance (JNCC *et al.,* 2025).

Residual significance of effect

11.365 Proposed measures in the MMMP and UWSMS would further reduce any potential residual effect. 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**). This considers the results of the iPCoD modelling, the quantitative assessment of the number of animals disturbed at any one time as well as consideration of repeated disturbance over time.

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)	MMMP and UWSMS (**Section 11.3.3**)	Not Significant (Minor adverse)
	Disturbance based on 26km EDR		Medium	Significant (Moderate adverse)		Not Significant (Minor adverse)
	DRC		Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	iPCoD modelling		n/a	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Bottlenose dolphin	Disturbance during ADD activation	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Negligible adverse)
	Disturbance based on TTS		Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Disturbance based on dose-response curve		High	Significant (Major adverse)		Not Significant (Minor adverse)
	iPCoD modelling		n/a	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Common dolphin	Disturbance based on TTS	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)

Species/ receptor	Impact	Sensitivity	Magnitude	Significance of effect	Additional mitigation measures proposed	Residual effect
	Disturbance based on dose-response curve		Negligible	Not Significant (Minor adverse)		Not Significant (Negligible adverse)
	Disturbance during ADD activation		Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Risso's dolphin	Disturbance based on TTS	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Disturbance based on dose-response curve		Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Disturbance during ADD activation		Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
White-beaked dolphin	Disturbance based on TTS	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Disturbance based on dose-response curve		Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Disturbance during ADD activation		Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Minke whale	Disturbance based on 30km EDR	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Disturbance during ADD activation		Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)

Species/ receptor	Impact	Sensitivity	Magnitude	Significance of effect	Additional mitigation measures proposed	Residual effect
	iPCoD modelling		n/a	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Grey seal	Disturbance during ADD activation	Medium	Low (negligible)*	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Disturbance based on 25km EDR		High (low)*	Significant (Major adverse)		Not Significant (Minor adverse)
	DRC		Negligible (negligible)*	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	iPCoD modelling		n/a	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Harbour seal	Disturbance during ADD activation	Medium	Negligible (negligible)*	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Disturbance based on 25km EDR		Low (negligible)*	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	DRC		Negligible (negligible)*	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	iPCoD modelling		n/a	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)

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

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

11.367 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.

11.368 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.

11.369 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).

11.370 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.

11.371 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.

11.372 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).

11.373 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).

11.374 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.

11.375 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.

11.376 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).

11.377 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.

11.378 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.

11.379 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).

11.380 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**)).

11.381 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.

11.382 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

11.383 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.

11.384 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))

11.385 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.

11.386 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).

11.387 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.

11.388 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**).

11.389 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.

11.390 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^2s) 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^2s) 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^2s) 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^2s) 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

11.391 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**).

11.392 For disturbance, all marine mammal receptors had a **medium** 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

11.393 The number of marine mammals that could be impacted at a single point in time, 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**).

11.394 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**).

11.395 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 at one time (**Table 11.47**).

11.396 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, although it is acknowledged that a number of activities could be undertaken at the same time and there would be repeat disturbances throughout the construction period.

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 at a single point in time

Species	Potential Impact	Maximum number of individuals at a single point in time (% of reference population) for each individual activity	Maximum number of individuals at a single point in time (% 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 at a single point in time (% of reference population) for each individual activity	Maximum number of individuals at a single point in time (% 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

11.397 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).

11.398 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**).

11.399 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.

11.400 All related construction activities were considered to be moving sources, and therefore, once the activity/vessel moved past a certain area, the marine mammals could return to the area. However, it is noted that construction activities over the construction period could cause repeated disturbance and displacement, with assocated disturbance effects such as increased energetic costs.

11.401 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 at a single point in time as a result of underwater noise associated with other (non-piling) construction activities at the Project

Species	Maximum number of individuals (% of reference population) at a single point in time that could be disturbed for one activity (50.27km^2)	Maximum number of individuals (% of reference population) at a single point in time 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

Species	Maximum number of individuals (% of reference population) at a single point in time that could be disturbed for one activity (50.27km²)	Maximum number of individuals (% of reference population) at a single point in time that could be disturbed for two activities (100.54km²)	Magnitude (temporary effect)
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
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

11.402 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. However, it is noted that there would be repeated construction activities, and therefore disturbance events over the construction peiod.

11.403 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

11.404 The quantitative assessments provide a snapshot of the number of animals disturbed and the percentage of their reference population at a single point in time, which forms the basis for determining the magnitude of effect. Although this assessment quantifies a single event, the duration of effects is also considered. Repeated disturbance events are not expected to have a sustained significant effect on the wider population, given the levels of noise associated. Additionally, the effects of disturbance are not considered permanent and are recoverable over time. However, recoverability may reduce with repeated exposure to disturbance events, particularly when the duration between events is short. It is also important to note that animals may incur some energetic cost during the construction period (e.g. Williams *et al*., 2006; Hastie *et al*., 2021; Frankish *et al.,* 2023). Considering a professional analysis of the full evidence base, including the number of

animals impacted at any one time and the duration of effects, the magnitude of the effect has been deemed appropriate and proportional to help determine the overall significance of effects.

11.405 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**), along with the noise levels associated with other construction activites and effects of repeated disturbance events, 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**).

11.406 Taking into account the medium marine mammal sensitivity to disturbance from all other noisy activity assessed in this section there would be a **minor adverse** effect (not significant in EIA terms) for all species (**Table 11.48**).

Residual significance of effect

11.407 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 **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 additional mitigation required but best practice	Not Significant (Minor adverse)
	Bottlenose dolphin	Medium	Negligible	Not Significant (Negligible adverse)		Not Significant (Minor adverse)

Potential impact	Species/receptor	Sensitivity	Magnitude	Significance of effect	Additional mitigation measures proposed	Residual effect
(other than piling)	Common dolphin	Medium	Negligible	Not Significant (Minor adverse)	measures employed (see **Section 11.3.3**) would help reduce disturbance	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)

* 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

11.408 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.

11.409 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.

11.410 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.

11.411 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.

11.412 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).

11.413 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.

11.414 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

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

11.416 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).

11.417 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))

11.418 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**).

11.419 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.

11.420 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.

11.421 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 μPa^2s) Non-impulsive	<0.1km (<0.03km^2)	<0.1km (<0.03km^2)	1.16km^2
Dolphin species (HF)	SEL_{cum} Weighted (178 dB re 1 μPa^2s) Non-impulsive	<0.1km (<0.03km^2)	<0.1km (<0.03km^2)	1.16km^2
Minke whale (LF)	SEL_{cum} Weighted (179 dB re 1 μPa^2s) Non-impulsive	<0.1km (<0.03km^2)	<0.1km (<0.03km^2)	1.16km^2
Grey and Harbour seal (PCW)	SEL_{cum} Weighted (181 dB re 1 μPa^2s) Non-impulsive	<0.1km (<0.03km^2)	<0.1km (<0.03km^2)	1.16km^2

Sensitivity

11.422 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**).

11.423 For disturbance effects, all marine mammal species were considered **medium** 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

11.424 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 at one time in each of the modelled impact ranges (**Table 11.50**).

11.425 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.

11.426 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.

11.427 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 at a single point in time (**Table 11.51**).

11.428 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 at a single point in time

Species	Maximum number of individuals (% of reference population) for one vessel at a single point in time	Maximum number of individuals (% of reference population) for up to 37 vessels at a single point in time	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 at a single point in time	Maximum number of individuals (% of reference population) for up to 37 vessels at a single point in time	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

11.429 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).

11.430 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).

11.431 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.

11.432 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).

11.433 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).

11.434 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.

11.435 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**).

11.436 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.

11.437 **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.

11.438 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**.

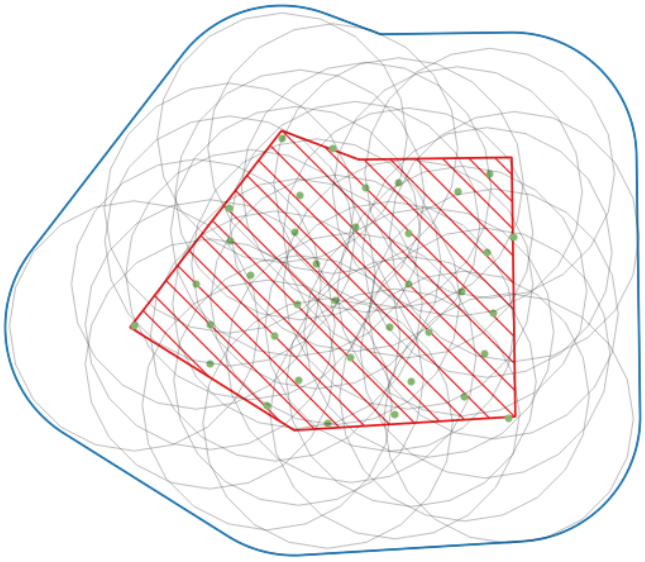

Plate 11.8 Project windfarm site (hatched in red), with 4km buffer (blue), and 37 vessels (green dots) and their 4km buffer (grey) randomly allocated within the site.

11.439 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 at a single point in time 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) at a single point in time	Magnitude (temporary effect)	Maximum number of individuals (% of reference population) for revised site+4km buffer (285.4 km^2) at a single point in time	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) at a single point in time	Magnitude (temporary effect)	Maximum number of individuals (% of reference population) for revised site+4km buffer (285.4 km^2) at a single point in time	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

11.440 The quantitative assessments provide a snapshot of the number of animals disturbed and the percentage of their reference population at a single point in time, which forms the basis for determining the magnitude of effect. Although this assessment quantifies a single event, the duration of effects is also considered. Repeated disturbance events from vessels are not expected to have a sustained significant effect on the wider population, considering the existing baseline and the level of noise associated with vessel disturbance. Additonally, the effects of disturbance are not considered permanent and are recoverable over time. However, recoverability may reduce with repeated exposure to disturbance events, particularly when the duration between events is short. It is important to note that animals may incur some energetic cost during overall construction (e.g. Williams *et al*., 2006; Hastie *et al*., 2021; Frankish *et al.,* 2023). Considering a professional analysis of the overall evidence base, including the number of animals impacted at any one time and the duration of effects, the magnitude of the effect has been deemed appropriate and proportional to help determine the overall significance of effects.

11.441 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 **minor adverse** (not significant in EIA terms) for all species (see **Table 11.53**).

Residual significance of effect

11.442 No additional mitigation is required. 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**).

11.443 It is noted that the best practice measures as outlined in **Section 11.3.3**, would help reduce the potential disturbance from vessels, in particular when considering repeat disturbances over the construction period.

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	Medium	Low	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)

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

11.6.3.5 Impact 5: Barrier effects caused by underwater noise

11.444 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.

11.445 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.

11.446 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.

11.447 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

11.448 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.

11.449 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.

11.450 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.

11.451 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

11.452 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).

11.453 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

11.454 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).

11.455 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).

11.456 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.

11.457 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

11.458 In line with their sensitivity to disturbance from underwater noise, all marine mammal receptors have been assessed as having a **medium** sensitivity (**Table 11.16**) to barrier effects from underwater noise.

Magnitude

11.459 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.

11.460 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**).

11.461 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).

11.462 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**) 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.

11.463 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.

11.464 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**).

11.465 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.

11.466 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.**

11.467 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.

11.468 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

11.469 Considering the medium sensitivity for all marine mammal species 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) (**Table 11.54**).

Residual significance of effect

11.470 No additional mitigation is required or proposed. Therefore, the residual significance of effect would be **minor adverse** (not significant in EIA terms) for all marine mammal 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	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)

* 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

11.471 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.

11.472 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.

11.473 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.

11.474 Marine mammals are able to detect and avoid vessels (National Oceanic and Atmospheric Administration (NOAA), 2021).

11.475 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.

11.476 Research shows that larger vessels, such as cruise ships and cargo vessels over 80 meters in length, are more likely to cause severe or fatal injuries to marine mammals (Laist *et al*., 2001; Keen *et al*., 2023) in comparison to smaller vessels. High speeds are a key factor in collisions with cetaceans; for instance, the likelihood of a lethal injury to large whales, specifically the North Atlantic right whale in this study, increased from around 20% to 80% when vessel speeds increased from 8 to 15 knots (Vanderlaan & Taggart, 2007). Serious injuries have also been documented at lower speeds of 2 and 5.5 knots (Conn & Silber, 2013). Conversely, vessels traveling at speeds below 10 knots rarely cause serious injuries, making reduced speed one of the most effective mitigation strategies (Laist *et al*., 2001; Conn & Silber, 2013; Laist *et al*., 2014; Keen *et al*., 2023).

11.477 The predictability of vessel movements by marine mammals is crucial in minimising the risks posed by vessel traffic (Nowacek *et al*., 2007, Lusseau, 2003; 2006). Reducing vessel speed not only allows more time for marine mammals to move away but also significantly reduces emitted vessel noise. This reduction in noise enables marine mammals to hear approaching ships and prevents interference with intra-species communication (Leaper, 2019).

11.478 An analysis of the International Whaling Commission (IWC) Ship Strike Database reveals that baleen whales, specifically fin and humpback whales, followed closely by right whales, constitute the majority of ship strike victims (Winkler *et al*., 2020). However, a significant proportion of reported cases (12.1%) lacked species identification. Reports of collisions involving smaller cetacean species are generally scarce due to reporting biases, such as unnoticed collisions, quickly sinking carcasses, or less concern for smaller species (Schoeman *et al*., 2020). The IWC report underscores that the lack of species identification and the mis- or underreporting of ship strikes remain global issues, leading to uncertainties in the numbers and species affected (Van Waerebeek *et al*., 2007; Winkler *et al*., 2020).

11.479 In the United Kingdom, approximately 4-6% of stranded small cetaceans (harbour porpoise, common dolphin, white-beaked dolphin and Risso's dolphin) showed evidence of physical trauma during postmortem examinations, potentially attributable to ship strikes. This is compared to 15-20% of stranded whales, based on data from the Cetacean Strandings Investigation Programme (CSIP) database (1990-2010) (Evans *et al*., 2011).

11.480 Harbour porpoises, being small and highly mobile, are generally expected to avoid vessels due to their responses to vessel noise (e.g., Thomsen *et al*., 2006; Polacheck & Thorpe, 1990). Predictive modelling indicated a negative relationship between the number of ships and the distribution of harbour porpoises in the Irish and Celtic Seas, and North Sea during summer. This suggests that harbour porpoises may exhibit avoidance behaviour, thereby reducing the risk of collisions with vessels (Heinänen & Skov, 2015).

11.481 Vessel activity influences dolphin behaviour, with socialising and foraging often occurring in the presence of various vessel sizes, as demonstrated in a study conducted by Mills *et al.* (2023) in a busy shipping channel in the Gulf of Mexico. It has been suggested in this study that vessel movements enhanced nutrient mixing, thereby increasing prey abundance. Locally, bottlenose dolphins in Cardigan Bay exhibit responses to vessels that vary based on the type of vessel and their degree of habituation (Koroza & Evans, 2022). Observations indicated that the resident bottlenose dolphins in Cardigan Bay were more likely to tolerate disturbances compared to more transient dolphins in the region (Hudson, 2014). Currently, there is no information or recorded instances of ship strikes for bottlenose dolphin in Cardigan Bay.

11.482 In a telemetry study of harbour and grey seals, alongside vessel Automatic Identification System (AIS) information across the British Isles, data indicated vessel and seal co-occurrence was high and that spatial overlap with ships occurred within 50km of the coast close to haul-out sites (Jones *et al*., 2017). Areas with high risk of vessel exposure included 11 SACs. In an attempt to determine the likelihood of harbour seal injury occurring due to co-presence

with large vessels within the Moray Firth, there appeared to be to be no relationship between areas in high co-occurrence and incidences of injury (Onoufriou *et al*., 2016). In fact, seals were observed not to react to close passing vessels.

11.483 The information provided above highlights that larger whale species, such as minke whales, are at a greater risk of vessel collisions compared to smaller cetaceans. Evidence shows a lower incidence of physical trauma in strandings of smaller species, like dolphins and seals, which often display normal behaviour around vessels or even habituate to their presence. In contrast, harbour porpoises exhibit strong avoidance behaviour due to their sensitivity to noise and movement. However, minke whales, being less agile and more prone to ship strikes, do not demonstrate the same avoidance capabilities. Given their size, behaviour, and the documented increase in collisions, baleen whales, such as minke whale, should be considered to have a higher sensitivity to vessel strikes than dolphins, seals, or porpoises.

Sensitivity

11.484 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.

11.485 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

11.486 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.

11.487 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

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

CSIP, however, there is a Natural England (2019) report on seal necropsies in England between November 2015 and March 2016. Information from the 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.

11.488 **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	1617	75	16	0.056	5.6
Bottlenose dolphin	152	45	1	0	0.022	2.2
Common dolphin	1805	628	17	13	0.048	4.8
Risso's dolphin	139	41	2	1	0.073	7.3
White-beaked dolphin	186	110	5	0	0.045	4.5
Minke whale	236	86	0	6	0.07	7.0
Grey seal	1909	417	18	0	0.043	4.3
Harbour seal	624	179	6	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

11.489 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**).

11.490 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**).

11.491 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).

11.492 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.

11.493 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**).

11.494 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**.

11.495 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

11.496 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**).

11.497 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.

11.498 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.

11.499 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

11.500 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.

11.501 These measures would be detailed within the final PEMP, with an Outline PEMP and VTMP included with the DCO Application.

Residual significance of effect

11.502 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 and VTMP (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

11.503 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

11.504 Any impacts on prey species have the potential to affect marine mammals.

Sensitivity

11.505 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.

11.506 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.

11.507 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.

11.508 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.

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

Magnitude

Physical seabed disturbance

11.510 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).

11.511 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.

11.512 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

11.513 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**).

11.514 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.

11.515 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.

11.516 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.

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

11.518 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

11.519 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.

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

11.521 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

11.522 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.

11.523 **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.

11.524 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).

11.525 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

11.526 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.

11.527 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}).

11.528 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.

11.529 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**).

11.530 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

11.531 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.

11.532 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

11.533 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

11.534 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

11.535 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.

11.536 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.

11.537 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

11.538 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.

11.539 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

11.540 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.

11.541 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.

11.542 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

11.543 The sensitivity of marine mammals to any increased SSCs was assessed as **negligible**.

Magnitude

11.544 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

11.545 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

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

11.547 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).

11.548 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).

11.549 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.

11.550 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.

11.551 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).

11.552 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).

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

Sensitivity

11.554 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.

11.555 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

11.556 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).

11.557 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**).

11.558 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.

11.559 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**.

11.560 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).

11.561 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.

11.562 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.

11.563 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.

11.564 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).

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

Significance of effect

11.566 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**).

11.567 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

11.568 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.

11.569 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.

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

Residual significance of effect

11.571 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

11.572 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

11.573 Assessments have been presented for each individual impact for the Project alone during the operation and maintenance phase. However, there is the potential for interactions of multiple impacts during this phase. Further information on these interactions is presented in **Section 11.10**. Additionally, there is also the potential for disturbance effects from various impacts to occur simultaneously and throughout the duration of the operation and maintenance phase, leading to additive effects. These have been assessed in **Section 11.10.1.** A lifetime assessment for all phases of the Project has also been presented.

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

11.574 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).

11.575 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).

11.576 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).

11.577 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).

11.578 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).

11.579 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**).

11.580 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).

11.581 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.

11.582 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.

11.583 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

11.584 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**).

11.585 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.

11.586 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.

11.587 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.

11.588 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**).

11.589 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

11.590 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**).

11.591 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

11.592 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**).

11.593 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.

11.594 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.

11.595 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 (at any one time) 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 at a single point in time

Species	Maximum number of individuals (% of reference population) for one WTG at a single point in time	Maximum number of individuals (% of reference population) for 35 WTGs at a single point in time	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

11.596 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

11.597 The quantitative assessments provide a snapshot of the number of animals disturbed and the percentage of their reference population at a single point in time, which forms the basis for determining the magnitude of effect. Although this assessment quantifies a single event, the duration of effects are also considered within the assignment of the magnitude. Long-term exposure to operational noise is not expected to have a sustained significant effect on the wider population, as the effects are small and localised. Considering a professional analysis of the overall evidence base, including the number of animals impacted at any one time and the duration of effects, the magnitude of the effect has been deemed appropriate and proportional to help determine the overall significance of effects.

11.598 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**).

11.599 Taking into account the medium sensitivity of the 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

11.600 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)
All marine mammal species	Disturbance	Medium	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

11.601 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.

11.602 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.

11.603 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

11.604 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**).

11.605 For disturbance effects, all marine mammal receptors were assigned a **medium** 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

11.606 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**).

11.607 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**).

11.608 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

11.609 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 at any one time (**Table 11.67**).

11.610 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 at a single point in time

Species	Potential Impact	Maximum number of individuals (% of reference population) for each activity	Maximum number of individuals (% of reference population) for two activities at a single point in time	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

11.611 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.

11.612 The maximum number of individuals (% of reference population) that could be disturbed for one activity (at a single point in time) is the same as assessed for construction activities (see **Table 11.48**), with a **negligible** magnitude determined for all species.

11.613 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.

11.614 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 at a single point in time 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) at a single point in time	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

11.615 The quantitative assessments provide a snapshot of the number of animals disturbed and the percentage of their reference population at a single point in time, which forms the basis for determining the magnitude of effect. Although this assessment quantifies a single event, the duration of effects is also considered. Repeated disturbance events are not expected to have a sustained significant effect on the wider population, as the effects of disturbance would be intermittent over the operational period, not considered permanent and are recoverable over time. However, recoverability may reduce with repeated exposure to disturbance events, particularly when the duration between events is short. It is also important to note that animals may incur some energetic cost during the construction period (e.g. Williams *et al.*, 2006; Hastie *et al*., 2021; Frankish *et al.,* 2023). Considering a professional analysis of the overall evidence base, including the number of animals impacted at any one time and the duration of effects, the magnitude of the effect has been deemed appropriate and proportional to help determine the overall significance of effects.

11.616 Taking into account the medium marine mammal sensitivity to TTS and 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 **minor adverse** (not significant in EIA terms) for all species (**Table 11.69**).

Residual significance of effect

11.617 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 **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)
All species	Disturbance	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)

11.6.4.3 Impact 3: TTS and disturbance from underwater noise due to the presence of vessels

11.618 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.

11.619 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.

11.620 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.

11.621 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**).

11.622 The vessels in the windfarm site during operation and maintenance activities would be slow moving or stationary.

Sensitivity

11.623 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**).

11.624 For disturbance effects, all marine mammal species had a **medium** sensitivity assigned (**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

11.625 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**).

11.626 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.

11.627 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.

11.628 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

11.629 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 at a single point in time (**Table 11.71**).

11.630 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 at a single point in time

Species	Maximum number of individuals (% of reference population) for one vessel	Maximum number of individuals (% of reference population) for up to 10 vessels at a single point in time	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
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

11.631 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**).

11.632 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).

11.633 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.

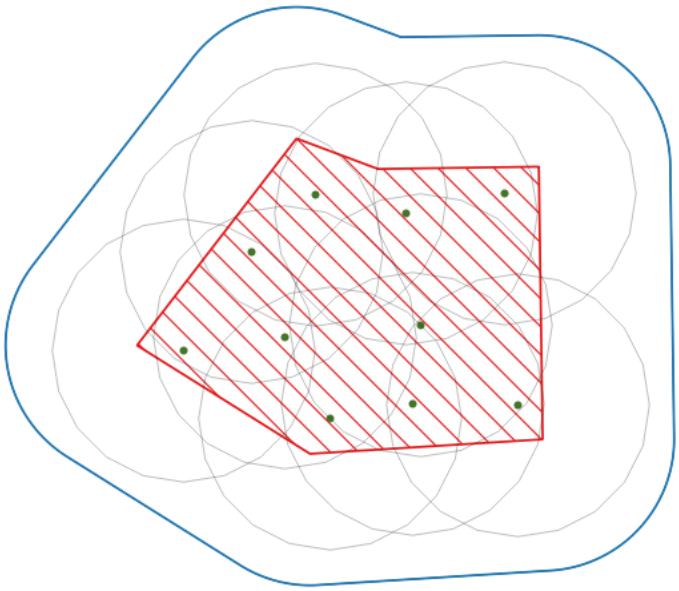

Plate 11.9 Revised site (hatched in red), with 4km buffer (blue), and 10 vessels (green dots) and their 4km buffer (grey) randomly allocated within the site.

11.634 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**).

11.635 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.

11.636 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 at a single point in time 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) at a single point in time	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

11.637 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**).

11.638 The quantitative assessments provide a snapshot of the number of animals disturbed and the percentage of their reference population at a single point in time, which forms the basis for determining the magnitude of effect. Although this assessment quantifies a single event, the duration of effects is also considered. Repeated disturbance events from vessels over the operational period are not expected to have a sustained significant effect on the wider population. This is due to the existing baseline, the level of noise associated with vessel disturbance, the intermittent nature of effects and the fact that the effects of vessel disturbance are not considered permanent and are recoverable over time. However, recoverability may reduce with repeated exposure to disturbance events, particularly when the duration between events is short. It is important to note that animals may incur some energetic cost during the overall operational period (e.g. Williams *et al*., 2006; Hastie

et al., 2021; Frankish *et al*., 2023). Considering a professional analysis of the overall evidence base, including the number of animals impacted at any one time and the duration of effects, the magnitude of the effect has been deemed appropriate and proportional to help determine the overall significance of effects.

11.639 Based on the medium 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 all marine mammal species (**Table 11.73**).

Residual significance of effect

11.640 No additional mitigation is required. Therefore, the residual significance of effect for TTS or disturbance due to underwater noise from operation and maintenance vessels at the Project would be **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 help reduce the potential disturbance from vessels, in particular when considering repeat disturbances over the construction period.

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	Medium	Low	Not Significant (Minor adverse)		
	Common dolphin	Medium	Negligible	Not Significant (Minor adverse)		
	Risso's dolphin	Medium	Negligible	Not Significant (Minor adverse)		

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

11.6.4.4 Impact 4: Barrier effects from underwater noise during operation and maintenance

11.641 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.

11.642 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.

11.643 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.

11.644 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).

11.645 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 **minor adverse** effect (not significant in EIA terms).

11.646 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

11.647 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.

11.648 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 sub-population did, however, exhibit seasonal movements towards the northwest of Scotland, as observed by Gaskin (1984).

11.649 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).

11.650 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).

11.651 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.

11.652 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**).

11.653 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).

11.654 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

11.655 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.

11.656 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.

11.657 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.

11.658 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

11.659 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**.

11.660 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

11.661 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**).

11.662 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**).

11.663 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

11.664 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**).

11.665 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

11.666 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

11.667 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 and VTMP (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

11.668 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**).

11.669 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

11.670 Any impacts on prey species have the potential to affect marine mammals.

Sensitivity

11.671 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

11.672 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).

11.673 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**).

11.674 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

11.675 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.

11.676 The significance of effect on fish species due to such impacts was assessed as negligible to minor adverse (**Chapter 10 Fish and Shellfish Ecology**).

11.677 The magnitude of impact for any change to prey resources for marine mammals would be **negligible**.

Underwater noise

11.678 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.

11.679 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.

11.680 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

11.681 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.

11.682 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.

11.683 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).

11.684 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).

11.685 The magnitude of impact for any changes in prey resource for marine mammals from EMF during operation and maintenance would be **negligible**.

Barrier effects

11.686 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.

11.687 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

11.688 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.

11.689 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.

11.690 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).

11.691 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

11.692 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.

11.693 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

11.694 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

11.695 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 (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 (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

11.696 During the operation and maintenance phase, there is the potential for maintenance activities to disturb sediment, potentially resulting in increases in SSCs.

11.697 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.

11.698 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

11.699 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.

11.700 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

11.701 As a precautionary approach, both grey and harbour seals were considered to have **low** sensitivity to disturbance at seal haul-out sites.

Magnitude

11.702 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.

11.703 Disturbance from operation and maintenance activities occurring at the windfarm site was considered a **negligible** magnitude of impact.

Significance of effect

11.704 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**).

11.705 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

11.706 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

11.707 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

11.708 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.

11.709 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

11.710 Assessments have been presented for each individual impact for the Project alone during the decommissioning phase. However, there is the potential for interactions of multiple impacts during this phase. Further information on these interactions is presented in **Section 11.10**. There is also the potential for disturbance effects from various impacts to occur simultaneously and throughout the duration of the decommissioning phase, leading to additive effects. These have been assessed in **Section 11.10.1.** A lifetime assessment for all phases of the Project has also been presented.

11.711 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.

11.712 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).

11.713 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.

11.714 **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 and UWSMS to reduce risk of PTS and disturbance	Not Significant (Minor adverse)
Impact 2: Disturbance from underwater noise	All marine mammal species	Medium	Low - Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Impact 3: Disturbance from underwater noise, presence and movements of vessels	All marine mammal species	Medium	Low – Negligible	Not Significant (Minor adverse)	No additional required, but best practice measures (see **Section 11.3.3**) would help reduce disturbance	Not Significant (Minor 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 species	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

11.715 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.

11.716 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

11.717 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).

11.718 **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

11.719 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)	Yes	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, 2010, 2025). 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. However, the risk of any residual PTS from the Project could therefore increase the potential risk of cumulative PTS, and has therefore been screened in to 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)	Yes	There is a pathway for cumulative effects from OWF maintenance activities. See **Section 11.7.3** for a qualitative assessment.
Decommissioning phase			
Underwater noise from the decommissioning activities	Not Significant (Minor adverse)	Yes	As per construction. There is also a pathway for cumulative effects from decommissioning activities from other plans and projects. See **Section 11.7.3** for a qualitative assessment.

11.7.2 Identification of other plans, projects and activities

11.720 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.

11.721 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**.

11.722 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

11.723 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**).

11.724 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)

11.725 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'

[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.

assessment has been made considering both the Project and the Transmission Assets. This provides an assessment of impact interactions and additive effects and thus any change in the significance of effects as assessed separately. The Transmission Assets PEIR (Morgan Offshore Wind Limited and Morecambe Offshore Windfarm Ltd, 2023a and ES, Morgan Offshore Wind Limited, Morecambe Offshore Windfarm Ltd, 2024) informs the assessment.

11.726 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)

11.727 The following (Project-alone) impacts to marine mammals were concluded in the Transmission Assets):

- Injury and disturbance from underwater sound generated from piling – Since the writing of the Project ES a decision has been taken that the OSPs and the Morgan offshore booster station would not be included within the DCO Application for the Morgan and Morecambe Offshore Wind Farms Transmission Assets, removing the requirement for piling altogether. This change affects the combined assessment which captures both the PTS/TTS and disturbance assessments for the key noisy components, which have now been removed. As a result of this change, the effect of injury and disturbance from underwater noise during piling from the Project and Transmission Assets can be screened out from further assessment (Morgan ES, Morgan Offshore Wind Limited, Morecambe Offshore Windfarm Ltd, 2024).
- 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)**

11.728 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**).

11.729 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 non-piling construction activities
- Increase in collision risk with vessels
- Injury and disturbance from UXO detonation (assessed under cumulative effect 2c in **Section 11.7.3.2**, in which the potential for two UXO clearances for each of the projects was assessed)

11.730 There was no assessment for white-beaked dolphin for the Transmission Assets PEIR or ES (Morgan Offshore Wind Limited and Morecambe Offshore Windfarm Ltd, 2023; Morgan Offshore Wind Limited, Morecambe Offshore Windfarm Ltd, 2024) and therefore they have not been assessed any further.

Cumulative effect 1: Injury and disturbance from underwater noise

Cumulative effect 1a: Injury and disturbance from other construction or operational activities

11.731 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 Ltd, 2023; Morgan Offshore Wind Limited, Morecambe Offshore Windfarm Ltd, 2024).

11.732 The Project has assessed auditory injury for vessels and other (non-piling) construction activities separately, while for the Transmission Assets a combined assessment was undertaken. An assessment on the combined effect of vessel disturbance is assessed in **Cumulative effect 2a**.

11.733 Since the decision has been taken to remove key components of the planned infrastructure with regard to the Transmission Assets, the requirement for any major additional construction activities associated with the preparation for foundations was removed. During construction, the Transmission Assets expects burial/installation of 484km of cables via trenching, jetting, ploughing

(including pre-lay ploughing), and mechanical cutting. During operation and maintenance, the activities at the Transmission Assets that will be carried out include routine inspections, geophysical surveys, and cable repair or reburial. The number of vessels, from which activities will be conducted at any one time, has been assessed under the effect of vessel presence (the combined effect with the Project has been outlined in **Cumulative effect 2a**.

Magnitude

11.734 As assessed in **Section 11.6.3.3** the impact magnitude for undertaking two (non-piling) Project construction activities at the same time was assessed as negligible for all marine mammal species. Considering available monitoring studies for operational wind farms suggest that marine mammals would not be significantly disturbed, and that any impact would be localised and temporary (e.g. Diederichs *et al*. 2008; Teilmann *et al*. 2006; McConnell *et al*. 2012). Cable laying or activities of similar source level (see Table 5-2 in **Appendix 11.1**) are not considered to cause additional effects that would result in change of effect significances. When adding the number of animals affected from construction vessel disturbance for the Transmission Assets (see below **paragraph 11.741**) and the amount of animals disturbed by two construction activities at the Project (**Table 11.48**), the total number of affected animals at a point in time could be up to 198 harbour porpoise, 5 Risso's dolphin, 5 minke whale, 3 common dolphin, 1 white-beaked dolphin and bottlenose dolphin, 17 grey seal, and less than one individual harbour seal (numbers were rounded up where animals were less than one individual).

11.735 The affected percentage at any one time of the relevant population remains under 0.5% of the relevant population and, therefore, considering the scale and duration of effects the magnitude is negligible for all species.

Significance of effect

11.736 The significance of effect for other construction activities is **minor adverse** (not significant in EIA terms), in line with the result of the combined vessel disturbance assessment in **Cumulative effect 2a**: Disturbance from vessels The magnitude of impact as a result of underwater noise from operation and maintenance activities is expected to be less than that assessed for construction. Vessels are however considered a long-term impact (see **Table 11.72**) for marine mammals, thus a **minor adverse** effect (not significant in EIA terms) presents a precautionary approach, having taken repeated vessel disturbance into consideration. The Project has assessed auditory injury for vessels and 'other (non-piling) construction' activities separately, while for the Transmission Assets the assessment was undertaken all together. Based on the information provided from both projects and considering all impacts together, 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.

Cumulative effect 1b: Assessment of disturbance from other industries and activities

11.737 An assessment of other industries is included in the CEA for all plans and projects (**Section 11.7.3.2**). Within the CEA Section with all plans and projects, **Cumulative effect 2c** 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.

11.738 There is no requirement to assess the Transmission Assets and the Project in addition to what is presented in **Section 11.7.3.2**, the resulting impact would likely resemble that of the Project operating alone (refer to **Table 11.107** for assessment results).

Cumulative effect 2a: Disturbance from vessels

Sensitivity

11.739 As outlined in **Section 11.6.3.4,** the sensitivity of disturbance is medium for all marine mammal species.

Construction

Magnitude

11.740 The combined vessel return trips for the Project (maximum of 2,583 in one year) and the Transmission Assets (up to 226 per year) would total up to 2,809 annually at the worst case. This indicates that the Transmission Assets add, on average, 19 more vessel return trips per month to the 215 vessel trips already associated with the Project each month.

11.741 Disturbance estimates from vessel activity indicate that, during construction, at one point in time, the Transmission Assets could affect up to 35 harbour porpoise, five Risso's dolphins, four minke whales, 17 grey seals, and less than one individual of bottlenose dolphin, common dolphin, or harbour seal (Morgan Offshore Wind Limited, Morecambe Offshore Windfarm Ltd, 2024). In comparison, the Project estimated effects at any one time on up to 463 harbour porpoise, one Risso's dolphin, three minke whales, bottlenose and white-beaked dolphins, eight common dolphins, 29 grey seals, and less than one harbour seal. The total number of disturbed animals at any one time could be up to 498 harbour porpoise, six Risso's dolphin, seven minke whale,

three white-beaked dolphin and bottlenose dolphin, eight common dolphin, 46 grey seal, and less than one individual harbour seal.

11.742 In addition to the number of animals that could be impacted at a point in time, the cumulative impact of increased disturbance from vessels over the construction period has been considered. Disturbance over the construction period is predicted to be of local spatial extent, intermittent (vessel activity will not be constant) and reversible (disturbance effects are temporary).

11.743 As a result of the total numbers of disturbed animals and the affected percentage of the relevant population, and in consideration of the spatial scale, intermittent and reversible effect over construction, there remains a low magnitude for bottlenose dolphin, and negligible magnitude for all remaining species. The magnitudes have not changed and thus have not altered the effect significance conclusions as set out in **Section 11.6.3.4** for the Project-alone assessment.

Significance of effect

11.744 The effect of cumulative vessel disturbance on marine mammals with a medium sensitivity would result in a **minor adverse** effect significance for all other species, which is not significant in EIA terms.

11.745 There are available measures to reduce the potential level of disturbance from vessels as included in the Outline PEMP and Outline VTMP which have been secured in the dDCO Schedule 6 Condition 9(1)e(v) and Condition 9(1)j, respectively.

Operation and maintenance

Magnitude

11.746 Since the removal of key components for the Transmission Assets (booster stations and offshore substations), the number of vessels required during operation and maintenance has reduced from 1,155 (Morgan Offshore Wind Limited and Morecambe Offshore Windfarm Ltd, 2023) to 77 (Morgan Offshore Wind Limited, Morecambe Offshore Windfarm Ltd, 2024) annual vessel return trips (see **Table 11.113** for details on vessel transfers from the Transmission Assets). Similarly, as discussed for construction, the additional 77 annual vessel transfers, in addition to the 832 vessel transits for the Project, will not significantly change the overall conclusion. This is because the additional number of animals affected by vessels for the Transmission Assets has not altered the conclusion from the Project alone, which contributes more vessels in comparison.

11.747 However, quantitative assessments like that in ‘Construction’ (**paragraph 11.740** and any subsequent paragraphs) represent a snapshot of the number of marine mammals potentially disturbed at a single point in time. Repeated

disturbances throughout the Project's lifetime would occur which might have longer-term implications for marine mammal populations. While short-term behavioural responses to disturbances, such as boat approaches, can be observed, the long-term effects are more challenging to quantify. Susceptibility to disturbance may also be dependent on the characteristics of the population, such as its size and resource availability (New *et al.,* 2020).

11.748 A study by Hao *et al.* (2024) examined harbour porpoise reactions to small boats traveling at 10 and 20 knots in Danish waters, using drone footage. Porpoises typically responded within 200m of approaching vessels but resumed natural behaviours within one minute after the boats passed. Wisniewska *et al.* (2018) also found that despite potential short-term effects on foraging, porpoises quickly recover from vessel interactions and remain in high-traffic areas despite temporary disruptions. A study on bottlenose dolphins indicated that they resumed normal behaviour after the disturbance from boats had ceased, but the exact timing varied based on several factors, including the intensity and duration of the disturbance (New *et al.,* 2020). Overall, while boats may cause short-term avoidance, the evidence suggests that marine mammals quickly return, making prolonged displacement unlikely. However, frequent and prolonged disturbances can lead to increased stress and potential long-term impacts on marine mammal well-being (Dyndo *et al*., 2015).

11.749 Although the study by Hao *et al.* (2024) focused on small boats, Wisniewska *et al.* (2018) included various sizes of vessels, primarily focusing on large ships such as tankers and bulk freighters, as well as smaller vessels, including fishing boats and fast passenger ferries. Larger vessels, associated with offshore wind activities, are, when on site, generally slow-moving or stationary, which reduces noise emissions. Stationary vessels emit less propulsion noise and experience reduced cavitation compared to moving vessels (Hildebrand, 2009; Ainslie, 2010). This difference may further minimise potential disturbance to marine mammals.

11.750 While the duration of impact is longer, the number of vessels expected on site during the operation and maintenance phase will be less than during construction. The cumulative impact of increased disturbance from vessels is predicted to be of local spatial extent, long-term duration (vessel presence is expected throughout the operational period), intermittent (vessel activity will not be constant) and reversible (disturbance effects are temporary).

11.751 The additional vessel traffic associated with the Transmission Assets does not significantly increase the overall volume of vessel activity over the lifetime of the Project. Despite limited data on the disturbance and recovery times of marine mammals from larger vessels, the available evidence (as stated above) suggests a low risk of prolonged displacement. As stated, the number of vessels is not significantly greater than that for the Project alone. As such,

the magnitude of disturbance to marine mammals from cumulative vessel activity associated with the Project and Transmission Assets is considered to be to be low for all species.

Significance of effect

11.752 As above, the mitigation to reduce the potential level of disturbance remains in place throughout the lifetime of the Project.

11.753 The effect of cumulative vessel disturbance on marine mammals with a medium sensitivity would result in a **minor adverse** effect significance for all species, which is not significant in EIA terms.

Decommissioning

11.754 A detailed Offshore Decommissioning Programme will be developed for the Project and Transmission Assets, detailing the works required. Until then, the impact from decommissioning for each project is expected to be the same as assessed during the construction phase. As such, the effect of cumulative vessel disturbance on marine mammals with a medium sensitivity would result in a **minor adverse** effect significance for all species, which is not significant in EIA terms.

Cumulative effect 2b: Increased collision risk with vessels

Construction

11.755 Vessel activity during construction is likely to increase within the cumulative marine mammal study area when considering the Project and Transmission Assets.

11.756 Most vessels will travel at slow speeds, well below 14–15 knots, minimising collision risks for marine mammals (Laist *et al*., 2001; Wilson *et al*., 2007). Studies have shown that vessel speed is one of the most critical factors influencing collision risk, with speeds below 10 knots posing minimal threat (Vanderlaan & Taggart, 2007; Gende *et al*., 2011; Conn & Silber, 2013). With the exception of Crew Transfer Vessels, the majority of construction vessels will operate at even slower speeds, further mitigating risks.

11.757 Both projects have committed to implementing VTMPs and Offshore PEMP to reduce potential disturbances and collision risks. VTMPs are widely recognised as effective tools for minimising vessel-related impacts on marine mammals, as demonstrated in previous offshore projects (Dolman & Simmonds, 2010).

11.758 Sound emissions from vessels may temporarily deter animals from the immediate area (Benhemma-Le Gall *et al.,* 2023), reducing collision likelihood. Studies indicate that marine mammals, including harbour porpoises, often respond to vessel noise by maintaining safe distances, particularly in high-traffic areas (Wisniewska *et al*., 2018; Nowacek *et al*.,

2001). Vessel movements are expected to remain localised within project areas and along established shipping routes, consistent with existing traffic patterns.

11.759 Construction activities occur in regions already characterised by high levels of marine traffic. Mitigation measures, including avoidance protocols, have been successfully implemented in similar contexts to minimise risks to marine life (Silber *et al*., 2010).

11.760 Overall, vessel activity will be intermittent over the construction phase. With established mitigation measures in place, cumulative impacts are predicted to be of limited spatial extent, and low in magnitude, with minimal risk of collisions.

11.761 As described in **Section 11.6.3.6**, the sensitivity of all marine mammals to collision risk is low, with the exception of minke whale with a sensitivity of medium, leading to an overall effect of **minor adverse** for all species (not significant in EIA terms).

Operation and Maintenance

11.762 The vessel traffic during operation and maintenance reduces at both the Project and Transmission Assets. The Transmission Assets are expected to use a maximum of 14 vessels at any one time, while the Project may have up to 10 vessels in the wind farm site.

11.763 Unlike during construction, the presence of maintenance vessels is considered long-term, spanning the entire lifetime of the projects. Maintenance activities will occur intermittently, with up to 24 vessels on-site at any given time. Although the overall number of vessels has decreased, the longevity of their presence must be considered. However, given the baseline levels of shipping in the area, it is not considered that the additional vessels will significantly increase the collision risk to marine mammals.

11.764 Taking a precautionary approach, vessel activity will be intermittent throughout the lifetime of the projects. With established mitigation measures in place, cumulative impacts are predicted to be of limited spatial extent, long-term in duration, and low in magnitude, with minimal risk of collisions impacting sensitive receptors.

11.765 As described in **Section 11.6.3.6**, the sensitivity of all marine mammals to collision risk is low, with the exception of minke whale with a sensitivity of medium, leading to an overall effect of **minor adverse** for all species (not significant in EIA terms).

Cumulative effect 3: Injury and disturbance from UXO detonation

Injury

11.766 The number of animals that could experience PTS or TTS from UXO clearance at the Transmission Assets led to the conclusion of a:

- moderate significance for harbour porpoise; and minor significance for all other species.

11.767 The assessment for the Project (noting information was provided only for information as a separate marine license application would be made for any UXO clearance required) led to the conclusion that the effect significance is:

- major adverse for harbour porpoise and grey seal (significant in EIA terms);
- major to minor adverse for harbour seal (significant in EIA terms);
- moderate adverse (significant in EIA terms) for bottlenose dolphin; and
- minor adverse (not significant in EIA terms) for all other species.

11.768 For the Project, the affected animals are based on the worst-case scenario with no mitigation measures applied. As such, it is expected that the residual level of significance would be reduced to minor adverse, once mitigation as per the draft MMMP is in place.

11.769 High-order clearance is the last resort in the mitigation hierarchy. In addition, the MMMPs of both projects would be designed to ensure any potential for PTS is reduced as far as is practicable. As a combined effect, a **minor adverse** effect (not significant in EIA terms) can be expected to occur with regard to auditory injury from, mitigated, UXO clearance.

Disturbance

11.770 It was concluded for the Project that two UXO clearances, at the same time as piling at the Project, would result in a high magnitude for bottlenose dolphin, medium for harbour porpoise, low for minke whale or grey seal, and negligible for the remaining dolphins and harbour seal (see cumulative assessment in ES Chapter 11 Marine Mammals (APP-048), **Section 11.7.3.2**, **Cumulative effect 1c**).

11.771 The assessment was carried out on a precautionary basis as the number of UXOs at either project has not been confirmed at the time of writing. As such, re-assessment and mitigation will be secured via the final MMMPs (and marine wildlife license applications) for each project and the separate Marine License application that will be applied for the Project UXO clearance if required.

11.772 As mentioned above, both projects must adhere to a MMMP for UXO. These strategies will secure measures to reduce auditory impacts on marine mammals, thereby also mitigating disturbances. Furthermore, the position statement by the UK Regulators (UK Government *et al*., 2025) supports the principle of using lower noise alternatives to high order detonations of UXO. Where low noise alternatives are not feasible, suitable mitigation such as a noise abatement system would be considered. Consequently, the conclusion from a combined assessment of UXO clearance at Transmission and piling at the Project is that the impact would be of **minor adverse** significance (not significant in EIA terms).

Cumulative effect 4: Changes in prey availability

11.773 The effect from changes in prey resource is explored in detail in Cumulative effect 6: Changes to prey resources (for all plans and projects). This assessment concluded that the cumulative effects, including all projects overlapping with the proposed Project, would result at worst in a minor adverse significance of impact. While the effect interactions are additive in nature across the study area, their overall significance is not elevated beyond the levels assessed individually within the assessments. This is considered to be suitably precautionary given that no significant effects have been identified in Chapter 10 Fish and Shellfish and measures in the UWSMS and MMMP will also reduce disturbance to fish. Detailed information about marine mammal feeding ecology has been provided for each species in Appendix 11.2, which indicated that most species have a wide range of common prey species that they can rely on. Any impact that might affect fish would be mitigated by marine mammals' extensive swimming ranges, which allow them to forage away from their usual or nearest feeding locations. Over the lifetime of the Project and Transmission Assets, prey is unlikely to be affected significantly by ongoing windfarm activities. In fact, both seal and harbour porpoise have been seen feeding in operational windfarms, leading to the assumption that prey availability is plentiful (e.g., Lindeboom *et al*. 2011; Russell *et al*. 2014, Leemans & Fijn, 2023).

Summary

11.774 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 11.80**).

Table 11.80 Summary of impacts from the Project and Transmission Assets alone and combined[14]

Impact	Residual significance of effect		Combined assessment
	Transmission Assets (ES)	Project	
Construction / decommissioning phases			
Auditory injury from piling	11.775 n/a	Not Significant (Minor adverse)	Auditory injury: Not assessed further. Disturbance: Not assessed further.
Disturbance from piling		Not significant (Minor adverse)	
Auditory injury and disturbance from other construction noise	Not significant (Minor adverse) (incl. vessels)	Not significant (Minor adverse) (excl. vessels)	See **Cumulative effect 1a** in which the additive nature is further discussed, deriving at a conclusion of: Not significant (Minor adverse)
TTS and disturbance through vessels	Assessed under 'other construction noise'	Not significant (Minor adverse)	See **Cumulative effect 2a** in which the additive nature is further discussed, deriving a conclusion of: Not significant (Minor adverse)
Vessel collision risk	Not significant (Minor adverse)	Not Significant (Minor adverse)	See **Cumulative effect 2b** in which the additive nature is further discussed, deriving a conclusion of: Not significant (Minor adverse)
Injury and disturbance from UXO detonation	Significant (Moderate adverse) for harbour porpoise Not significant (Minor adverse) for all other species	Not Significant (Minor adverse) (**Appendix 11.3**)	See **Cumulative effect 3** which the additive nature is further discussed, deriving a conclusion of: Not significant (Minor adverse)

[14] Note: wording of impacts has been summarised to encompass both projects. Where impacts were not considered or scoped out = n/a

Impact	Residual significance of effect		Combined assessment
	Transmission Assets (ES)	Project	
			This conclusion is based on the use of low order clearance in the first instance and the use of mitigation available in preference to unmitigated high order.
Barrier effects as result of UWN	n/a	Not significant (Minor adverse)	Not assessed further.
Changes to prey resources/ availability	Not significant (Minor adverse)	Not significant (Minor to negligible adverse)	See **Cumulative effect 4** in which the additive nature is further discussed, deriving at a conclusion of: Not significant (Minor adverse).
Changes to water quality	n/a	Not significant (Negligible adverse)	Not assessed further.
Disturbance of seals at haul-out sites	n/a	Not significant (Minor to negligible adverse)	Not assessed further.
Operation and maintenance phase			
Auditory injury & disturbance from operational WTG	n/a	Not significant (Minor adverse)	Not assessed further.
Auditory injury and disturbance from other operational activities	Not significant (Minor adverse) (incl. vessels)	Not significant (Minor adverse) (excl. vessels, assessed separately below))	See **Cumulative effect 1a** in which the additive nature is further discussed, deriving at a conclusion of: Not significant (Minor adverse)

Impact	Residual significance of effect		Combined assessment
	Transmission Assets (ES)	Project	
TTS and disturbance through vessels	Assessed under 'other operational noise'	Not significant (Minor adverse)	See **Cumulative effect 2a** in which the additive nature is further discussed, deriving at a conclusion of: Not significant (Minor adverse)
Vessel collision risk	Not significant (Minor adverse)	Not significant (Minor to negligible adverse)	See **Cumulative effect 2b** in which the additive nature is further discussed, deriving at a conclusion of: Not significant (Minor adverse)
Barrier effects as result of UWN	n/a	Not significant (Minor adverse)	Not assessed further.
Changes to prey resources/ availability	Not significant (Minor adverse)	Not significant (Minor to negligible adverse)	See **Cumulative effect 4** in which the additive nature is further discussed, deriving at a conclusion of: Not significant (Minor to Negligible adverse
Changes to water quality	n/a	Not significant (Negligible adverse)	Not assessed further.
Disturbance of seals at haul-out sites	n/a	Not significant (Minor to negligible adverse)	Not assessed further.

11.7.3.2 Cumulative assessment – All plans and projects

11.776 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).

11.777 The cumulative assessment for the Project was based on the most up to date information at the time of writing for the DCO Application submission in May 2024. All included information was available in the public domain and presented as a precautionary worst case approach. During the examination process for some projects, assessment information has evolved. It is considered that any refinements in these assessments would not impact the overall conclusions of the Project CEA. A review of newly available information (including the ES for Transmission Assets, Morgan Generation and Mona projects) confirms the robust approach to capture potential effects within the cumulative assessment which remain valid.

11.778 The following quantitative assessments present numbers of animals predicted to be affected or disturbed at a single point in time, however, the magnitude also considers the duration of effects. With regard to disturbance, it is further noted that not all animals within these potential disturbance areas would be uniformly displaced. While some animals would flee there may be other disturbances in other areas of the management unit. Others might remain in the area of effect but additionally (or again) be disturbed by other noise sources. Precise assessments of repeated disturbances over a period of time are currently not available. In lack thereof, a qualitative approach has been taken whereby the Cumulative effect of repeated disturbance events was investigated. It is also acknowledged that the noisy activities would not just occur simultaneously but rather intermittently over time and have the ability to both overlap and cause repeated disturbance events over the length of the Project's phases and its lifetime. These interactions or additive effects of multiple disturbance pathways are further discussed in **Section 11.10.1.3.**

Cumulative effect 1: PTS from underwater noise

11.779 The sensitivity of marine mammals with regard to PTS due to underwater noise was high for all marine mammal species.

11.780 The potential risk of (residual) PTS from other OWF projects has been incorporated in the cumulative disturbance assessment using population modelling (iPCoD). The iPCoD approach is a tool for assessing both PTS and disturbance on marine mammal populations (Sinclair *et al*., 2019).

11.781 PTS is considered in the iPCoD as a critical factor affecting marine mammal populations. The iPCoD framework was developed, using expert opinions, to

forecast the potential effects of disturbances, including PTS, on vital rates such as survival and reproduction in marine mammals (Booth & Heinis, 2018). The model incorporates statistical distributions generated from expert opinions to simulate the impacts of PTS on the population. The model also allows for comparisons between impacted and unimpacted populations, using modified survival and birth rates for animals that have experienced disturbance and PTS, while maintaining baseline rates for unimpacted populations (Sinclair *et al*., 2019).

11.782 iPCoD is only applicable to certain species (UK priority species), and this method cannot be used for common dolphins and white-beaked dolphins due to, among other reasons, the absence of species-specific sensitivity assessments (Sinclair *et al*., 2019). However, the PTS ranges for high-frequency cetaceans, such as dolphins, are relatively small compared to those of other species, e.g. the PTS SEL_{cum} impact range for dolphin species, for the installation of one or multiple monopiles is 100m (**Table 11.21**), making the risk of residual PTS negligible given that a minimum monitoring zone of 500m is required by JNCC guidance (JNCC, 2010).

11.783 PTS is considered to be localised to each project with regard to the modelled impact ranges. Effects would be mitigated with the measures secured in the Outline UWSMS and the draft MMMP, which will be further developed post-consent and pre-construction and with consideration of the latest guidance (JNCC *et al.,* 2025). The Project is committed to additional mitigation to ensure that if the Project worst case was to be actualised (the high strike rate scenario with the maximum hammer energy) the potential PTS effects would be fully mitigated by using noise reduction methods such as NAS and to ensure there is no residual PTS after the ADD use. Furthermore, all other projects that were screened-in for an overlap in piling, committed to mitigate PTS with measures detailed in their respective MMMPs.

11.784 The potential magnitude of cumulative impact for PTS to marine mammals as a result of cumulative underwater noise impacts was assessed to be **negligible** given the short PTS impact ranges, the distance to other OWFs and activities, and the mitigation that each project has committed to (as below). The potential for a PTS effect due to underwater noise was assessed as **minor adverse** (not significant in EIA terms) (**Section 11.6.4.4**).

11.785 Evidence that projects committed to reduce PTS via MMMP is as follows:

- **Awel y Mor**: submitted a Draft Marine Mammal Mitigation Protocol with their DCO to PINS under REP8-069;
- **Erebus**: submitted a Draft Marine Mammal Mitigation Protocol to NRW under licence: ORML2170
- **Transmission Assets**: submitted an Outline Marine Mammal Mitigation Protocol with their DCO to PINS under APP-223;

- **Morgan**: submitted an Outline marine mammal mitigation protocol with their DCO to PINS under REP4-018;
- **Mona**: submitted an Outline Marine Mammal Mitigation Protocol to NRW under licence: ORML2429T J21; and
- **White Cross**: submitted a Draft Marine Mammal Mitigation Protocol; accessible via developer website.

Cumulative effect 2: Disturbance from underwater noise

11.786 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)
- 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)

11.787 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.

11.788 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).

11.789 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**.

11.790 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 2a: Indicative assessment of underwater noise impacts from piling at other OWFs

11.791 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).

11.792 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).

11.793 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 11.81**).

Table 11.81 Plans and projects screened in for overlap in piling with piling at the Project

Project	PINS Tier [15]	Distance to Project	Species included in assessment
AyM OWF [16]	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
White Cross OWF	1	306km	All species but Risso's dolphin, white-beaked dolphin and harbour seal

[15] Information on project stages and tiers see **Appendix 11.4**

[16] 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

11.794 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

11.795 As outlined in **Section 11.6.2**, all marine mammal receptors were assessed as having **medium** sensitivity to disturbance from underwater noise from piling at OWFs.

Magnitude

Quantified Assessment

11.796 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

11.797 For all other projects, the worst-case disturbance numbers were taken from the relevant PEIRs and ESs for the cumulative assessment.

11.798 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. Not all animals within the

effect radius would be uniformly displaced. While some animals would flee, others might remain in the area of effect from piling but additionally (or again) be disturbed by other noise sources. There is a potential for additive effects for multiple sources of noisy activities. However, displacement of animals from activities such as piling can potentially reduce their exposure to other noisy activities from the Project. . Disturbance events could also be occurring elsewhere across the MU and CEA screening area. The effects of these repeated and additive disturbances that could be ongoing during the lifetime of the Project are considered in iPCoD modelling and further considered in Section **11.10.1** considering all activities. 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).

11.799 The approach to the CEA for piling at OWFs was based on the potential for piling activity at each windfarm at the same time as 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. The application of iPCoD modelling allows for the full pilling schedule of each project to be considered, allowing for overlapping and sequential piling (repeated disturbances) events over the construction period.

11.800 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 simultaneous impact to occur, but could occur repeatedly over time.

Harbour porpoise

11.801 **Table 11.82** provides a quantified assessment of magnitude of cumulative disturbance due to piling overlap with other OWF, utilising project-specific data from published PEIRs and ESs as outlined in **Appendix 11.2**. With or without the project, the magnitude for harbour porpoise is high.

Table 11.82 Quantified Cumulative Effects Assessment (CEA) for the potential disturbance at a single point in time for harbour porpoise during single piling at the OWF projects which could be piling at the same time as the Project

Harbour porpoise			
Project	**Harbour porpoise density (/km$^{2)}$**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed at a single point in time during single piling**
The Project	1.621	2123.7	3,442.5
Awel y Môr	1.00	DRC	2,112
Mona	0.097	DRC	429.0
Morgan Generation Assets	0.274	DRC	979.0
Morgan and Morecambe Transmission Assets[17]	0.560	DRC	1,793.0
Erebus	0.400	DRC	1,967.0
White Cross	0.92	2123.7	1,949.6
Total number of harbour porpoise (*without the Project*)			**12,672.1**
			9,229.6
Percentage of CIS MU (*without the Project*)			**20.3%**
			14.8%
Magnitude of cumulative effect (*without the Project*)			**High**
			High

Bottlenose dolphin

11.802 **Table 11.83** provides a quantified assessment of disturbance to bottlenose dolphin due to piling overlap with other OWF, utilising project-specific data from PEIRs and ESs as outlined in Table 7.6 in Appendix 11.2 and shows that a high percentage of bottlenose dolphins would be at risk of potential disturbance, for which a high magnitude was assigned.

[17] At the time of writing the ES, a decision had been taken that the offshore substation platforms (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 Offshore Booster Station (OBS) would no longer be required. Whilst the OSPs, OBS 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 the ES.

Table 11.83 Quantified CEA for the potential disturbance at a single point in time for bottlenose dolphin during single piling at the OWF projects which could be piling at the same time as the Project

Bottlenose dolphin			
Project	**Bottlenose Dolphin density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed at a single point in time during single piling**
The Project	0.0104	DRC	56.3
Awel y Môr	0.0350	DRC	23
Mona	0.0350	DRC	13
Morgan Generation Assets	0.0350	DRC	11
Morgan and Morecambe Transmission Assets[17]	0.0010	DRC	4
Total number of bottlenose dolphin *(without the Projects)*			**107.3**
			51.0
Percentage of IS MU *(without the Project)*			**36.6%**
			17.4%
Magnitude of cumulative effect *(without the Project)*			**High**
			High

11.803 **Table 11.95** presents the significance of effect from cumulative disturbance due to piling for bottlenose dolphin. It is considered that using the DRC assessments from other projects is over precautionary, as these assessments are not specifically designed for dolphin species. Furthermore, the population modelling incorporated the worst-case numbers of disturbance and auditory injury and provided data on how that could impact the IS bottlenose dolphin population (see paragraph **11.820** for further information).

Common and Risso's dolphin

11.804 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 11.84**. The potential magnitude for the cumulative impacts of piling activities was assessed as low for Risso's dolphin and common dolphin.

Table 11.84 Quantified CEA for the potential disturbance at a single point in time for common dolphin and Risso's dolphin 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 at a single point in time 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 (*without the Project*)			**2,514.6**
			2,387
Percentage of CGNS MU (*without the Project*)			**2.5%**
			2.3%
Magnitude of cumulative effect (*without the Project*)			**Low**
			Low
Risso's Dolphin			
Project	**Risso's Dolphin density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed at a single point in time 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 *(without Morecambe OWFs)*			**335.4**
			333
Percentage of CGNS MU *(without the Project)*			**2.74%**
			2.72%
Magnitude of cumulative effect *(without the Project)*			**Low**
			Low

Minke whale

11.805 **Table 11.85** provides a quantified assessment of disturbance to minke whale due to piling overlap with other OWF, utilising project-specific data from PEIRs and ESs as outlined in Table 7.6 in Appendix 11.2, and results in a low magnitude.

Table 11.85 Quantified CEA for the potential disturbance at a single point in time for minke whale during single piling at the OWF projects which could be piling at the same time as the Project

Minke whale			
Project	**Minke whale density (/km$^{2)}$**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed during single piling**
The Project	0.0088	2827.43	24.9
Awel y Môr	0.0170	DRC	36
Mona	0.0173	DRC	77
Morgan Generation Assets	0.0173	DRC	69
Morgan and Morecambe Transmission Assets[17]	0.0050	DRC	17
Erebus	0.0112	DRC	53
White Cross	0.0112	TTS 100m	0.0004
Total number of minke whale (*without the Project*)			**276.9**
			252.0
Percentage of CGNS MU (*without the Project*)			**1.38%**
			1.25%
Magnitude of cumulative effect (*without the Project*)			**Low**
			Low

Grey seal

11.806 **Table 11.86** provides a quantified assessment of disturbance to grey seal due to piling overlap with other OWF, utilising project-specific data from PEIRs and ESs as outlined in **Appendix 11.2** and results in a low magnitude.

Table 11.86 Quantified CEA for the potential disturbance at a single point in time for grey seal during single piling at the OWF projects which could be piling at the same time as the Project

Grey seal			
Project	**Grey seal density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed at a single point in time during single piling**
The Project	0.1	1963.5	196.4
Awel y Môr	0.070	DRC	81
Mona	0.196	DRC	45
Morgan Generation Assets	0.041	DRC	45
Morgan and Morecambe Transmission Assets[17]	0.106	DRC	28
Erebus	0.070	DRC	18
Total number of grey seal *(without the Projects)*			**413.4**
			217
Percentage of wider reference population *(without the Project)*			**3.11%**
			1.63%
Magnitude of cumulative effect *(without the Project)*			**Low**
			Low

Harbour seal

11.807 **Table** 11.87 provides a quantified assessment of cumulative disturbance to harbour seal due to piling overlap with other OWFs, utilising project-specific data from PEIRs and ESs for other OWFs as outlined in **Appendix 11.2** and results in a negligible magnitude.

Table 11.87 Quantified CEA for the potential disturbance at a single point in time of harbour seal during single piling event at the OWF projects which could be piling at the same time as the Project

Harbour seal			
Project	**Harbour seal density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed at a single point in time during single piling**
The Project	0.22	1963.5	0.22
Awel y Môr*	0.22	n/a	0.22
Mona	1	DRC	1
Morgan Generation Assets	1	DRC	1
Morgan and Morecambe Transmission Assets[17]	1	DRC	1
Total number of harbour seal			**3.44**
(without the Project)			***3.22***
Percentage of wider reference population			**0.30%**
(without the Project)			***0.28%***
Magnitude of cumulative effect			**Negligible**
(without the Project)			***Negligible***

*This project did not assess harbour seal. However, due to the proximity to the Project, the same values as the Project have been applied as a precautionary measure at a single point in time

Cumulative Effect Significance – Quantified Assessment only

11.808 A large number of animals could be at risk of potential disturbance, although the assessment does not consider the unlikelihood of all activities occurring simultaneously, nor the distances to the piling activities. Factors such as project schedules, technical and mechanical issues, port calls, and varying weather conditions affecting vessels and equipment contribute to this. All marine mammal species have a sensitivity of **medium** as a result of disturbance from underwater noise.

11.809 The quantitative impact assessment for disturbance to harbour porpoise and bottlenose dolphin from piling activities at OWFs, including the Project was **major adverse** (significant in EIA terms).

11.810 The quantitative impact assessment for disturbance to Risso's and common dolphin, minke whale and both seal species from piling activities at OWFs, including the Project was **minor adverse** (not significant in EIA terms).

11.811 As a result of the quantified assessment, applied assumptions and potentially inflated numbers of animals, particularly for common and Risso's dolphin, the overall impact assessment may be conservative, and any interpretations made need to have these caveats in mind. Furthermore, none of the projects

included any mitigation measures such as noise abatement in their assessments which have the potential to reduce the number of individuals at risk.

11.812 As a consequence of the potential significant effects identified, population modelling was used, which incorporates detailed demographic information and an understanding of the relationship between days of disturbance and individual survival and reproductive rates (Sinclair *et al*., 2023). This method is considered the most appropriate for assessing potential cumulative disturbance and its population consequences for harbour porpoise, bottlenose dolphin, minke whale, grey seal and harbour seal, and is presented below.

11.813 As previously outlined, there are numerous caveats to consider when qualitatively assessing the effects of piling from multiple projects. For instance, all included projects were assigned their worst-case disturbance numbers, while for others, no data was available, and a generic assessment approach was used.

Population modelling for cumulative disturbance from OWF projects

11.814 To show if the results indicated a significantly disturbed population, the decline is considered, and a threshold of a 1% annual population decline per year, compared to the modelled unimpacted reference populationis used in this determination. It should also be noted that the results of the population modelling show the significance of a population level of effect, rather than a magnitude.

11.815 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[17]: 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

11.816 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).

11.817 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%.

11.818 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 11.88**).

11.819 For harbour porpoise, iPCoD modelling resulted in no significant effect on the population (**Table 11.88**). Whether the mean or median value is used to inform the results, the results show a less than 1% average annual decline over the first six years and over the 25 year period for both the mean and median. Therefore, disturbance from cumulative underwater noise from piling is assessed as **minor adverse** which is **not significant in EIA terms**. There would be no significant effect on the harbour porpoise population due to cumulative effects of piling.

Table 11.88 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 2051 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	Mean impacted as % of un-impacted	Un-impacted population median	Impacted population median	Median impacted as % of un-impacted
Start	62,516	62,516	100.00%	62,516	62,516	100.00%
End 2027	62,574	62,569	99.99%	62,730	62,721	100.00%
End 2028	62,509	62,278	99.63%	62,837	62,508	99.78%
End 2031	62,389	61,703	98.91%	62,426	61,650	99.22%
End 2036	62,482	61,818	98.95%	62,299	61,505	99.26%
End 2046	62,436	61,770	98.95%	61,605	60,900	99.27%
End 2051	62,564	61,897	98.95%	61,739	61,130	99.26%

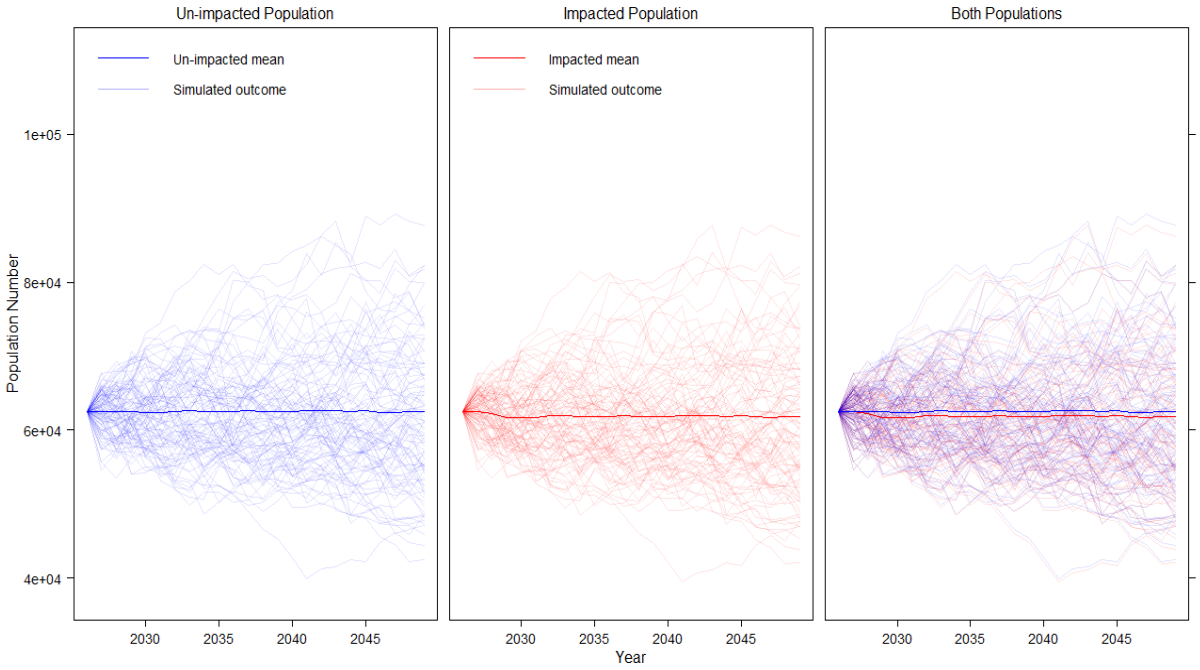

Plate 11.10 Simulated worst-case harbour porpoise population sizes for both the un-impacted and the impacted populations for the cumulative assessment (scientific notation used in these charts, e.g. 4e+04 = 40,000)

Bottlenose dolphin

11.820 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 11.89** and **Plate 11.11**).

11.821 For bottlenose dolphin, iPCoD modelling resulted in no significant effect on the population (**Table 11.89**). Whether the mean or median value is used to inform the results, the results show a less than 1% average annual decline over the first six years and over the 25 year period for both the mean and median. Hence, disturbance from cumulative underwater noise from piling is assessed as **minor adverse** and **not significant in EIA terms**. There would be no significant effect on the bottlenose dolphin population due to cumulative effects of piling.

Table 11.89 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 2051 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	Mean impacted as % of un-impacted	Un-impacted population median	Impacted population median	Median impacted as % of un-impacted
Start	296	296	100.00%	296	296	100.00%
End 2027	295	289	98.13%	296	292	100.00%
End 2028	292	281	96.14%	294	284	98.61%
End 2031	286	271	94.85%	288	272	97.71%
End 2036	277	264	95.64%	276	262	97.87%
End 2046	261	249	95.32%	260	245	97.80%
End 2051	254	242	95.27%	250	236	97.97%

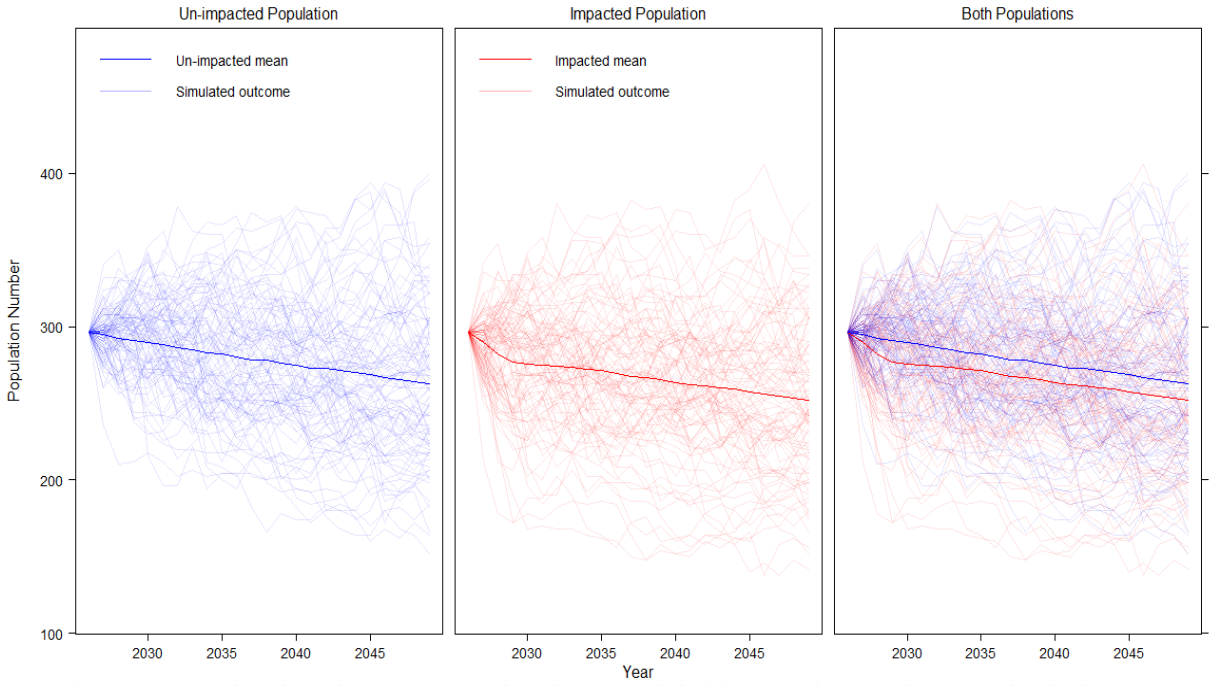

Plate 11.11 Simulated worst-case bottlenose dolphin population sizes for both the un-impacted and the impacted populations for the cumulative assessment

Minke whale

11.822 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 11.90** and **Plate 11.12**).

11.823 For minke whale, iPCoD modelling resulted in no significant effect on the population (**Table 11.90).** Whether the mean or median value is used to inform the results, the results show a less than 1% average annual decline over the first six years and over the 25 year period for both the mean and median. Hence, disturbance from cumulative underwater noise from piling is assessed as **minor adverse** and **not significant in EIA terms**. There would be no significant effect on the minke whale population due to cumulative effects of piling.

Table 11.90 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 2051 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	Mean impacted as % of un-impacted	Un-impacted population median	Impacted population median	Median impacted as % of un-impacted
Start	20,118	20,118	100.00%	20,118	20,118	100.00%
End 2027	20,125	20,123	99.99%	20,293	20,289	100.00%
End 2028	20,185	20,140	99.78%	20,378	20,348	99.87%
End 2031	20,226	19,885	98.31%	20,406	20,129	98.75%
End 2036	20,270	19,691	97.13%	20,451	19,834	97.63%
End 2046	20,472	19,724	96.33%	20,513	19,746	96.88%
End 2051	20,525	19,757	96.25%	20,355	19,707	96.80%

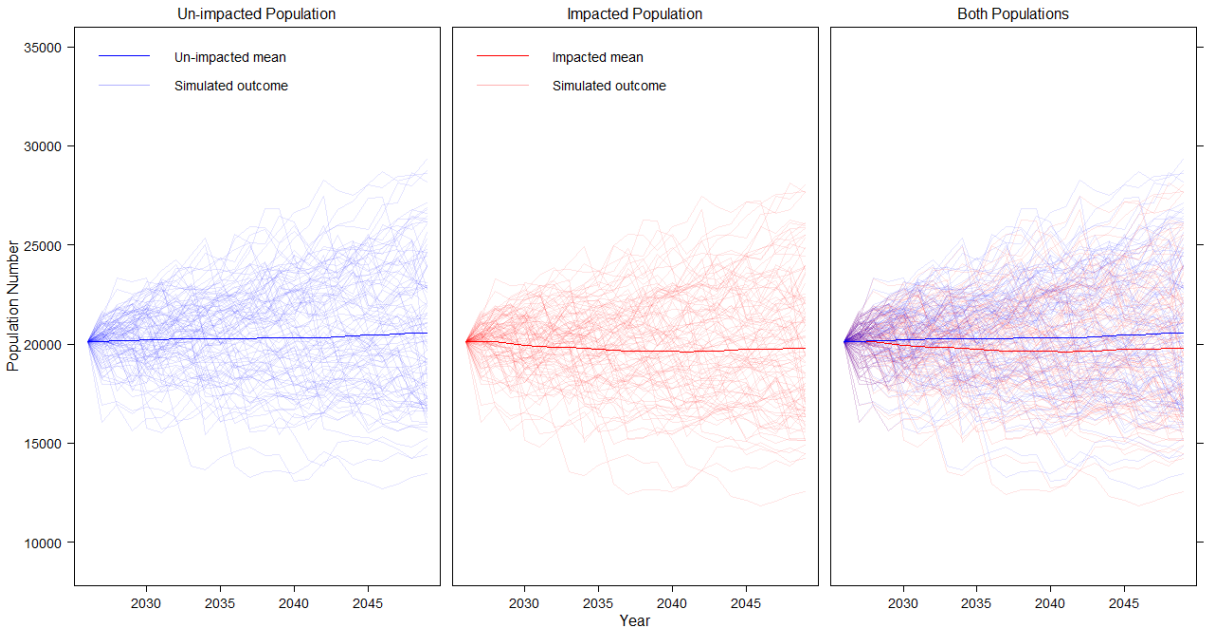

Plate 11.12 Simulated worst-case minke whale population sizes for both the un-impacted and the impacted populations for the cumulative assessment

Grey seal

11.824 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 11.91** and **Plate 11.13**).

11.825 For grey seal, iPCoD modelling resulted in no significant effect on the wider reference population (**Table 11.91**) nor on the smaller 'combined' population (NW England and IoM MU; see **Section 11.5.9**) (**Table 11.92)**. Whether the mean or median value is used to inform the results, the results show a less than 1% average annual decline over the first six years and over the 25 year period for both the mean and median. Hence, disturbance from cumulative underwater noise from piling is assessed as a **minor adverse** effect which is **not significant in EIA terms**. There would be no significant effect on the grey seal population due to cumulative effects of piling.

*Table 11.91 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 2051 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	Mean impacted as % of un-impacted	Un-impacted population median	Impacted population median	Median impacted as % of un-impacted
Start	13,288	13,288	100.00%	13,288	13,288	100.00%
End 2027	13,393	13,393	100.00%	13,458	13,458	100.00%
End 2028	13,473	13,475	100.02%	13,547	13,548	100.01%
End 2031	13,727	13,732	100.04%	13,759	13,767	100.04%
End 2036	14,192	14,197	100.04%	14,148	14,154	100.04%
End 2046	15,049	15,054	100.04%	14,984	14,986	100.03%
End 2051	15,557	15,563	100.03%	15,450	15,448	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

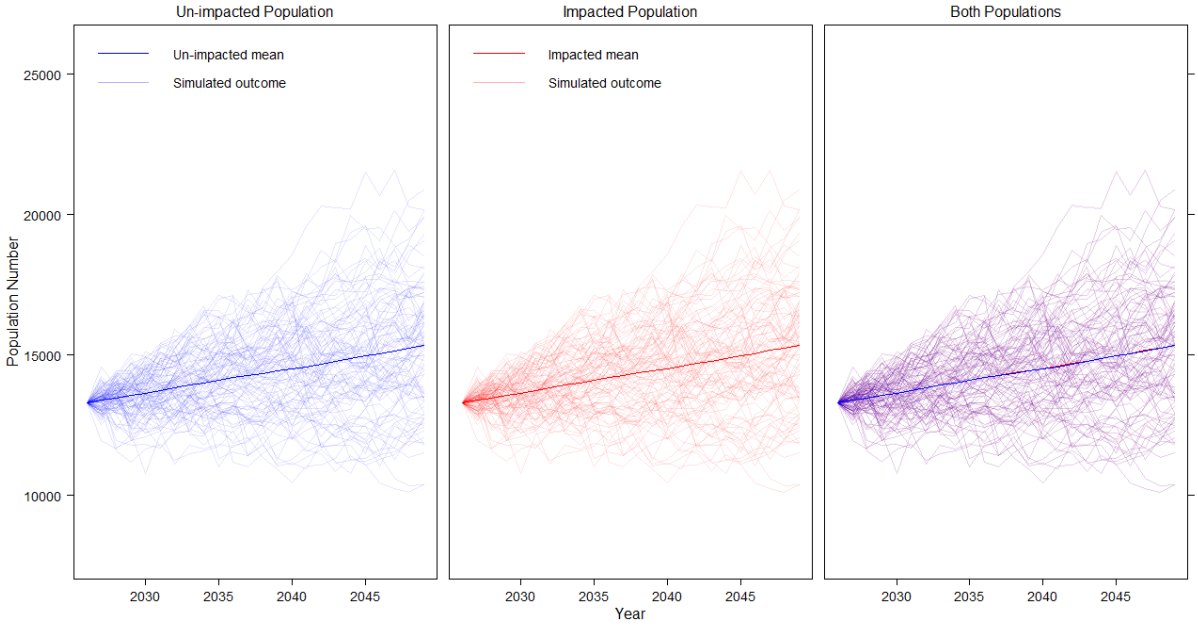

Plate 11.13 Simulated worst-case grey seal population sizes for both the un-impacted and the impacted populations for the cumulative assessment of the wider reference population.

11.826 In addition to the wider reference population, the model was also run for the smaller 'combined population' for which the iPCoD model predicted no discernible effect (**Table 11.92** and **Plate 11.14**).

*Table 11.92 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 2051 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	Mean impacted as % of un-impacted	Un-impacted population median	Impacted population median	Median impacted as % of un-impacted
Start	1,592	1,592	100.00%	1,592	1,592	100.00%
End 2027	1,603	1,603	100.00%	1,608	1,608	100.00%
End 2028	1,612	1,611	99.98%	1,616	1,616	100.00%
End 2031	1,645	1,642	99.82%	1,654	1,652	99.88%
End 2036	1,711	1,708	99.78%	1,708	1,706	99.86%
End 2046	1,834	1,830	99.77%	1,826	1,822	99.96%
End 2051	1,896	1,892	99.78%	1,872	1,870	100.00%

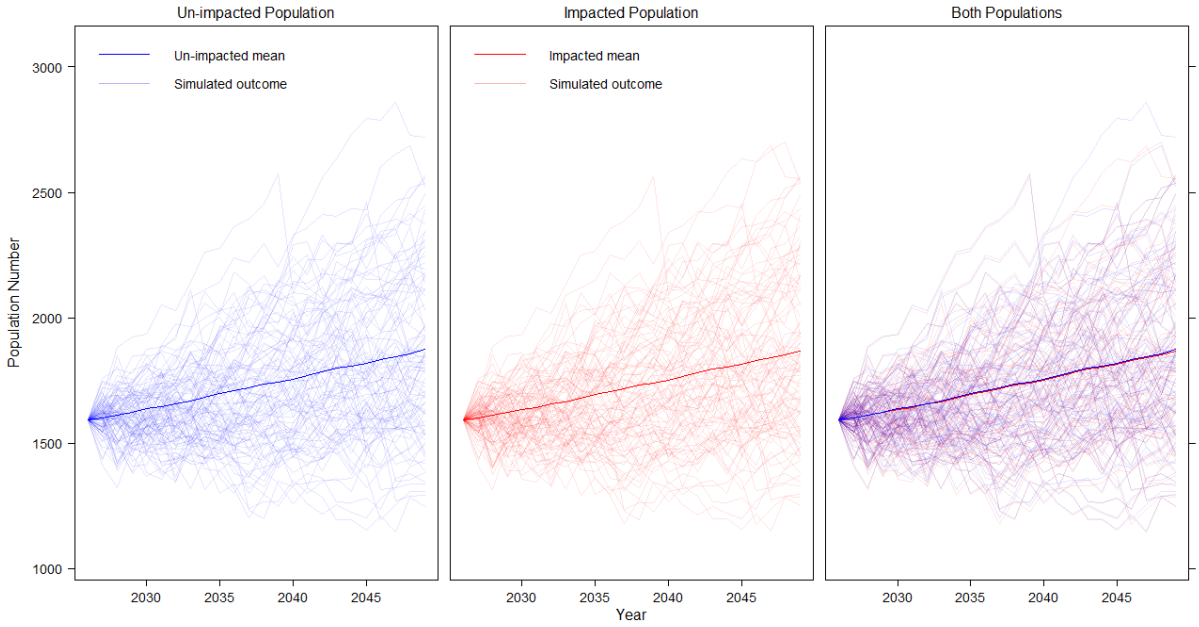

Plate 11.14 Simulated worst-case grey seal population sizes for both the un-impacted and the impacted populations for the cumulative assessment

Harbour seal

11.827 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 11.93** and **Plate 11.15**).

11.828 For harbour seal, iPCoD modelling resulted in no significant effect on the NW England and NI MU population (**Table 11.93**) nor on the NW England MU (**Table 11.94**). Whether the mean or median value is used to inform the results, the results show a less than 1% average annual decline over the first six years and over the 25 year period for both the mean and median. Hence, disturbance from cumulative underwater noise from piling is assessed as **minor adverse**, which is **not significant in EIA terms**. There would be no significant effect on the harbour seal population due to cumulative effects of piling.

Table 11.93 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 2051 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	Mean impacted as % of un-impacted	Un-impacted population median	Impacted population median	Median impacted as % of un-impacted
Start	1,412	1,412	100.00%	1,412	1,412	100.00%
End 2027	1,415	1,415	100.00%	1,418	1,418	100.00%
End 2028	1,413	1,413	100.00%	1,414	1,414	100.00%
End 2031	1,416	1,416	100.00%	1,416	1,416	100.00%
End 2036	1,420	1,420	100.00%	1,414	1,414	100.00%
End 2046	1,430	1,430	100.00%	1,420	1,420	100.00%
End 2051	1,436	1,436	100.00%	1,420	1,420	100.00%

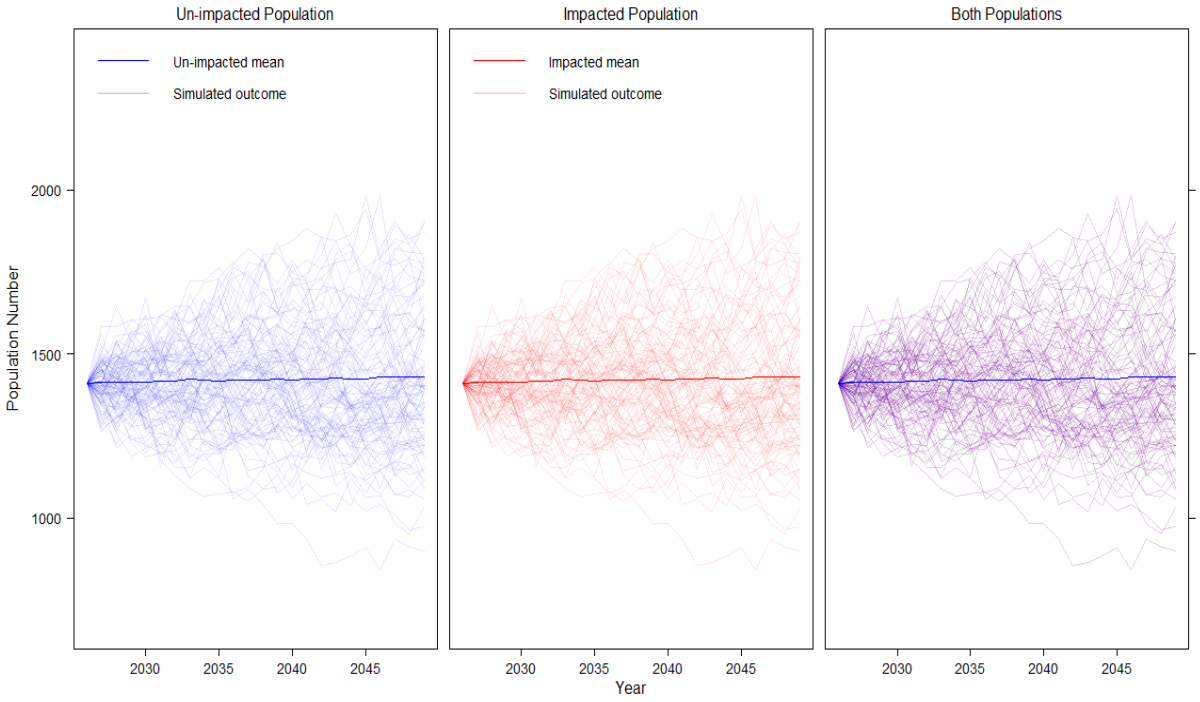

Plate 11.15 Simulated worst-case harbour seal population sizes for both the un-impacted and the impacted populations for the cumulative assessment

11.829 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 11.94**).

11.830 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 11.94 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 2051 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	Mean impacted as % of un-impacted	Un-impacted population median	Impacted population median	Median impacted as % of un-impacted
Start	4	4	100.00%	4	4	100.00%
End 2027	3	3	100.00%	4	4	100.00%
End 2028	3	3	100.00%	4	4	100.00%
End 2031	3	3	100.00%	4	4	100.00%
End 2036	3	3	100.00%	2	2	100.00%
End 2046	3	3	100.00%	0	0	100.00%
End 2051	3	3	100.00%	0	0	100.00%

Summary of cumulative population level consequences due to disturbance

11.831 For all species assessed, the modelled impact of piling at the Project and other OWFs fell below the threshold of a 1% annual decline in population which was considered insignificant. The population consequences of disturbance were therefore assessed as **not significant** (in EIA terms) for all species. This assessment considers repeated disturbance of piling events of a number of projects over a three year period (as based on the full piling schedues for all cumulative project) and reflects the effect to the population over the long term.

Cumulative Effect 2a) Significance of Effect

11.832 As outlined above, the population modelling does not result in a magnitude *per se*, but the result itself is an effect significance.

11.833 The result presented in the quantified disturbance assessment highlighted that there are potential significant effects to the harbour porpoise and bottlenose dolphin, populations. As a result, population modelling was conducted for these species, as well as grey seal, harbour seal and minke whale for which the necessary modelling parameters are available.

11.834 The population modelling indicates that for all species there is no significant effect, as the average annual change over the six-year FCS period was below 1% population level change.

11.835 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).

11.836 A summary of magnitudes and resulting effect significances from all disturbance assessment methods covered in this Section are listed in **Table 11.95**.

11.837 All marine mammal species have a sensitivity of medium as a result of disturbance from underwater noise.

11.838 The quantitative impact assessment for disturbance to harbour porpoise and bottlenose dolphin from piling activities at OWFs, including the Project was **major adverse** (significant in EIA terms), while the population modelling identified a **minor adverse** effect (not significance in EIA terms).

11.839 The quantitative impact assessment for disturbance to minke whale and both seal species from piling activities at OWFs, including the Project was **minor adverse** (not significant in EIA terms), and the population modelling also identified a **minor adverse** effect (not significance in EIA terms).

11.840 For Risso's and common dolphin, the quantitative impact assessment for disturbance from piling activities at OWFs, including the Project was **minor adverse** (not significant in EIA terms)

11.841 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 given the short duration of piling activity in the Project windfarm site. The presentation of the numbers of animals disturbed at any one time is precautionary, but does not reflect the overall number of animals disturbed over time. The iPCoD modelling considers repeat disturbances over time for piling.

11.842 The quantitative assessments provide a snapshot of the number of animals disturbed and the percentage of their reference population at a single point in time, which forms the basis for determining the magnitude of effect. Although this assessment quantifies a single event, the duration of effects is also considered. Repeated disturbance events are not expected to have a sustained significant effect on the wider population.. This is shown in the results of the iPCoD modelling that considers piling disturbance over time. Considering a professional analysis of the overall evidence base, including the number of animals impacted at any one time and the duration of effects, the magnitude of the effect has been deemed appropriate and proportional to help determine the overall significance of effects.

11.843 Upon finalisation of the UWSMS in the Project pre-construction phase, an updated assessment would confirm any further mitigation measures such as primary and/or secondary noise reduction mechanisms (in consideration of latest guidance (JNCC *et al.,* 2025) and/or management measures 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 within Project piling as embedded mitigation. The Project is committed to additional mitigation to ensure that if the Project worst case was to be actualised (the high strike rate scenario with the maximum hammer energy) the potential PTS effects would be fully mitigated by using noise reduction methods such as NAS and to ensure there is no residual PTS after ADD use. Measures have been secured in the Draft MMMP and Outline UWSMS, considering both design refinement and noise reduction methods as appropriate and in in consideration of latest guidance (JNCC *et al.,* 2025).

11.844 It is considered the Project has secured sufficient measures to mitigate contribution to cumulative effects, and notes that each Round 4 Irish Sea project has also implemented mitigation at a project level through their own individual UWSMS and MMMP. As such the overall level of significance was determined to be **minor adverse** and not significant in EIA terms.

Table 11.95 Assessment of significance of effect for disturbance of all marine mammal receptors from cumulative effects of underwater noise

Marine mammal species/receptors	Impact	Sensitivity	Magnitude	Significance of effect	Additional mitigation measures proposed	Residual effect
Harbour porpoise	Quantitative assessment	Medium	High	Significant (Major adverse)	MMMP and UWSMS (**Section 11.3.3**)	Not Significant (Minor adverse)
	iPCoD modelling		*n/a*	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Bottlenose dolphin	Quantitative assessment	Medium	High	Significant (Major adverse)		Not Significant (Minor adverse)
	iPCoD modelling		*n/a*	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Common dolphin	Quantitative assessment	Medium	Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Risso's dolphin	Quantitative assessment	Medium	Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Minke whale	Quantitative assessment	Medium	Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	iPCoD modelling		*n/a*			
Grey seal	Quantitative assessment	Medium	Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	iPCoD modelling		*n/a*			
Harbour seal	Quantitative assessment	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	iPCoD modelling		*n/a*			

Cumulative effect 2b: Indicative assessment of underwater noise impacts from construction activities (other than piling) at other OWFs

11.845 All OWFs with construction dates that have the potential to overlap with the construction window for the Project have the potential for cumulative effects.

11.846 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.

11.847 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

11.848 As outlined in **Section 11.6.2**, all marine mammals were assessed as having **medium** sensitivity to disturbance from underwater noise sources.

Magnitude

11.849 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.

11.850 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.

11.851 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**).

11.852 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 at any one time (**Table 11.96**). This was considered precautionary given the limited and intermittent duration of piling activities at the Project.

Table 11.96 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 at a point in time**
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*

11.853 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 11.97**).

11.854 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.

11.855 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 11.97 Quantified CEA for the potential disturbance at a single point in time 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 (/km²)**	**Impact area (km²)**	**Maximum number of individuals potentially disturbed at a point in time**
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 *(without the Project)*			91.7 *35.5*
Percentage of IS MU *(without the Project)*			31.3% *12.1%*
Magnitude of cumulative effect *(without the Project)*			High *High*
Common dolphin			
Project	**Common dolphin density (/km²)**	**Impact area (km²)**	**Maximum number of individuals potentially disturbed at a point in time**
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 *(without the Project)*			143.4 *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 at a point in time**
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 at a point in time**
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 at a point in time**
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 *(without the Project)*			39.4
			14.5
Percentage of CGNS MU *(without the Project)*			0.2%
			0.07%
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 during single piling at a point in time**
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 *(without the Project)*			244.7
			40.5
Percentage of wider reference population *(without the Project)*			1.8%
			0.3%
Magnitude of cumulative effect *(without the Project)*			Low
			Negligible

Significance of effect

11.856 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.

11.857 Taking into account the medium receptor sensitivity of 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, **major adverse** for bottlenose dolphin, **minor adverse** for minke whale, grey seal, and the remaining dolphin species (**Table 11.97**).

11.858 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**).

11.859 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.

11.860 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 Project is committed to additional mitigation to ensure that if the Project worst case was to be actualised (the high strike rate scenario with the maximum hammer energy) the potential PTS effects would be fully mitigated by using primary and/or secondary noise reduction methods such as NAS and to ensure there is no residual PTS after ADD use (in consideration of latest guidance (JNCC *et al.,* 2025). Measures have been secured in the Draft MMMP and Outline UWSMS, considering both design refinement and noise reduction methods as appropriate.

11.861 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. 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. Still, a further qualitative assessment (below) has been undertaken to consider the disturbance effects from further projects, including those assessed in Cumulative effect 2b, and other projects where construction timelines were unknown and there remained potential for overlap.

11.862 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 2b)i: Additional assessment: Projects with unknown timelines

11.863 As outlined in **Appendix 11.4**, in addition to the four Irish projects that were selected in the first offshore wind auction (as assessed above), Arklow Bank Phase 2, Oriel, Shelmalere and Inis Ealga Marine Energy Park (IEMEP) have been screened in for further assessment where there remained potential for overlap.

11.864 The available information regarding the anticipated construction and operational dates for Shelmalere OWF and IEMEP remains high level as scoping information only. A cumulative quantitative assessment would be highly conservative, given the current circumstances of the Project being further along in its consenting process, while these projects have not yet published an ES. It is noted that is it unlikely for all the projects/activities assessed within the CEA to occur at the same time given the different stages and build out of each project.

11.865 As an additional assessment to that of Cumulative effect 2b, this section provides a qualitative assessment of the following Irish projects

- Arklow Bank Phase 2,
- Shelmalere,
- IEMEP,
- Codling Wind Park,
- Dublin Array,
- North Irish Sea Array (NISA),
- Sceirde Rocks,
- Oriel,

11.866 It is noted that the CEA is considered precautionary as it includes quantitative assessment of four Irish projects and given the timescales and different stages of these projects, it would not be realistic to expect more than four projects to be constructed at the same time. However, this assessment provides further information on the wider number of projects potentially being developed in Irish waters and includes information from projects EIAR's where available.

Magnitude

11.867 The projects included in this additional assessment are:

- **Arklow Bank Phase 2** (EIAR available) (considered for all species except harbour seal as is outside the CEA screening area).
- **Codling Wind Park** (EIAR available) (considered for all species except harbour seal as is outside the CEA screening area).
- **Dublin Array** (no EIAR available) (considered for all species except harbour seal as is outside the CEA screening area).

- **IEMEP** (no EIAR available) (considered for all species except bottlenose dolphin and harbour seal as is outside the CEA screening area).
- **North Irish Sea Array** (EIAR available) (considered for all species except harbour seal as is outside the CEA screening area).
- **Sceirde Rocks** (no EIAR available) (considered for all species except bottlenose dolphin, Risso's dolphin, grey and harbour seal as are outside the CEA screening area).
- **Shelmalere** (no EIAR available) (considered for all species except harbour seal).
- **Oriel** (EIAR available) (considered for all species except harbour seal as is outside the CEA screening area).

11.868 Consequently, all species assessed for the Project, apart from harbour seal, are considered.

11.869 Despite the uncertain status of timelines, and unrealistic chance of occurrence, this updated assessment assumes that all projects have a possible overlap in construction windows with piling at the Project and provides a qualitative analysis allowing for the variable level of detail available from each project.

11.870 To recap, overall, the significance of cumulative disturbance is considered to be at worst minor (when considering the results of the population modelling undertaken). The results from the quantitative assessment alone, as per **paragraph 11.857**) capture the effect from construction activities of four projects (but do not take into account the results of the population modelling or mitigation):

- moderate adverse for harbour porpoise and bottlenose dolphin
- minor adverse for minke whale and grey seal
- negligible adverse for the remaining dolphin species

11.871 **Arklow Bank Phase 2** - The EIAR for Arklow Bank Phase 2 OWF (SSE Renewables, 2024) included population modelling using iPCoD, covering Arklow, Codling, Dublin Array, North Irish Sea Array (NISA), and Oriel. The results showed that disturbance from piling was not significant, indicating that the predicted disturbance levels are insufficient to cause minor population level changes for any species. The iPCoD assessment found that Irish projects, including Arklow have no population impact from disturbance. The disturbance impact from piling is greater than other construction activities, thus, if those projects are undertaking less noisy construction activities there would be even less of an effect.

11.872 In the Arklow Bank Phase 2 CEA, the Project (Morecambe) was also considered as part of a quantitative assessment, together with other OWFs, two cable projects and seismic surveys. The EIAR concluded a slight adverse significance of effect from piling disturbance, which is not significant in EIA terms.

11.873 **North Irish Sea Array -** Cumulative population modelling, using iPCoD, for piling was undertaken for the NISA application (North Irish Sea Array Windfarm Ltd, 2024) for Arklow, Codling, Dublin Array, and Oriel (and NISA). The modelling concluded that there would be a short-term decrease in the bottlenose dolphin population, as some individuals could be affected during piling at cumulative projects. However, the long-term population trajectory would not be affected. Therefore, it was concluded that there would be no significant effects on bottlenose dolphin at the population level. For harbour porpoise, harbour seal and grey seal the results indicated a stable trajectory of both the impacted and un-impacted population throughout the modelling period. For common dolphin and minke whale (for which modelling was not conducted), the conclusion was a slight effect of cumulative disturbance, which is not significant in EIA terms (North Irish Sea Array, 2024).

11.874 In the NSIA CEA, the Project (Morecambe) was also considered as part of a quantitative assessment, together with NISA, Arklow, Codling, Dublin Array, and Oriel, Erebus, Awel y Mor and White Cross. iPCoD was conducted for the Irish projects. Following this, a qualitative assessment using reviews from iPCoD at other projects led to the NSIA CEA of conclusion of a slight adverse effect significance, which is not significant in EIA terms.

11.875 **Oriel** - The EIAR for Oriel (Parkwind & ESB, 2024) concluded that no estimates for affected animals from piling are available for Dublin Array, Arklow Bank, NISA and Codling, however a qualitative assessment concluded a slight adverse significance, which is not significant in EIA terms. A qualitative cumulative effect assessment was also conducted that included the Project (Morecambe) and other eastern Irish Sea projects (Morgan, Mona, Awel y Mor). It concluded that, based on the distance between Oriel and the eastern Irish Sea projects, the likelihood of any modelled disturbance range overlap would be negligible and highlighted that the proportion of the relevant populations for each project-alone assessment was relatively small. The EIAR for Oriel determined the significance of effect was deemed to be slight adverse, is not significant in EIA terms.

11.876 **Codling -** iPCoD, for piling was undertaken for the Codling application (Sinclair, 2024) in the Section *Phase 1 Irish offshore wind farms: cumulative iPCoD modelling) for NISA, Codling, Dublin Array, and Oriel (and Codling).*

The cumulative population modelling has shown no significant impacts to any marine mammal species resulting from disturbance from pile driving. The EIAR for Codling concluded that the level of disturbance predicted to occur within the Celtic and Irish Sea MU between 2023 and 2028 (including Morecambe) is expected to result in temporary changes in behaviour and / or distribution of individuals at a scale that could result in potential reductions to lifetime reproductive success to some individuals although not enough to affect the population trajectory over a generational scale. There is not expected to be any effect on the favourable conservation status and / or the long-term viability of the population.

11.877 The results of the Project CEA do not identify any significant population effects as a result of piling at the Project, Awel y Mor, Erebus, Mona, Morgan, Transmission Assets and White Cross (considered the worst-case noise source). Other construction noise is considered below noise levels from piling, and the results from the cumulative assessments presented in the EIARs for Arklow Bank, Codling, NISA and Oriel do not identify any significant effects for Irish project or when considering construction noise at the Project (Morecambe). It considered that, based on the distance between Irish projects and the eastern Irish Sea projects, the likelihood of any modelled disturbance range overlap would be negligible and the proportion of the relevant populations for each project-alone assessment is relatively small.

11.878 Based on the Project-alone assessments of auditory injury and disturbance from construction activities other than piling in **Section 11.6.3.3** and **11.6.3.4**, the impact and disturbance ranges are significantly lower than those for piling. The expected effect, from construction activities ongoing at potentially eight different Irish projects would be much more localised and confined to the immediate vicinity of the noise source. Additionally, all eight Irish projects are approximately over 200km from Morecambe OWF, with distances between each other ranging between 10-50km. Any disturbance effects are expected to be localised and would not significantly affect the marine mammal populations.

11.879 It is also noted that mitigation would be in place for the Irish projects as required through their consenting processes. This is also the case for Round 4 developers in the Irish sea who have each developed an outline UWSMS. It has also been shown in the ES for the Project, through population modelling, that no significant long terms effects result from the Project alone or cumulatively (Project piling overlapping with six projects (Awel y Mor, Erebus, Mona, Morgan, Transmission Assets, White Cross). Construction noise from the projects in Irish waters are not considered to elevate the

magnitude as assessed in the ES, and cumulative effects are limited to the 2.5-year construction period of the Project.

11.880 Considering the aforementioned information, the magnitude of impact would be temporary and limited to the Project's construction period. Consequently, the magnitude of effect would not be worse than already assessed at **Cumulative effect 2b**, which was assessed as **medium** for harbour porpoise and **high** for bottlenose dolphin, **low** for grey seal, and **negligible** for all other marine mammal species.

Significance of effect

11.881 Taking into account the medium sensitivity for all marine mammal receptors, the cumulative effect for disturbance from noise from construction activities when Project piling is ongoing, was determined as:

- major adverse (significant in EIA terms) for bottlenose dolphin;
- moderate adverse (significant in EIA terms) for harbour porpoise;
- minor adverse (not significant in EIA terms) for grey seal; and
- negligible adverse (not significant in EIA terms) for all remaining species.

11.882 Overall, while (as per **paragraph 11.857**) there is the potential for significant effects on harbour porpoise and bottlenose dolphin, population modelling identifies that there would be no long-term significant effects on the populations as a result of piling for the Project. It is also noted the methods used to determine the number of animals disturbed does not account for mitigation proposed by the projects. It is considered unrealistic to expect that eight projects in Irish waters and six (or seven, including the Project) in English waters would all be constructing at the same time. This is due to vessel availability and the different stages of the consenting process the projects are in, with some Irish projects facing uncertainty when an application would be made. It is also considered that, based on the distance between Irish projects and the eastern Irish Sea projects, the likelihood of any modelled disturbance range overlap would be negligible and the proportion of the relevant populations for each project-alone assessment was relatively small.

11.883 Considering all the information provided and the additional mitigation the Project is committed to (the MMMP and UWSMS, and deployment of noise reduction methods for the high strike rate scenario with the maximum hammer energy), an overall (at most) **minor adverse effect (not significant in EIA terms)** was concluded for the assessment of underwater noise impacts from construction activities (other than piling) at other OWFs at the same time as piling at the Project.

Cumulative effect 2c: Indicative assessment of underwater noise impacts from other industries and activities

11.884 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.

11.885 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

11.886 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

11.887 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.

11.888 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.

11.889 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[18] (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, 2023b) recommended the use of an EDR of 5km for geophysical surveys.

11.890 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).

11.891 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 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).

11.892 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 11.98** summarises the total impact area for each marine mammal species, taking into account the recommended disturbance ranges as discussed separately for each species below.

11.893 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 11.98 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)

[18] 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).

			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

11.894 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

11.895 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 11.99).

Table 11.99 Quantified CEA for the potential disturbance of harbour porpoise over the length of one geophysical survey at OWF projects at a single point in time

Harbour porpoise			
Project	**Harbour porpoise density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed at a single point in time**
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 *(without the Project)*			4,056.4
			613.9
Percentage of CIS MU *(without the Project)*			6.5%
			0.99%
Magnitude of cumulative effect *(without the Project)*			Medium
			Negligible

Dolphins and minke whale

11.896 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.

11.897 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 11.98**), resulting in an impact area of 707km^2 for marine mammals.

11.898 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 at a point in time, and **negligible** for the remaining dolphins and minke whale (**Table 11.100**).

Table 11.100 Quantified CEA for the potential disturbance of dolphins and minke whale over the length of one geophysical survey at OWF projects at a single point in time

Bottlenose dolphin			
Project	**Bottlenose dolphin density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed at a single point in time**
The Project (piling)	0.0104	DRC	56.3
Disturbance from two geophysical surveys	0.0104	707	7.4
Total number of bottlenose dolphin *(without the Project)*			63.7
			7.35
Percentage of IS MU *(without the Project)*			21.7%
			2.5%
Magnitude of cumulative effect (*without the Project*)			High
			Low
White-beaked dolphin			
Project	**White-beaked dolphin density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed at a single point in time**
The Project (piling)	0.007	DRC	17.9

Disturbance from two geophysical surveys	0.007	707	4.95
Total number of white-beaked dolphin *(without the Project)*			22.9
			5.0
Percentage of CGNS MU *(without the Project)*			0.05%
			0.01%
Magnitude of cumulative effect (*without the Project*)			Negligible
			Negligible

Common dolphin			
Project	**Common dolphin density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed at a single point in time**
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 (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed at a single point in time**
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 (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed at a single point in time**
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

11.899 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 11.98**).

11.900 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 11.101**).

Table 11.101 Quantified CEA for the potential disturbance of seals over the length of one geophysical survey at OWF projects at a single point in time

Grey seal			
Project	**Grey seal density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed at single point in time**
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 at single point in time**
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

11.901 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.

11.902 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)

11.903 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.

11.904 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.

11.905 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 11.102**).

11.906 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 11.102 Quantified CEA for the potential disturbance of harbour porpoise, delphinids, minke whale and grey seal during extraction and dredging activities at a single point in time

Harbour porpoise			
Project	**Harbour porpoise density (/km²)**	**Impact area (km²)**	**Maximum number of individuals potentially disturbed at single point in time**
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 (/km²)**	**Impact area (km²)**	**Maximum number of individuals potentially disturbed at single point in time**
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 (/km²)**	**Impact area (km²)**	**Maximum number of individuals potentially disturbed at single point in time**
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
			0.02%

Percentage of CGNS MU *(without the Project)*			*0.0001%*
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 at single point in time**
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 (/km²)**	**Impact area (km²)**	**Maximum number of individuals potentially disturbed at single point in time**
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

11.907 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.

11.908 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.

11.909 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 11.103** 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.

11.910 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 11.103 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

11.911 The potential impact area during seismic surveys, was based on a buffer of 12km, following the current JNCC disturbance guidance (JNCC, 2023b) (**Table 11.104**).

Table 11.104 Quantified CEA for the potential disturbance of harbour porpoise during the length of one seismic survey at a single point in time

Harbour porpoise			
Project	**Harbour porpoise density (/km²)**	**Impact area (km²)**	**Maximum number of individuals potentially disturbed at single point in time**
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 (*without the Project*)			4,315.1
			872.6
Percentage of CIS MU (*without the Project*)			6.9%
			1.4%
Magnitude of cumulative effect (*without the Project*)			Medium
			Low

Dolphins

11.912 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 1,518.63km² (**Table 11.105**).

Table 11.105 Quantified CEA for the potential disturbance of Dolphins during the length of a seismic survey at a single point in time

Bottlenose dolphin			
Project	**Bottlenose dolphin density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed at single point in time**
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 at single point in time**
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 at single point in time**
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 *(without the Project)*			170.1
			42.5
Percentage of CGNS MU *(without the Project)*			0.17%
			0.04%
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 at single point in time**
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 *(without the Project)*			3.31
			0.9
Percentage of CGNS MU *(without the Project)*			0.03%
			0.01%
Magnitude of cumulative effect *(without the Project)*			Negligible
			Negligible

Minke whale

11.913 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 1,349.16km^2 (**Table 11.106**).

Table 11.106 Quantified CEA for the potential disturbance of minke whale during the length of one seismic survey at a single point in time

Minke whale			
Project	**Minke whale density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed at single point in time**
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 (*without the Project*)			36.8
			11.9
Percentage of CGNS MU (*without the Project*)			0.2%
			0.06%
Magnitude of cumulative effect (*without the Project*)			Negligible
			Negligible

Seals

11.914 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.

11.915 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 11.107**).

Table 11.107 Quantified CEA for the potential disturbance of grey seal and harbour seal during the length of one seismic survey at a single point in time

Grey seal			
Project	**Grey seal density (/km²)**	**Impact area (km²)**	**Maximum number of individuals potentially disturbed at single point in time**
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 at single point in time**
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*

11.916 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

11.917 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.

11.918 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.

11.919 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.

11.920 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.

11.921 The magnitude of the potential disturbance from UXO clearance has been estimated based on the following:

Harbour porpoise

11.922 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 11.108**).

Table 11.108 Quantified CEA for the potential disturbance of harbour porpoise at a single point in time during UXO clearance at OWF projects

Harbour porpoise			
Project	**Harbour porpoise density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed at single point in time**
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

11.923 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 (3.8km^2) for high-order clearance, and 0.13km (0.053km^2) 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.

11.924 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 (24,884.56km^2) for high-order clearance, and 4.5km (63.62km^2) for low-order clearance.

11.925 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 (804.25km^2) for high-order clearance, and 0.8km (2.01km^2) for low-order clearance (**Table 11.109**).

Table 11.109 Quantified CEA for the potential disturbance of delphinids at a single point in time during UXO clearance at OWF projects

Bottlenose dolphin			
Project	**Bottlenose dolphin density (/km²)**	**Impact area (km²)**	**Maximum number of individuals potentially disturbed at single point in time**
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 *(without the Project)*			57.9 *1.6*
Percentage of IS MU *(without the Project)*			25.9% *0.6%*
Magnitude of cumulative effect *(without the Project)*			High *Negligible*
White-beaked dolphin			
Project	**White-beaked dolphin density (/km²)**	**Impact area (km²)**	**Maximum number of individuals potentially disturbed at single point in time**
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 *(without the Project)*			19 *1.1*
Percentage of CGNS MU *(without the Project)*			0.04% *0.003%*
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 at**

			single point in time
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 *(without the Project)*			132
			4.4
Percentage of CGNS MU *(without the Project)*			0.13%
			0.004%
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 at single point in time**
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 *(without the Project)*			2.5
			0.09
Percentage of CGNS MU *(without the Project)*			0.02%
			0.001%
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 at single point in time**
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
			244.43

Total number of minke whale *(without the Project)*	*219.54*
Percentage of CGNS MU *(without the Project)*	1.21%
	1.09%
Magnitude of cumulative effect *(without the Project)*	Low
	Low

Grey seal			
Project	**Grey seal density (/km^2)**	**Impact area (km^2)**	**Maximum number of individuals potentially disturbed at single point in time**
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 *(without the Project)*			318.90
			122.55
Percentage of wider reference population *(without the Project)*			2.4%
			0.9%
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 at single point in time**
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			0.31
(without the Project)			*0.097*
Percentage of wider reference population			0.03%
(without the Project)			*0.008%*
Magnitude of cumulative effect			Negligible
(without the Project)			*Negligible*

11.926 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, 2025).

11.927 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.

11.928 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)

11.929 **Table 11.110** lists all noisy activities that could coincide with piling at the Project, including piling and construction activities at other OWFs, as well as

any other potential noisy activities. It should be noted that other noisy activities such as geophysical surveys, seismic surveys, aggregate extraction, dredging and UXO clearance are indicative as it is difficult to know when these projects/activities may occur. Impacts of these activities would need to be licensed separately, taking account of the Project's consented activities in their licence applications (as highlighted in **Appendix 11.4).**

11.930 Therefore, taking this indicative approach determines the associated potential magnitude of cumulative effect of the listed noisy activities should they all occur at the same time

11.931 **Table 11.110** presents the magnitude of the potential for cumulative disturbance taking account of all of the piling and other OWF construction activities as well as other noisy activities (i.e. seismic, geophysical, UXO clearance and aggregates and dredging) indicatively.

11.932 **Table 11.111** presents the same assessment as **Table 11.110** but uses the population modelling results to showcase the difference in magnitudes and effect significances, compared to those in **Table 11.110**. Only those species for which population modelling was conducted are presented in **Table 11.111**.

Table 11.110 Quantitative assessment for all overlapping piling and construction at other OWFs, as well as other industry noisy activities with the potential for cumulative disturbance effects for marine mammals, based on data from other Projects' published PEIRs and ESs only (activities in grey are indicative only; no formal application has been made) (magnitude levels based on the percentage of the reference population affected, as set out in Table 11.10). The numbers presented represent a single point in time.

Impact	Number of individuals (based on published PEIRs and ESs only)							
	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
Piling at other OWFs	9,233.8	51.0	0.0	2,387.0	333.0	252.0	226.5	3.66
Construction activities at other OWFs (excluding piling)	146.7	35.5	2.4	15.8	0.5	14.5	40.5	0.0
Geophysical surveys	613.9	7.4	5.0	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	**15,439.5**	**167.6**	**37.0**	**2,599.0**	**339.7**	**529.0**	**1,056.1**	**4.3**
(without indicative activities)	*12,818.9*	*142.8*	*20.3*	*2,532.3*	*336.0*	*291.4*	*463.6*	*3.86*
Percentage of MU	**24.7%**	**57.2%**	**0.08%**	**2.5%**	**2.8%**	**2.6%**	**7.9%**	**0.4%**
(without indicative activities)	*20.5%*	*48.7%*	*0.05%*	*2.4%*	*2.7%*	*1.5%*	*3.5%*	*0.3%*

Impact	Number of individuals (based on published PEIRs and ESs only)							
	Harbour porpoise	Bottlenose dolphin	White-beaked dolphin	Common dolphin	Risso's dolphin	Minke whale	Grey seal	Harbour seal
Magnitude of cumulative effect	**High**	**High**	**Negligible**	**Low**	**Low**	**Low**	**Medium**	**Negligible**
(without indicative activities)	*High*	*High*	*Negligible*	*Low*	*Low*	*Low*	*Low*	*Negligible*

*Table 11.111 Illustrative assessment for all overlapping piling and construction activities at other OWFs, as well as other industry noisy activities with the potential for cumulative disturbance effects for harbour porpoise, bottlenose dolphin, minke whale and seals based on population modelling results (activities in grey are indicative only; no formal application has been made) (magnitude levels based on the percentage of the reference population affected, as set out in as set out in **Table 11.10**). The numbers presented represent a single point in time*

Impact	Number of individuals (based on population modelling results for piling)				
	Harbour porpoise	Bottlenose dolphin	Minke whale	Grey seal	Harbour seal
Worst-case disturbance from the Project (piling) and piling at other projects*	<1% reduction in population**	<1% reduction in population**	<1% reduction in population**	0% change in population**	0% change in population**
Construction activities at other OWFs (excluding piling)	146.7	35.5	14.5	40.5	0.0
Geophysical surveys	*613.9*	*7.4*	*6.2*	*64.5*	*0.05*
Aggregate extraction and dredging	0.035	-	0.02	0.2	-
Seismic surveys	*872.6*	*15.8*	*11.9*	*405.4*	*0.3*
UXO clearance	*1,134.2*	*1.6*	*219.5*	*122.6*	*0.097*
Total number of individuals	**2,767.4**	**60.3**	**252.1**	**633.2**	**0.5**
(without indicative activities)	*146.7*	*35.5*	*14.5*	*40.7*	*0*
Percentage of MU	**4.4%**	**20.6%**	**1.3%**	**4.8%**	**0.04%**
(without indicative activities)	*0.2%*	*12.1%*	*0.07%*	*0.3%*	*0%*
Magnitude of cumulative effect	**Low**	**High**	**Low**	**Low**	**Negligible**
(without indicative activities)	*Negligible*	*High*	*Negligible*	*Negligible*	*Negligible*

Worst-case disturbance has been presented as the average annual decline over the first six years and over the 25 year period taken from the tables and figures in **Section 11.7.3.2, Cumulative effect 2a, **paragraph 11.81411.791**.*
***The percentages were not added to the calculations and are for illustrative purposes only as no value was assigned to it.*

2c: Significance of effect

11.933 The significance of effect for these noisy activities (based both on data from other projects' published PEIRs and ESs and on population modelling results) has then been evaluated and includes all disturbance assessments provided in the cumulative effects assessment.

11.934 **Table 11.110** and **Table 11.111** both include an assessment of magnitudes, if the indicative activities (geophysical and seismic surveys, and UXO clearance) are removed from the overall assessment. These activities are included on a worst-case and precautionary approach, however, none are currently consented or applied for, and therefore their inclusion represents a currently unrealistic future prediction of activities.

11.935 Based on the assessment using other projects' published PEIRs and ESs (**Table 11.110**) the results of the CEA for disturbance from all noisy activities including piling are **major adverse** for harbour porpoise and bottlenose dolphin and **moderate adverse** for grey seal (which are significant in EIA terms). However, for all three species, a large proportion of the individuals potentially disturbed would be from piling at both the Project and other OWFs without any mitigation or noise reduction applied. If these were to be removed from the assessments, the resultant significance would be reduced to **minor adverse** for dolphin species, minke whale, harbour seal and grey seal (**Table 11.110**).

11.936 The resultant magnitudes (taking into account all other activities except piling) indicate that the significance of effect would be **major adverse** for bottlenose dolphin, and all other species were assessed as having a **minor adverse significance** (not significant in EIA terms).However, another factor to take into account is that not all activities are likely to occur at the same time, and this level of significance of effect does not include any mitigation.

11.937 The quantitative assessments provide a snapshot of the number of animals disturbed and the percentage of their reference population at a single point in time, which forms the basis for determining the magnitude of effect. Although this assessment quantifies a single event, the duration of effects is also considered. Repeated disturbance events are not expected to have a sustained significant effect on the wider population, as the effects of disturbance are not permanent and are recoverable over time. This is shown in the results of the iPCoD modelling that considers piling disturbance over time.

11.938 Taking into account the population modelling results, because the iPCoD takes the worst case numbers for disturbance and permanent auditory injury along with detailed demographic information and an understanding of the relationship between days of disturbance and individual survival and reproductive rates (Sinclair *et al*., 2023), it is deemed as the most

representative method. Considering a professional analysis of the overall evidence base, including the number of animals impacted at any one time and the duration of effects, in addition to the indicative nature of some activities, and that it is unlikely that all activities would take place at the same time, the overall effect significance for all species would be **minor adverse** (not significant in EIA terms).

11.939 Further, while commitment to specific additional mitigation is yet to be fully confirmed for other all projects, it is noted the Project has committed to additional mitigation to ensure that if the Project worst case was to be actualised (the high strike rate scenario with the maximum hammer energy) the potential PTS effects would be fully mitigated and disturbance reduced by using noise reduction methods such as NAS and to ensure there is no residual PTS after ADD use. Measures have been secured in the Draft MMMP and Outline UWSMS, considering both design refinement and noise reduction methods as appropriate; these can be used as a mechanism to secure further potential measures when details for the other cumulative projects have been further developed. This approach of securing a Strategy to mitigate underwater noise impacts is in line with the other Irish Sea Round 4 projects and in consideration of latest guidance (JNCC *et al.,* 2025).

11.940 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.

Significance of effect - Cumulative effect 2

11.941 As it has been highlighted throughout the Section **Cumulative effect 2**, some projects and activities included in the cumulative disturbance assessment are based on speculative assessments, as there are no current licenses or pending applications to confirm timing or details. However, the likelihood of these activities occurring and overlapping with Project piling is low. For example, there are no current licences or licence applications for seismic surveys, so they have been included for informational purposes only. It is very unlikely that all activities would occur on the same day or in the same season, making this assessment an over-precautionary and worst-

case estimate of the marine mammals potentially at risk of disturbance during the 2.5 years of scheduled construction of the Project.

11.942 The result presented in the quantified disturbance assessment highlighted that there are potential significant effects to the harbour porpoise and bottlenose dolphin populations (**Cumulative effect 2a**). As a result, population modelling was conducted for these species, as well as minke whale for which the necessary modelling parameters are available.

11.943 A summary of magnitudes and resulting effect significances from both the overall quantitative disturbance assessment, and from the overall assessment taking into account the population modelling results for piling (**Table 11.112**).

11.944 For the quantitative impact assessment for disturbance to harbour porpoise and bottlenose dolphin, including indicative activity assessment, the overall effect was **major adverse** (significant in EIA terms) and **moderate adverse** (significant in EIA terms) for grey seal , while the overall assessment (with reference to population modelling) identified no change for bottlenose dolphin but a **minor adverse** effect (not significance in EIA terms) for harbour porpoise and grey seal (**Table 11.112**).

11.945 For the quantitative impact assessment for disturbance to minke whale and harbour seal, including indicative activity assessment, the overall effect significance including the Project was **minor adverse** (not significant in EIA terms), and the overall assessment (with the reference to population modelling) remained a **minor adverse** effect (not significance in EIA terms). For the quantitative impact assessment for disturbance to Risso's, common and white-beaked dolphin, including indicative activity assessment, the overall effect including the Project was **minor adverse** (not significant in EIA terms).

11.946 If all OWFs included in the CEA were undertaking piling or construction activities at the same time as the Project piling, the magnitude of impact could range from high to negligible, depending on the species. However, as noted at the start of the CEA, due to a lack of methodologies for assessing repeated and additive disturbances, the reported numbers of animals disturbed present only a snapshot in time. In reality, it is highly unlikely that all OWFs would carry out piling or construction activities at exactly the same time due to the short duration of piling activity at the Project windfarm site. More realistically, noisy activities would occur intermittently over time and the magnitude of effects does factor in the duration of activities.

11.947 Although population modelling provides assessment of the potential additive effects of piling over time, it does not account for other noise sources that animals may be exposed to in the wider MU or screening area. Currently, it is not possible to quantify these effects. Further, the assessment considers

a qualitative evaluation of how repeated and additive disturbances contribute to the overall stressor load experienced by marine mammals. Considering a professional analysis of the overall evidence base, the magnitude of the effect has been deemed appropriate and proportional to help determine the overall significance of effects, and it is not expected that the effects would have a sustained significant effect on the wider population. Disturbance effects are not considered to be permanent and are recoverable over time. However, recoverability may reduce with repeated exposure to disturbance events, particularly when the duration between events is short.It is important to note that animals may incur some energetic cost during this period (e.g. Williams *et al*., 2006; Hastie *et al*., 2021; Frankish *et al.,* 2023)

11.948 Upon finalisation of the UWSMS in the Project pre-construction phase, an updated assessment would secure any further mitigation measures such as NAS and/or management measures that 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 within Project piling as embedded mitigation. The Project is committed to additional mitigation to ensure that if the Project worst case was to be actualised (the high strike rate scenario with the maximum hammer energy) the potential PTS effects would be fully mitigated by using noise reduction methods such as Noise Abatement Systems (NAS). Measures have been secured in the Draft MMMP and Outline UWSMS, considering both design refinement and noise reduction methods as appropriate (**Section 11.3.3**) and in consideration of latest guidance (JNCC *et al.,* 2025).

11.949 Overall, considering all sources of disturbance a **minor adverse** effect is identified, which is not significant in EIA terms.

Table 11.112 Assessment of effect significance for the potential of a cumulative disturbance effect due to other noisy projects and activities[19]

Marine mammal species/receptor	Assessment approach	Sensitivity	Magnitude	Significance of effect	Additional mitigation measures proposed	Residual effect
Harbour porpoise	based on information in **Table 11.110**	Medium	High	Significant (Major adverse)	MMMP and UWSMS (**Section 11.3.3**)	Not Significant (Minor adverse)
	based on information in **Table 11.111**		Low	Not significant (Minor adverse)		
Bottlenose dolphin	based on information in **Table 11.110**		High	Significant (Major adverse)		Not Significant (Minor adverse)
	based on information in **Table 11.111**Error! Not a v alid result for table.		High	Significant (Major adverse)		
Risso's dolphin	based on information in **Table 11.110**		Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	based on information in **Table 11.111**		*n/a*	*n/a*		
Common dolphin	based on information in **Table 11.110**		Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	based on information in **Table 11.111**		*n/a*	*n/a*		
White-beaked dolphin	based on information in **Table 11.110**		Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)

[19] The table reflects the assessments of concurrent piling at multiple projects alongside piling at the Project.

Marine mammal species/receptor	Assessment approach	Sensitivity	Magnitude	Significance of effect	Additional mitigation measures proposed	Residual effect
	based on information in **Table 11.111**		*n/a*	*n/a*		
Minke Whale	based on information in **Table 11.110**		Low	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	based on information in **Table 11.111**		Low	Not Significant (Minor adverse)		
Grey seal	based on information in **Table 11.110**		Medium	Significant (Moderate adverse)		Not Significant (Minor adverse)
	based on information in **Table 11.111**		Low	Not Significant (Minor adverse)		
Harbour seal	based on information in **Table 11.110**		Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	based on information in **Table 11.111**		Negligible	Not Significant (Minor adverse)		

Cumulative effect 3: Barrier effects

Cumulative effect 3a: Barrier effects from underwater noise

11.950 The sensitivity of marine mammals with regard to barrier effect due to underwater noise was medium for all marine mammal species.

11.951 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**).

11.952 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.

11.953 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.

11.954 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.

11.955 No additional mitigation was identified to be required for the potential for cumulative barrier effects from underwater noise impacts.

Cumulative effect 3b: Physical barrier effects

11.956 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.

11.957 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.

11.958 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.

11.959 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.

11.960 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.

11.961 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).

11.962 No additional mitigation has been identified to be required for the potential for cumulative physical barrier effects.

Cumulative effect 4: Underwater noise and increased collision risk with vessels

Collision risk

11.963 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.

11.964 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**).

11.965 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.

11.966 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.

11.967 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; see **paragraph 11.988** below for details).

11.968 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.

11.969 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.

11.970 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.

11.971 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.

11.972 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.

Vessel disturbance from underwater noise

11.973 It is difficult to quantify the level of increased disturbance to marine mammals resulting from increased vessel activity on a cumulative basis, given the large degree of temporal and spatial variation in vessel movements between projects and regions, coupled with the spatial and temporal variation in marine mammal movements across the region.

11.974 However, vessel routes to and from offshore windfarms and other offshore projects will, for the majority of time, use existing vessel routes for pre-existing vessel traffic which marine mammals will be accustomed to. They may also have become habituated to the volume of regular vessel movements and therefore the additional risk is predominantly confined to the array area. The vessel movements for OWFs are likely to be limited and slow, resulting in less risk of disturbance to marine mammal receptors. In addition, projects are required to adopt measures to minimise any potential effects on marine mammals, as this is considered standard mitigation across the offshore wind industry.

11.975 Of all the screened-in projects with construction and operational phases overlapping with the Project, **Table 11.113** presents the number of vessels at any one time and vessel trips for Nationally Significant Infrastructure Projects (NSIPs) in the vicinity of the Project. The distances to all but one operational offshore renewable energy project (Morlais) are between 287 and 546km away from the Project and also outside the grey seal, harbour seal and bottlenose dolphin screening area. These projects would have additional shipping effects across the wider Irish Sea but it would be unlikely that impacts would interact or that marine mammal species would be affected by vessel disturbance across the wider MU and/or screening areas in such a way that it would significantly impact the relevant population as a whole (although it is acknowledged that animals could be disturbed within the MU). Furthermore, there was no project-specific vessel data available for Flowatt Tidal, Saint-Brieuc, and Twin-Hub to undertake meaningful assessment.

11.976 The projects listed in **Table 11.113** are located in relatively close proximity (<100km) to the Project and therefore this could lead to higher and more concentrated levels of traffic within the Liverpool Bay region. Vessel movements and other activities will be largely confined to the array areas and/or offshore cable corridor and vessel routes are likely to follow existing

shipping routes to and from port. Outside of 100km from the Project, effects would be dispersed and localised.

Table 11.113 Summary of number of construction / operation and maintenance vessels for the screened-in projects (<100km distance from the Project) that are overlapping with Project construction

Project	Phase screened in	Maximum number of vessels at any one time	Vessel transfers	Distance to Project (km)
Transmission Assets[20]	Construction and Operational	Construction: 19 Operational: 14	286 over the 30-month construction phase =114/year; and 77 O&M trips each year	0
Mona[21]	Construction and Operational	Construction: 96 Operational: 21	849 over the construction phase of four years =221/year; and 849 O&M return trips annually	10
Morgan[22]	Construction and Operational	Construction: 69 Operational: 16	1,929 over the construction phase of four years =482/year; and 719 O&M return trips annually.	17
Awel y Mor[23]	Construction and Operational	Construction: 35 Operational: 4	No information available	29
Morlais[24]	Construction and Operational	Construction:16 Operational: 16	No information available	83

Sensitivity

11.977 The sensitivity for marine mammals to disturbance is medium.

Construction

20 Morgan Offshore Wind Limited, Morecambe Offshore Windfarm Ltd, 2024
21 Mona Offshore Wind Ltd, 2024
22 Morgan Offshore Wind Limited, 2024
23 RWE, 2023
24 Menter Mon Morlais Limited, 2019

Magnitude

11.978 While the numbers presented reflect the absolute worst-case scenario of vessel presence, the actual number of vessels is likely to be much smaller. The data in **Table 11.113** indicates that for projects with available data (and within 100km of the Project), the number of construction vessels on-site at any given time could range from 16 to 96 per project, with annual return trips ranging from 114 to 482.

11.979 It is unrealistic to assume that the maximum number of vessels at each project would be present at the construction site simultaneously with all 37 vessels at the Project. Therefore, providing a quantified assessment is not representative. This snapshot would give an unreasonable estimate of the total number of vessels, not accounting for any potential overlap in disturbance ranges.

11.980 While there is evidence that marine mammals can become habituated to vessel traffic to some degree (Nowacek *et al*., 2007; Hudson, 2014; Onoufriou *et al*., 2016; Jones *et al*., 2017; Koroza & Evans, 2022), a possible response to vessels is temporary displacement from the area. Marine mammals will be exposed to a short-term fluctuation of vessel traffic during the respective project construction phase but will return once the vessel has passed (see review in **paragraph 11.748** and any subsequent paragraphs). Therefore, a low magnitude was assigned to construction vessel effects, as any impact from vessel presence will be both localised, temporary and limited to the 2.5-year construction phase.

Significance of effect

11.981 Available measures to reduce the potential level of disturbance from vessels are included in the Outline PEMP and Outline VTMP which have been secured in the dDCO Schedule 6 Condition 9(1)e(v) and Condition 9(1)j, respectively. Best practice measures are also outlined for other projects as further detailed in the operation and maintenance section below.

11.982 The effect of cumulative vessel disturbance on marine mammals during the 2.5-year construction phase of the Project with a medium sensitivity and a **low** magnitude would result in a **minor adverse** effect for all marine mammal receptors, which is not significant in EIA terms.

Operation and maintenance

Magnitude

11.983 During the 35-year operational period of the Project, there is the potential for projects to be overlapping in their operational phase, meaning that an increase in vessel traffic is likely to disturb marine mammals in the area.

11.984 The data in **Table 11.113** indicates that for projects with available data (and within 100km of the Project), the number of vessels on-site at any given time could range from 4 to 21 per project, with annual return trips ranging from 77 to 719. As described above during 'Construction', the total number of vessels expected to be transiting or on site at any one time at each project would not reflect the actual number of vessels. Firstly, the numbers represent the maximum worst-case for each project, and secondly, vessels conducting maintenance will be temporally spaced within each year over the 35-year period. The potential for all operation and maintenance vessels to be at sea working on the Project on the same day is unlikely.

11.985 While the disturbance from vessels during construction is considered a temporary impact (as assessed for Project-alone in **Table 11.52**, vessels during O&M are a long-term impact (as assessed Project-alone in **Table 11.72**. This means that marine mammals could be affected by repetitive exposure to vessel disturbance over the lifetime of the individual project. However, the literary evidence, as discussed in **paragraph 11.748** (and any subsequent paragraphs), highlights that the long-term effects of shipping disturbance is difficult to quantify but that short-term effects are likely to occur and recovery has been observed (Wisniewska *et al.*, 2018, New *et al.,* 2020, Hao et al., 2024).

11.986 Currently available monitoring studies for operational wind farms suggest that marine mammals are not significantly disturbed by vessel traffic, and that any impact is localised and temporary (e.g. Diederichs *et al*. 2008; Teilmann *et al*. 2006; McConnell *et al*. 2012). Harbour porpoise and seals have also been found to continue to forage within operational wind farm sites (Lindeboom *et al.* 2011; Russell *et al.* 2014; Leemans & Fijn, 2023). These monitoring studies suggest that there is no significant disturbance from operational wind farms, which may have a number of vessels present at any one time.

11.987 Vessels associated with operation are likely to undertake similar activities to those for construction, albeit with much lower frequency. Russel (2016) found that harbour seal foraged within an area undergoing OWF construction. It is expected that the vessel movements to the screened in projects, and from any port, will be largely incorporated within existing vessel routes and therefore to areas where marine mammals may already be accustomed to their presence.

11.988 Best practice measures, as implemented for the Project (see **Section 11.3.3**), would be in place for all other projects considered, further limiting the potential for disturbance:

- **Morgan and Morecambe OWF Transmission Assets**: "*Detailed Vessel Traffic Management Plan(s) (VTMP) will be developed pre-*

construction in line with legislation, guidance and industry best practice which will: • determine vessel routing to and from construction areas and ports; • include vessel standards and a code of conduct for vessel operators; and • minimise, as far as reasonably practicable, encounters with marine mammals and basking sharks. These plans will be developed in accordance with the Outline VTMP prepared and submitted with the application for development consent." (Table 4.12; Morgan Offshore Wind Limited and Morecambe Offshore Windfarm Ltd, 2024).

- **Morgan and Mona Offshore Wind Project:** "*The Offshore EMPs* [Environmental Management Plans] *(CoT65) (Table 4.12) outlines instructions for vessel behaviour and vessel operators, including advice to operators to not deliberately approach marine mammals and to avoid sudden changes in course or speed*" and "*The Offshore EMP will include a commitment that the site induction processes will incorporate the principles of the Wildlife Safe (WiSe) Scheme to ensure that key personnel are aware of the need to follow the WiSe Code of Conduct. The WiSe Scheme (https://www.wisescheme.org/), which is a UK national training scheme for minimising disturbance to marine life, key measures from the scheme will reduce the disturbance of vessel transits on marine mammals and rafting birds visible at the water surface, or as otherwise agreed with the Statutory Nature Conservation Bodies (SNCBs)* (paragraph 4.11.4.14 and Table 4.17; Mona Offshore Wind Limited, 2024; Morgan Offshore Wind Limited, 2024)
- **Awel y Mor:** *"The adoption of best practice vessel handing protocols (e.g. following the Codes of Conduct provided by the WiSe Scheme, Scottish Marine Wildlife Watching Code or Guide to Best Practice for Watching Marine Wildlife) will minimise the potential for any impact. The final codes of conduct will be discussed and agreed with NRW and JNCC."* (Table 19; RWE, 2023).
- **Morlais**: "*Where possible, all vessel movements will be kept to the minimum number that is required to reduce any potential collision risk. Additionally, vessel operators will use good practice to reduce any risk of collisions with marine mammals*." (paragraph 510; Menter Môn Morlais Limited, 2019).

11.989 Once on-site, vessels would be stationary or slow moving while undertaking their activities, minimising the potential for disturbance. However, in a worst-case scenario, projects' array areas could become areas of disturbance if several vessels were to be present simultaneously. This type of scenario was presented in an illustration in **Plate 11.9**. The space between the individual projects and corridors within the array sites would allow sufficient space for marine mammals to travel in between turbines to reach their foraging grounds, haul-out sites or migration routes.

11.990 The magnitude of impact is therefore considered to be **low** but is considered a long-term impact due to the presence of operation vessels as a continuous impact.

Significance of effect

11.991 Available measures to reduce the potential level of disturbance from vessels are included in the Outline PEMP and Outline VTMP.

11.992 The effect of cumulative vessel disturbance on marine mammals during the 35-year operational phase of the Project with a medium sensitivity and a **low** magnitude would result in a **minor adverse** effect, which is not significant in EIA terms.

Decommissioning

11.993 A detailed Offshore Decommissioning Programme will be developed individually for the Project and other projects, detailing the vessels required. Until then, the impact from decommissioning is expected to be the same as assessed during the construction phase. As such, the effect of cumulative vessel disturbance on marine mammals with a medium sensitivity would result in a **minor adverse** effect for all marine mammal receptors, which is not significant in EIA terms.

Cumulative effect 5: Disturbance at seal haul-out sites

11.994 The sensitivity of grey seal and harbour seal to disturbance at haul-out sites was **low** (see **Section 11.6.2**).

11.995 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.

11.996 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.**

11.997 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).

11.998 No additional mitigation has been identified as being required for the potential for cumulative disturbance at seal haul-out sites.

Cumulative effect 6: Changes to prey resources

11.999 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.

11.1000 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.

11.1001 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**.

11.1002 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).

11.1003 No additional mitigation has been identified as being required for the potential for cumulative effects to prey species.

Cumulative effect 7: Assessment of disturbance from operational offshore turbines generators

11.1004 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.

11.1005 The screened in projects (**Table 11.114**) 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 11.114 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

11.1006 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.

11.1007 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.

11.1008 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

11.1009 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).

11.1010 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).

11.1011 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).

11.1012 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.

11.1013 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).

11.1014 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).

11.1015 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).

11.1016 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.

11.1017 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.

11.1018 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

11.1019 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.

11.1020 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.

11.1021 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).

11.1022 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

11.1023 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.

11.1024 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).

11.1025 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.

11.1026 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

11.1027 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.

11.1028 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

11.1029 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 11.115**).

Table 11.115 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
All marine mammal receptors	Medium	Low	Not Significant (Minor adverse)	None identified	Not Significant (Minor adverse)

Cumulative effect 8: Underwater noise from operational OWFs

Disturbance from operational wind turbines

11.1030 Assessed above as **Cumulative effect 7**.

Disturbance from maintenance activities

11.1031 Vessels associated with offshore wind farm operation are likely to undertake similar activities to those for construction, albeit with much lower frequency. Russel (2016) found that harbour seal foraged within an area undergoing offshore wind farm construction, and Benhemma-Le Gall *et al*., (2021) found that harbour porpoise could be disturbed up to 4km from construction related vessels, although a higher proportion are disturbed at 2km.

11.1032 Maintenance activities at OWFs, such as such as additional rock placement or cable re-burial, would be very localised, short in duration and temporary.

11.1033 Once on-site, OWF vessels would be stationary or slow moving, as they undertake the activity they are associated with, and therefore the potential for disturbance would be minimal. The potential for disturbance is considered to be localised and temporary, and marine mammals are expected to return to the project areas shortly after vessels have completed their works and left the area.

11.1034 The potential for disturbance due to maintenance activities was assessed as minor adverse for the Project alone, and it is considered that the potential for disturbance from all other OWFs that are operational at the same time as the Project would have an equally low potential for effect. Therefore, a magnitude of low (as a precautionary basis) is appropriate.

Significance of effect

11.1035 With the sensitivity of medium for all marine mammal species, a magnitude of low would result in an overall **minor adverse effect** which is not significant in EIA terms.

Disturbance from increased vessel presence

11.1036 There is the potential for vessels to be present throughout the operational phase of OWFs, in order to undertake maintenance activities. While the number of vessels present is likely to be less than during the construction phase, they are also likely to be present for longer periods of time, with the operational phases of OWFs being upwards of 25 years.

11.1037 It is expected that the vessel movements to an operational OWF, and from any port, will be incorporated within existing vessel routes where possible and therefore to areas where marine mammals may already be accustomed to their presence. The increase in vessel presence from operational OWFs is expected to be relatively small compared to the baseline levels of vessel

movements in the area. It is also expected that good practice measures, as implemented for the Project, would be in place for all operational OWFs, further limiting the potential for disturbance.

11.1038 **Cumulative effect 4** provides a detailed assessment of the potential for disturbance from vessels across multiple projects, with a resultant magnitude of effect of low.

Significance of effect

11.1039 With the sensitivity of medium for all marine mammal species, a magnitude of low would result in an overall **minor adverse effect** which is not significant in EIA terms.

Cumulative effect 9: Underwater noise from decommissioning activities

11.1040 Given their age and expected operational lifetime, the decommissioning of existing UK and European OWFs could overlap with the Project duration. There is also potential for overlap of decommissioning with oil and gas infrastructure in the vicinity of the windfarm site.

11.1041 Based on currently available information, underwater noise during decommissioning of oil and gas installations would be less than levels for PTS to occur and any disturbance would be localised and not be significantly greater than that arising from vessels (Fernandez-Betelu *et al.,* 2024). Therefore, potential cumulative effects from decommissioning activities, such as cutting equipment are not considered to have any potential for significant levels of disturbance.

11.1042 There is currently limited information available on the potential for underwater noise and disturbance effects to marine mammals as a result of OWF decommissioning activities, as very few OWFs have yet to undertake this stage. However, it is expected that activities required would be similar to that undertaken for the decommissioning of oil and gas infrastructure as described above, and therefore it is not expected that there would be any risk of PTS onset, and that any disturbance would be localised and in line with noise levels associated with vessel presence. Any underwater noise levels due to the decommissioning of OWFs would be less than that of construction (as pile driving noise and UXO clearance, the most significant activities in terms of underwater noise levels, would not occur).

11.1043 Regarding the potential for cumulative effects from vessels associated with the decommissioning of oil and gas installations, while there would be in increase in vessels, the majority would consist of jack up barges in the close vicinity of oil and gas infrastructure.

11.1044 Further, in respect of the oil and gas infrastructure in the vicinity of the windfarm site the Applicant is in discussion with these operators to agree

simultaneous activity management, whereby the likelihood of project activities (such as piling) occurring at the same time as major decommissioning activities could be limited.

11.1045 Therefore, as above, potential cumulative effects from decommissioning vessels are not considered to have any potential for significant levels of disturbance over the lifetime of the Project.

Significance of effect

11.1046 Based on the above, the potential magnitude of effect due to the construction of the Project at the same time as decommissioning activities is not expected to be higher than the worst-case of the Project under construction, as it is not expected that there would be any kind of materially additive effect when considered together.

11.1047 Therefore, the magnitude of effect is considered to be low, and with a sensitivity of medium due to disturbance, the overall effect is **minor adverse** which is not significant in EIA terms.

Cumulative effect of repeated disturbance events – summary

11.1048 A scenario of cumulative disturbance events over the long term for noisy activities other than piling can be caused by:

- OWFs;
  - Piling events throughout the 2.5-year construction period (has already been assessed using iPCoD modelling (see **Cumulative effect 2a**);
  - Construction, operation and maintenance, or decommissioning activities (other than piling) throughout the 35-year lifetime;
  - Presence of vessels throughout the 35-year lifetime (has been assessed in **Cumulative effect 4**); and
  - Operational turbine noise throughout the 35-year lifetime (has been assessed in **Cumulative effect 7**)
- Oil and gas seismic surveys and geophysical surveys;
- UXO clearance;
- Other offshore projects (such as subsea cables, disposal activities, and aggregates and dredging projects); and
- Decommissioning activities.

11.1049 From the list of disturbance impacts, piling represents the worst-case disturbance scenario for marine mammals during construction. Consequently, activities that produce much lower levels of noise, such as

other construction activities, are expected to have comparatively less impact on marine mammal populations.

11.1050 With regard to repeated disturbance from cumulative activities, **Table 11.110** and **Table 11.111** in **Cumulative effect 2**, present a quantitative assessment of effects from all overlapping piling and construction at other OWFs, as well as other industry noisy activities occurring simultaneously to piling at the Project. The result of this assessment presents a snapshot of the cumulative effect on the marine mammal populations, but the assessment in **Cumulative effect 2** (**Table 11.110**) highlights that the likelihood of this effect to occur on the same day is very low. However, throughout the Project duration, any of these activities may occur at any one point. The effect would therefore be spatially and temporally dispersed.

OWFs

Piling

11.1051 As quantitative methods on long-term effects are lacking, the iPCoD model was used, which simulates the changes in a population, following disturbance from piling over time, for both a disturbed and an undisturbed population as described in **Cumulative effect 1a.** The population that has been used is the relevant management unit that is presented in **Table 11.14**. This provides a comparison of the type of changes that could occur resulting from natural environmental variation, demographic stochasticity (i.e. variability in population growth rates) and disturbance from piling (Harwood *et al.,* 2014; King *et al.,* 2015).

11.1052 The potential for prolonged exposure to noisy activities to affect marine mammals is not well understood, with a limited number of studies mainly focusing on harbour porpoise. Nabe-Neilson *et al.* (2018) found that harbour porpoise densities returned to normal levels between two and six hours following piling, and Brandt *et al.* (2011) found that porpoise densities recovered between 2.5 and 11.5 hours post piling.

11.1053 Graham *et al*. (2019) found that the level of response from harbour porpoise to piling reduced over time (i.e. as the piling campaign continued, the response and recovery time of harbour porpoise reduced). At the beginning of the piling campaign (in the Moray Firth), there was more than a 50% chance of harbour porpoise responding to piling in the 24 hours directly following the cessation of piling up to 7.4 km (95% CI = 5.7–9.4). By the middle of the piling campaign, this 50% response distance had decreased to 4.0 km (95% CI = 2.7–5.2), and decreased to 1.3 km (95% CI = 0.2–2.8) by the end of the piling campaign. This demonstrates that for this piling campaign, harbour porpoise recovery was within 24 hours at a closer range to the piling itself by the end of the piling, indicating a level of habituation, and of decreased disturbance over time.

Construction, operation and maintenance, and decommissioning activities (other than piling)

11.1054 During the lifetime of the Project and other projects, maintenance activities will be required and are likely to be conducted using vessels. The effect of repeated and cumulative vessel disturbance has already been discussed in **Cumulative effect 4**. The evidence provided in these sections found that while repeated disturbance events are likely to occur, there would be no long-term effect on marine mammals. This is because individual events such as maintenance work or vessel presence would be temporary and intermittent and not continuously present throughout the 35 years of operation.

11.1055 As the worst-case disturbance impacts from piling at several projects within the same time window have shown no significant effects on the relevant marine mammal populations, it can be expected that any noisy activity (other than piling) that is quieter, and/or non-impulsive would result in even less numbers of disturbed marine mammals. Further, the Project has outlined mitigation measures to reduce its contribution to cumulative effects in the MMMP and UWSMS.

11.1056 While seismic surveys are not a good proxy for construction noise, due to their comparatively high levels of underwater noise, the evidence (included below) shows that marine mammals returned to natural behaviour shortly after the noise had dissipated, similar to observations for piling.

11.1057 In contrast to loud activities such as seismic surveys and piling, one study by Taormina *et al.* (2018) concluded that the effects of cable-laying activities were insignificant, as the noise is likely to be masked by the noise emitted from the vessels conducting the work. Taormina *et al.* (2018) stated that noise from submarine cable installation has a negligible to weak impact on marine mammals, as the underwater noise associated with installation of undersea cables remains low. Cable installation is a spatially localised, temporary event, so the impact of noise on marine communities is expected to be minor and brief.

11.1058 While the long-term effects of construction activities (other than piling) are unknown, the evidence provided above and below (sub-section: oil and gas seismic surveys and geophysical surveys) suggests that disturbance from comparatively loud sources such as piling or seismic surveys is unlikely to have a significant long-term impact, and therefore is it considered unlikely that other construction activities would have a long-term impact on any marine mammal population.

Operational noise

11.1059 During the 35-year operational lifetime of the project, there is the possibility that recurring disturbances have the potential to affect marine mammal

populations. Piling activities and other construction noise from all screened-in projects would have ceased, with the operational turbine noise commencing following turbine commissioning at the Project and the other screened-in projects. This effect has been assessed quantitatively in **Cumulative effect 6** and concluded a minor adverse effect (not significant in EIA terms).

11.1060 In addition to the literary evidence provided, **Cumulative effect 6**, disturbance at operational windfarms would be limited to the array sites themselves (Leemans & Fijn, 2023), and as such there would be no overlapping areas of disturbance with other projects.

11.1061 However, even within the array areas themselves, marine mammals are not excluded as several studies have shown (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). The level of noise from the turbines has not been shown to disturb animals, in contrast, harbour porpoise and seals have been recorded foraging within operational windfarm sites (e.g., Lindeboom et al. 2011; Russell et al. 2014, Leemans & Fijn, 2023).

11.1062 It can therefore be concluded that operational noise from turbines is not likely to have a repeated effect to marine mammals as the evidence suggests that operational noise minimally affects them.

Oil and gas seismic surveys and geophysical surveys

11.1063 Similarly to the discussion in **paragraph 11.985,** longer-term consequences of exposure to noise from activities other than piling, such as shipping or seismic surveys, have not been well studied and are difficult to quantify (Gordon et al., 2003). For example, the effects from seismic surveys are more evidenced than those from other construction activities. As for piling, the evidence of cumulative effects, which may be biologically significant, is poorly researched.

11.1064 Continuous exposure to any noise source could lead to chronic stress in marine mammals, potentially weakening their immune systems and making them more susceptible to diseases (Gordon et al., 2003). The study suggests potential implications for social organisation among marine mammals, for social bonds and survival. Disruptions can affect communication and cohesion within groups, potentially leading to effects on population dynamics.

11.1065 In contrast, Thompson *et al.* (2013) found that seismic surveys cause short-term disturbances, but these effects were minor compared to natural variation. Porpoises were detected at affected sites within a few hours of a seismic survey ceasing, indicating that the seismic survey did not result in

long-term displacement into suboptimal or higher-risk habitats. The animals typically returned to impacted sites shortly after the disturbance, and their response to the noise decreased over the 10-day survey period.

11.1066 The evidence provided above suggests that disturbance from seismic surveys is unlikely to have a significant long-term impact on any marine mammal population.

UXO Clearance

11.1067 UXO clearances are by their nature single pulse events, with limited potential for ongoing disturbance. There is currently a paucity of information available on the potential for disturbance of marine mammals to UXO clearance, and the latest guidance for assessing disturbance to harbour porpoise suggests the use of known piling disturbance as a proxy in lieu of further information (JNCC *et al.*, 2020).

Decommissioning

11.1068 Currently the exact timings and end-of-life procedures for decommissioning offshore infrastructures are unknown. Consequently, any anticipated cumulative disturbance events are also currently unknown. It can however be expected that some decommissioning activities such as cutting, as well as increased vessel traffic have the potential to cause a repeated disturbance effect. As construction is considered to be the worst-case phase of a project, it can be presumed for now that it would be the same as assessed for this phase.

11.1069 **Cumulative effect 9** provides a more detailed assessment of cumulative decommissioning activities with the Project.

Summary

11.1070 Due to the absence of empirical data on long-term cumulative effects, it is not possible to accurately quantify these impacts and a number of methods must be considered to analyse the impacts. It is noted that the Project would reduce the Project-alone contribution to additive cumulative disturbance via its embedded commitment to develop, agree, and implement the MMMP and UWSMS.

11.1071 While the long-term effects of the aforementioned activities remain uncertain, the available evidence suggests that activities such as piling or seismic operations are unlikely to have significant long-term impacts when considered in isolation. However, when examining the effects on the wider management units, additional projects and activities would introduce disturbance events throughout the Project's duration, resulting in repeated disturbances to which marine mammals could be exposed. While the effects of disturbance are not permanent and are recoverable over time,

recoverability may reduce with repeated exposure to disturbance events, particularly when the duration between events is short. Although there is potential for these disturbances to have a cumulative effect on the overall population, they would generally be localised to their sources. This could increase the stress load on individual animals, leading to higher energetic costs (e.g. Williams *et al*., 2006; Hastie *et al*., 2021; Frankish *et al.,* 2023). Nevertheless, due to the size of the management units and reference populations, the potential impacts are not expected to alter the overall significance of the effects presented in the cumulative assessment.

11.8 Transboundary effects

11.1072 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 11.116**). This approach has been taken through the assessments.

Table 11.116 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	CGNS MU (IAMMWG, 2023; see **Appendix 11.2**) CEA screening area (see **Appendix 11.4**)

Species/receptor	Countries/areas	Inclusion within assessments
	▪ NI ▪ SW Scotland	
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**)
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

11.1073 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).

11.1074 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

11.1075 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.

11.1076 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.

11.1077 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

11.1078 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).

11.1079 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

11.1080 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.

11.1081 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.

11.1082 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

11.1083 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.

11.1084 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

11.1085 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.

11.1086 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

11.1087 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.

11.1088 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.

11.1089 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

11.1090 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

11.1091 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 11.117** provides a summary of the principal inter-relationships and signposts to where those issues have been addressed in the relevant chapters.

Table 11.117 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.

Topic and description	Related chapter	Where addressed in this chapter	Rationale
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.
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

11.1092 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 11.118** and **Table 11.119**. This provides a screening tool for which impacts have the potential to interact.

11.1093 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.

11.1094 The potential combined effects of disturbance from piling, other construction activities and vessels at the Project (Impacts 2, 3 and 4; **Table 11.118** 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.

11.1095 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.

11.1096 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 11.118** - **Table 11.120**).

Table 11.118 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 11.119 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 11.120 Interaction between impacts – phase and lifetime assessment for marine mammals

Receptor	Highest residual significance level			Phase assessment	Lifetime assessment
	Construction	Operation and maintenance	Decommissioning		
Harbour porpoise	Minor adverse	Minor adverse	Minor adverse	**Construction** 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 (for additive disturbance effects see **Section 11.10.1.2**). 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 and repeat disturbances over each phase considered.	**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. However, it is noted that there would be repeated disturbance events over the lifetime of the Project. It was therefore considered that over the Project lifetime these impacts would not combine and represent an increase in
Bottlenose dolphin	Minor adverse	Minor adverse	Minor adverse		
Common dolphin	Minor adverse	Minor adverse	Minor adverse		

Receptor	Highest residual significance level			Phase assessment	Lifetime assessment
	Construction	Operation and maintenance	Decommissioning		
Risso's dolphin	Minor adverse	Minor adverse	Minor adverse	There are limited pathways for vessel interaction, or effects on prey resource to interact with noise impacts, as individuals could be excluded from the disturbance footprint (i.e. there cannot be a vessel interaction if the individual is excluded from the vicinity of the construction works). Once noisy activities have ceased, the footprint of disturbance and changes to prey resource 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 significance level (see **Section 11.10.1** for additional information)
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			Phase assessment	Lifetime assessment
	Construction	Operation and maintenance	Decommissioning		
				the interaction of these impacts would 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)	

11.10.1 Lifetime assessment - additional information

11.1097 The following sections serve as additional information to the Project-alone and cumulative assessment (particularly **Table 11.121)**.

11.10.1.1 Disturbance from all construction, operation, and decommissioning activities

11.1098 For the Project-alone, and cumulatively, it is expected that the highest level of disturbance would be generated during the construction phase due to the potential impacts from piling, but these effects would be intermittent. There would also be a lower level, with more continuous effect of disturbance, from other construction activities and the increased number of vessels throughout the construction period. It is not expected that this additional stressor load to the wider population would have a higher significance of effect than the assessment presented for piling. With the appropriate mitigation measures (as outlined in **Section 11.11**) the overall level of significance of effect for the Project alone and cumulatively during construction is considered to be **minor adverse** (not significant in EIA terms). 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 and therefore have an equivalent level of effect. During the 35-year operation and maintenance phase for the Project, the individual impacts are more intermittent in nature and shorter in duration than during construction, but they would be repeated throughout that timeframe. Overall, the level of significance of effect for the Project-alone and cumulatively during the operation and maintenance phase is considered to be **minor adverse** (not significant in EIA terms).

11.1099 While quantitative assessments have been undertaken for the impacts for each phase, they only provided a snapshot of the number of animals disturbed and the percentage of their reference population at a single point in time. This has formed the basis for determining the magnitude and significance of effect for the Project alone, and cumulatively, throughout its lifetime. Although this assessment quantifies single events, the magnitude also considers the duration of effects. Repeated disturbance events are not expected to have a sustained effect on the wider reference population, as the effects of disturbance are not considered permanent and are recoverable over time. However, recoverability may reduce with repeated exposure to disturbance events, particularly when the duration between events is short It is important to note that animals may incur some energetic cost during this period (e.g. Williams *et al*., 2006; Hastie *et al*., 2021; Frankish *et al.,* 2023). It is also noted that cumulatively, there would be a wider number of sources

impacting the reference populations that could be occuring at the same time and/or sequentially alongside Project activities.

11.1100 Taken all together, the construction of the Project at the same time as the operation of other OWFs, and any decommissioning activities is not expected to generate any additive effect over and above what has been assessed for the construction of the Project itself. This is also the case during the operation and maintenance phase and decommissioning phase of the Project (where noise disturbance for the Project is less). This is due to the minimal potential for disturbance at a population level from these activities and noise sources individually, as well as the distance between each potential project considered. In addition, it is expected that all projects would have mitigation measures in place, which would ensure disturbance is kept at the minimal level practicable. Based on the above, the potential magnitude of effect due to the construction of Project at the same time as both the operation and decommissioning of other OWFs is not expected to be higher than the worst-case of the Project under construction, as it is not expected that there would be any kind of additive significant effect when considered together.

11.1101 Considering a professional analysis of the overall evidence base, the significance of effect for the lifetime of the Project (both alone and cumulatively) is considered to be **minor adverse** (not significant in EIA terms) (**Table 11.120**) which is been deemed appropriate and proportional in context of the MU's assessed for marine mammals.

11.10.1.2 Vessels

The Project and Transmission Assets

11.1102 Vessels will be used throughout all phases of the Project and therefore the impact to marine mammals from elevated underwater sound due to vessel activities throughout all phases could cause additional disturbance to marine mammals compared to considering each phase separately. However, for all phases, vessel movements will primarily be located within the windfarm site or export cable route and travelling at a reduced speed. Vessels will also follow best practice measures to minimise disturbance to marine mammals as secured within the Project PEMP and VTMP. Across the Project lifetime, the effects on marine mammal receptors are not anticipated to interact in such a way as to result in combined effects of greater significance than the assessments presented for each individual phase.

All plans and projects

11.1103 Vessels will be used throughout all phases of the Project and therefore the impact from elevated underwater sound due to vessel activities throughout all phases could cause additional disturbance to marine mammals compared

to each stage separately. However, for all phases, Project vessel movements will primarily be located within the windfarm site and travelling at a reduced speed. Vessels will also follow the measures to minimise disturbance to marine mammals within the PEMP and VTMP. This is also the case for other offshore wind projects. Across the project lifetime, the effects on marine mammal receptors are not anticipated to interact in such a way as to result in combined effects of greater significance than the assessments presented for each individual phase.

11.10.1.3 Additive effects of multiple pathways of disturbance

11.1104 Activities such as geophysical surveys, seismic surveys, aggregate extraction, dredging, and UXO clearance are considered indicative, as it is challenging to determine when these projects/activities may occur. This uncertainty supports the conclusion that it is unlikely for all activities to occur simultaneously. However, it is acknowledged that, over time, these activities are likely to take place. Such activities would likely require separate licensing, which would take into account the consented activities of the Project during their own application processes and determine appropriate mitigation.

11.1105 It is not anticipated that the cumulative impacts' overall significance of would be elevated beyond the levels assessed individually. While individual activities may extend the overall duration of elevated underwater noise across the area and occur throughout the construction period independently of piling; the spatial extent of the most significant disturbance (i.e. piling) will remain limited to the maximum disturbance ranges identified for each species. Once piling is completed, any other construction, or operation and maintenance activities will be more localised to the Project's array site and intermittent throughout the lifetime of the Project. It is concluded that over this timeframe, the impacts will not exceed the significance of the individual impacts alone.

11.1106 Furthermore, animals are likely to be disturbed from the loudest source of noise, which could lead to the displacement for the Project area where disturbance is expected to take place. As mentioned, piling is the worst-case impact with regard to disturbance, and therefore additive effects from less noisy activities at the same project may affect areas that animals have already vacated. Temporally, animals may return to the area between periods of noise, resulting in repeated exposures. However, due to the intervals between activities, it is not anticipated that this would result in effects of greater significance than those from individual impacts considered in isolation.

11.1107 With the implementation of the MMMP and adherence to the UWSMS, PTS is not predicted to occur in any marine mammal species and TTS is a recoverable impact.

11.1108 With respect to disturbance, the potential for spatially inter-related effects is considered to be minimal as individual animals are likely to be disturbed over a range dictated by the 'loudest' sound (i.e. leading to the greatest disturbance range) such that the potential for secondary (additive) effects from other activities that result in smaller ranges is reduced, as animals are already disturbed and have moved away from the area of highest ensonification. Temporally, animals may return to the area between sound generating activities leading to repeated exposure to sound over extended duration, however it is not predicted that this will result in effects of greater significance than the individual impacts in isolation due to intervals between activities.

11.1109 Across the project lifetime, the effects on marine mammal receptors are not anticipated to interact in such a way as to result in combined effects of greater significance than the assessments presented for each individual phase including when considered cumulative effects with other projects.

11.1110 When looking at the effects on the wider management units on a cumulative basis, individual projects and activities would add repeated disturbance events throughout the lifetime of the Project. While there is the potential for this to have an additive effect on the overall population, in most cases these effects will be localised to the source. This could add to the stress load experienced by individual animals leading to increased level of expended energetic cost. However, due to the size of the MUs and reference populations the potential impacts would not alter the overall significance of effect that has been presented in the cumulative assessment (see **Section 11.7.3.2**). This considers the mitigation developed by the Project and other projects, but acknowledges that there would be spatially and temporally repeated disturbances.

11.11 Marine wildlife licence application

11.1111 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

11.1112 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.

11.1113 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

11.1114 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 unexploded ordnance (UXO) clearance in the marine environment (JNCC, 2025)
- Piling
  - Following the statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise (JNCC, 2010)
  - 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, 2023a)

11.1115 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.

11.1116 The Project is committed to additional mitigation to ensure that if the Project worst case was to be implemented (the high strike rate scenario with the maximum hammer energy) the potential PTS effects would be fully mitigated by using primary and/or secondary noise reduction methods such as NAS and to ensure there is no residual PTS after the ADD use. Measures have been included in the Draft MMMP and Outline UWSMS, considering both design refinement and noise reduction methods as appropriate and in consideration of latest guidance (JNCC *et al*., 2025).

11.1117 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.

11.1118 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).

11.1119 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.

11.1120 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.

11.1121 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.

11.1122 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

11.1123 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 11.121** and for cumulative effects in **Table 11.122**.

11.1124 The methodology for these assessments has been based on the best available techniques and professional analysis of the information presented. This approach has been used to derive conclusions whilst also considering the limitations where appropriate.

11.1125 Taking into account the proposed mitigation measures, where required, the worst case 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).

11.1126 For cumulative effects, residual **minor adverse** (and not significant in EIA terms) 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.

11.1127 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, 2025)
- It is noted that there would be repeated disturbance over the study area from a number of projects over time. Outside of population modelling for piling there is no quantitative method to present repeated impacts and the long term effects of multiple disturbance events. The quantative methods (noting the precaution built into this), iPCoD modelling, and review of available literature, all inform the overall evidence base to determine the overall significance of effects.

11.1128 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 (with additional information added throughout the examination period of the Project as required). The final MMMP and UWSMS would more realistically inform the potential mitigation requirements.

Table 11.121 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 and UWSMS (**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 and UWSMS (**Section 11.3.3**)	Not Significant (Minor adverse)
	Dolphins, minke whale, harbour seal		Negligible			
Impact 2: Disturbance from	Bottlenose dolphin, grey seal	Medium	High	Significant (Major adverse)	MMMP and UWSMS (**Section 11.3.3**)	Not Significant (Minor adverse)

Potential impact	Receptor	Sensitivity	Magnitude	Significance of effects	Additional mitigation measures proposed	Residual effect
underwater noise during piling	Harbour porpoise		Medium	Significant (Moderate adverse)		
	Harbour seal		Low	Not Significant (Minor adverse)		
	Common and Risso's dolphin, minke whale		Negligible	Not Significant (Minor adverse)		
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 but Best practice measures (see **Section 11.3.3**) would help reduce disturbance	Not Significant (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	Medium				
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	Harbour porpoise, minke whale	Medium	Negligible	Not Significant (Minor adverse)		

Potential impact	Receptor	Sensitivity	Magnitude	Significance of effects	Additional mitigation measures proposed	Residual effect
and presence of vessels	Bottlenose dolphin, grey seal	Medium	Low			
	All other dolphins, harbour seal	Medium	Negligible			
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		

Potential impact	Receptor	Sensitivity	Magnitude	Significance of effects	Additional mitigation measures proposed	Residual effect
				(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)
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					
Impact 2: TTS from underwater noise during	All marine mammal species	Medium	Negligible	Not Significant (Minor adverse)	None required or proposed for Project-alone	Not Significant (Negligible – Minor adverse)

Potential impact	Receptor	Sensitivity	Magnitude	Significance of effects	Additional mitigation measures proposed	Residual effect
maintenance activities						
Impact 2: Disturbance from underwater noise during maintenance activities	Harbour porpoise, minke whale	Medium	Negligible	Not Significant (Minor adverse)		
	All other species	Medium		Not Significant (Negligible adverse)		
Impact 3: 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 but Best practice measures (see **Section 11.3.3**) would help reduce disturbance	Not Significant (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.	Medium	Low			
	All other dolphins		Negligible			
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)

Potential impact	Receptor	Sensitivity	Magnitude	Significance of effects	Additional mitigation measures proposed	Residual effect
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)
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)		

Potential impact	Receptor	Sensitivity	Magnitude	Significance of effects	Additional mitigation measures proposed	Residual effect
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 haul-out sites, as provided in the Outline PEMP (see **Section 11.3.3**)	Not Significant (Negligible – Minor adverse)
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	Medium	Low - Negligible	Not Significant (Minor adverse)	None required or proposed for Project-alone but Best practice measures (see **Section 11.3.3**) would help reduce disturbance	Not Significant (Minor 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)

Potential impact	Receptor	Sensitivity	Magnitude	Significance of effects	Additional mitigation measures proposed	Residual effect
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)
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 11.122 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: PTS from underwater noise	All species	High	Negligible	Not Significant (Minor adverse)	MMMP and UWSMS (**Section 11.3.3**)	Not Significant (Minor adverse)
CEA 2: Disturbance from underwater noise[25]	Bottlenose dolphin, harbour porpoise	Medium	High	Significant (Major adverse)	MMMP and UWSMS (**Section 11.3.3**) best practice measures for vessels (see **Section 11.3.3**) would also help reduce disturbance.	Not Significant (Minor adverse)
	Grey seal		Medium	Significant (Moderate adverse)		
	Common and Risso's dolphin, minke whale		Low	Not Significant (Minor adverse)		
	White-beaked dolphin, harbour seal		Negligible	Not Significant (Minor adverse)		
CEA 3a: Barrier effects from underwater noise	Harbour porpoise, minke whale	Medium	Low	Not Significant (Minor adverse)	None required	Not Significant (Negligible adverse)
	Dolphins and seals	Low	Low	Not Significant (Minor adverse)		

[25] Significance of effect has been presented based on the worst case cumulative assessment from **Table 11.112**

Potential impact	Receptor	Sensitivity	Magnitude	Significance of effects	Additional mitigation measures proposed	Residual effect
CEA 3b: Physical barrier effects	Harbour porpoise, minke whale	Medium	Negligible	Not Significant (Minor adverse)	None required	Not Significant (Negligible adverse)
	Dolphins and seals	Low	Negligible	Not Significant (Negligible adverse)		
CEA 4: Underwater noise and increased collision risk with vessels	Harbour seal	Low	High	Significant (Moderate adverse)	Best practice measures, as identified in the Outline PEMP and VTMP (see **Section 11.3.3**); otherwise, no other mitigation required	Not Significant (Minor adverse)
	Harbour porpoise, Grey seal		Medium	Not Significant (Minor adverse)		
	Dolphin Spp.		Low			
	Minke whale	Medium	Low			
CEA 5: Disturbance of seals at haul-out sites	Seals Spp.	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 (Minor adverse)
CEA 6: 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 7: Disturbance from operational	Harbour porpoise, minke whale	Medium	Low	Not Significant (Minor adverse)	None required	Not Significant (Minor adverse)

Potential impact	Receptor	Sensitivity	Magnitude	Significance of effects	Additional mitigation measures proposed	Residual effect
offshore turbines generators	Dolphins and seals	Medium	Low	Not Significant (Minor adverse)		
CEA 8: Underwater noise from operational OWFs	All species	Medium	Low	Not Significant (Minor adverse)	None required	Not Significant (Minor adverse)
CEA 9: Underwater noise from decommissioning activities	All species	Medium	Low	Not Significant (Minor adverse)	None required	Not Significant (Minor adverse)

11.14 References

Ainslie, M.A., 2010. *Principles of sonar performance modelling* (Vol. 707). Berlin: Springer.

Andersen. L.W. 2003. Harbour porpoises (Phocoena phocoena) in the North Atlantic: Distribution and genetic population structure. NAMMCO Sci. Publ.5:11-30

ASCOBANS (2015). Recommendations of ASCOBANS on the Requirements of Legislation to Address Monitoring and Mitigation of Small Cetacean Bycatch.

Band, B., Sparling, C., Thompson, D., Onoufriou, J., San Martin, E. & West, N. (2016). Refining Estimates of Collision Risk for Harbour Seals and Tidal Turbines. Scottish Marine and Freshwater Science 7.

Beatrice Offshore Wind Farm Limited (2018). Beatrice Offshore Wind Farm Piling Strategy Implementation Report. Available from: http://marine.gov.scot/sites/default/files/lf000005-rep-2397_bowlpilingstrategyimplementationreport_rev1_redacted.pdf (Accessed January 2024)

BEIS (2020). Record of the Habitats Regulations Assessment undertaken under Regulation 5 of the Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (As Amended). ION Southern North Sea Seismic Survey. 103pp. Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/985175/ION_Southern_North_Sea_Seismic_Survey_2021_HRA_Rev_3.0.pdf (Accessed February 2024)

BEIS (2020). Record of The Habitats Regulations Assessment Undertaken Under Regulation 65 of the Conservation of Habitats and Species (2017), and Regulation 33 of The Conservation of Offshore Marine Habitats and Species Regulations (2017). Review of Consented Offshore Wind Farms in the Southern North Sea Harbour Porpoise SAC.

BEIS (2022a). UK Offshore Energy Strategic Environmental Assessment 4 (OESEA4): https://www.gov.uk/government/consultations/uk-offshore-energy-strategic-environmental-assessment-4-oesea4 (Accessed January 2024)

BEIS (2022b). UK Offshore Energy Strategic Environmental Assessment 4 (OESEA4) Appendix A1a.8 Marine mammals and otter.

BEIS (2022c). UK Offshore Energy Strategic Environmental Assessment 4 (OESEA4). Appendix A1a.6 Marine Reptiles.

Bellmann MA, Müller T, Scheiblich K & Betke K (2023) Experience report on operational noise - Cross-project evaluation and assessment of underwater noise measurements from the operational phase of offshore wind farms, itap report no. 3926, funded by the German Federal Maritime and Hydrographic Agency, funding no. 10054419.

Benhemma-Le Gall, A., Graham, I.M., Merchant, N.D. and Thompson, P.M. (2021). Broad-Scale Responses of Harbor Porpoises to Pile-Driving and Vessel Activities During Offshore Windfarm Construction. Front. Mar. Sci. 8:664724.

Benhemma-Le Gall, A., Hastie, G.D., Brown, A.M., Booth, C.G., Graham, I.M., Fernandez-Betelu, O., Iorio-Merlo, V., Bashford, R., Swanson, H., Cheney, B.J., Abad Oliva, N. & Thompson, P.M. (2024). Harbour porpoise responses to the installation of XXL monopiles without noise abatement; implications for noise management in the Southern North Sea. PrePARED Report, No. 004. August 2024

Benhemma-Le Gall, A., Thompson, P., Merchant, N. and Graham, I. (2023). Vessel noise prior to pile driving at offshore windfarm sites deters harbour porpoises from potential injury zones. *Environmental Impact Assessment Review*, 103, p.107271.

Blix, A.S. and Folkow, L.P. (1995). Daily energy expenditure in free living minke whales. Acta Physio. Scand., 153: 61-66.

Blue Gem Wind (2021). Project Erebus Environmental Statement Chapter 12: Marine Mammals. Available at: https://www.bluegemwind.com/wp-content/uploads/2020/07/Erebus-ES-Vol-1-Chapter-12-Marine-Mammals_final.pdf (Accessed 08th January 2025)

Booth, C., Harwood, J., Plunkett, R., Mendes, S. & Walker, R. (2017). Using The Interim PCoD Framework to Assess The Potential Effects Of Planned Offshore Wind Developments In Eastern English Waters On Harbour Porpoises In The North Sea – Final Report. SMRUCNEN-2017-007, Provided to Natural England and the Joint Nature Conservation Committee, March 2017, SMRU Consulting.

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

Botterell, Z.L.R., Penrose, R., Witt, M.J. and Godley, B.J. (2020). Long-term insights into marine turtle sightings, strandings and captures around the UK and Ireland (1910–2018). Journal of the Marine Biological Association of the United Kingdom, 100(6), 869-877.

Brandt, M., Diederichs, A., Betke, K. and Nehls, G. (2011). Responses of harbour porpoises to pile driving at the Horns Rev II offshore windfarm in the Danish North Sea. Marine Ecology Progress Series, 421: 205-215.

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

Brandt, M.J., Dragon, C.A., Diederichs, A., Schubert, A., Kosarev, V., Nehls G., Wahl, V., Michalik A., Braasch, A., Hinz, C., Ketzer, C., Todeskino, D., Gauger, M., Laczny, M., Piper, W. (2016). Effects of offshore pile driving on harbour porpoise abundance in the German Bight. Assessment of Noise Effects. Prepared for Offshore Forum Windenergie. Husum.

British Standards Institution (BSI) (2015). Environmental Impact Assessment for offshore renewable energy project – guide. PD 6900:2015.

Broadwater, M.H., Van Dolah, F.M. and Fire, S.E. (2018) Chapter 5. Vulnerabilities of Marine Mammals to Harmful Algal Blooms. In Harmful Algal Blooms: A

Compendium Desk Reference [Shumway, S.S., Burkholder, J.M. and Morton, S.L. (eds)], Wiley Publishers.

Brown, A.M., Ryder, M., Klementisová, K., Verfuss, U.K., Darias-O'Hara, A.K., Stevens, A., Matei, M., Booth, C.G., 2023. An exploration of time-area thresholds for noise management in harbour porpoise SACs: literature review and population modelling,

Canning, S.J., Santos, M.B., Reid, R.J., Evans, P.G., Sabin, R.C., Bailey, N. and Pierce, G.J. (2008). Seasonal distribution of white-beaked dolphins (Lagenorhynchus albirostris) in UK waters with new information on diet and habitat use. Journal of the Marine Biological Association of the United Kingdom, 88(6), pp.1159-1166.

Carter, M.I., Boehme, L., Duck, C.D., Grecian, J., Hastie, G.D., McConnell, B.J., Miller, D.L., Morris, C., Moss, S., Thompson, D. and Thompson, P. (2020). Habitat-based predictions of at-sea distribution for grey and harbour seals in the British Isles: Report to BEIS, OESEA-16-76, OESEA-17-78.

Carter, M.I.D., Boehme, L., Cronin, M.A., Duck, C.D., Grecian, W.J., Hastie, G.D., Jessopp, M., Matthiopoulos, J., McConnell, B.J., Miller, D.L., Morris, C.D., Moss, S.E.W., Thompson, D., Thompson, P.M. and Russell, D.J.F. (2022). Sympatric Seals, Satellite Tracking and Protected Areas: Habitat-Based Distribution Estimates for Conservation and Management. Front. Mar. Sci. 9:875869.

Cates, K. & Acevedo-Gutierrez, A. (2017). Harbor Seal (Phoca vitulina) Tolerance to Vessels Under Different Levels of Boat Traffic Kelly Cates and Alejandro Acevedo-Gutiérrez Aquatic Mammals 2017, 43(2), 193-200.

Cefas (2011). Guidelines for Data Acquisition to Support Marine Environmental Assessments of Offshore Renewable Energy Projects. Contract report: ME5403, September 2011.

Cheesman, S. (2016). Measurements of Operational Wind Turbine Noise in UK Waters. Advances in Experimental Medicine and Biology, 153–160. doi:10.1007/978-1-4939-2981-8_18

Cheesman, S. (2016). Measurements of Operational Wind Turbine Noise in UK Waters. Advances in Experimental Medicine and Biology, 153–160. doi:10.1007/978-1-4939-2981-8_18

Cheney, B., Thompson, P.M., Ingram, S.N., Hammond, P.S., Stevick, P.T., Durban, J.W., Culloch, R.M., Elwen, S.H., Mandleberg, L., Janik, V.M., Quick, N.J., Islas-Villanueva, V., Robinson, K.P., Costa, M., Eisfel, S.M., Walters, A., Phillips, C., Weir, C.R., Evans, P.G.H., Anderwald, P., Reid, R.J., Reid, J.B. and Wilson, B. (2013). Integrating multiple data sources to assess the distribution and abundance of bottlenose dolphins (Tursiops truncatus) in Scottish waters. Mammal Review. 43(1), pp.71- 88.

CIEEM (2019). Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater, Coastal and Marine. https://cieem.net/wp-content/uploads/2018/08/ECIA-Guidelines-2018-Terrestrial-Freshwater-Coastal-and-Marine-V1.1Update.pdf (Accessed February 2024)

Conn, P.B. and Silber, G.K. (2013). Vessel speed restrictions reduce risk of collision-related mortality for North Atlantic right whales. *Ecosphere*, 4(4), pp.1-16

CSIP (2004) Trends in cetacean strandings around the UK coastline and cetacean and marine turtle post-mortem investigations for the year 2003

CSIP (2005) Trends in cetacean strandings around the UK coastline and cetacean and marine turtle post-mortem investigations for the year 2004

CSIP (2011). UK Cetacean Strandings Investigation Programme. Final Report for the period 1st January 2005 – 31st December 2010

CSIP (2018) UK Cetacean Strandings Investigation Programme Marine Biodiversity Division, Defra. Final Contract Report 1st January2011 to 31st December 2017.

CSIP (2019). Marine Mammal & Marine Turtle Strandings (Welsh Coast). CSIP/Marine Environmental Monitoring Annual Report 2018.

CSIP (2020). Marine Mammal & Marine Turtle Strandings (Welsh Coast). CSIP/Marine Environmental Monitoring Annual Report 2019.

Cumbria Wildlife Trust (2023). News. *Seal deaths raise concerns as boat disturbance incidents blight start of pupping season* https://www.cumbriawildlifetrust.org.uk/news/seal-deaths-raise-concerns-boat-disturbance-incidents-blight-start-pupping-season (Accessed December 2023)

Davis, G.E., Baumgartner, M.F., Corkeron. P.J., *et al*. (2020) Exploring movement patterns and changing distributions of baleen whales in the western North Atlantic using a decade of passive acoustic data. Glob Change Biol. 2020;00:1–29.

DECC (2011a) Overarching National Policy Statement for Energy (EN-1). Presented to Parliament pursuant to Section 5(9) of the Planning Act 2008. The Stationary Office, London.

DECC (2011b) National Policy Statement for Renewable Energy Infrastructure (EN-3). Presented to Parliament pursuant to Section 5(9) of the Planning Act 2008. The Stationary Office, London.

DECC (2011c) National Policy Statement for Electricity Networks Infrastructure (EN-5). Presented to Parliament pursuant to Section 5(9) of the Planning Act 2008. The Stationary Office, London.

DECC (2016). UK Offshore Energy Strategic Environmental Assessment 3 (OESEA3). https://www.gov.uk/government/consultations/uk-offshore-energy-strategic-environmental-assessment-3-oesea3

Defra (2003). UK small cetacean bycatch response strategy. Department for Environment, Food and Rural Affairs. March 2003.

Department for Energy Security & Net Zero (2023). National Policy Statement for Renewable Energy Infrastructure (EN-3). Available at: https://assets.publishing.service.gov.uk/media/65a7889996a5ec000d731aba/nps-renewable-energy-infrastructure-en3.pdf. (Accessed October 2024)

DESNZ (2023a). Overarching National Policy Statement for Energy (EN-1). Available at: https://www.gov.uk/government/publications/overarching-national-policy-statement-for-energy-en-1 (Accessed February 2024)

DESNZ (2023b). National Policy Statement for Renewable Energy Infrastructure (EN 3). Available at: https://www.gov.uk/government/publications/national-policy-statement-for-renewable-energy-infrastructure-en-3 (Accessed February 2024)

Diederichs, A., Brandt, M. and Nehls, G. (2010). Does sand extraction near Sylt affect harbour porpoises? Wadden Sea Ecosystem, 26: 199–203.

Diederichs, A., Nehls, G., Dähne, M., Adler, S., Koschinski, S. and Verfuß, U. (2008). Methodologies for measuring and assessing potential changes in marine mammal behaviour, abundance or distribution arising from the construction, operation and decommissioning of offshore windfarms. Commissioned by COWRIE Limited, 231.

Dolman, S. and Simmonds, M., 2010. Towards best environmental practice for cetacean conservation in developing Scotland's marine renewable energy. Marine Policy, 34(5), pp.1021-1027.

Donovan, C., Harwood J., King S., Booth C., Caneco B. and Walker C. (2016). Expert elicitation methods in quantifying the consequences of acoustic disturbance from offshore renewable energy developments. Pages 231-237. The Effects of Noise on Aquatic Life II. Springer.

DP Energy & Iberdrola (2022a). Inis Ealga. EIAR Scoping Report. Available at https://inisealgamarineenergypark.com/eiar/. (Accessed December 2024)

DP Energy & Iberdrola (2022b). Shelmalere. EIAR Scoping Report. Available at: https://shelmalereoffshorewindfarm.com/wp-content/uploads/2022/06/S004IE_RPT_EIAR-Scoping-Report_20220623_Website-Version.pdf. (Accessed December 2024)

Dunlop, R.A., Noad, M.J., McCauley, R.D., Scott-Hayward, L., Kniest, E., Slade, R., Paton, D. and Cato, D.H. (2017). Determining the behavioural dose–response relationship of marine mammals to air gun noise and source proximity. Journal of Experimental Biology, 220(16), 2878–2886.

Dyndo, M., Wiśniewska, D.M., Rojano-Doñate, L. and Madsen, P.T. (2015) 'Harbour porpoises react to low levels of high frequency vessel noise', Scientific Reports, 5, 11083. doi: 10.1038/srep11083.

Edren, S.M.C., Andersen, S.M., Teilmann, J., Carstensen, J., Harders, P.B., Dietz, R. & Miller, L.A. (2010) The effect of a large Danish offshore wind farm on harbor and gray seal haul-out behavior. Marine Mammal Science, 26, 614-634.

Evans, P. G., Baines, M.E., and Anderwald, P. (2011). Risk Assessment of Potential Conflicts between Shipping and Cetaceans in the ASCOBANS Region. 18th ASCOBANS Advisory Committee Meeting AC18/Doc.6-04 (S) rev.1 UN Campus, Bonn, Germany, 4-6 May 2011 Dist. 2 May 2011.

Evans, P., & Waggitt, J. (2023). Distribution and Abundance of Cetaceans and Seabirds in Wales and Surrounding Waters. NRW Evidence Report No. 646. Bangor: Natural Resources Wales.

Evans, P.G.H and Waggitt, J.J. (2020). Impacts of climate change on marine mammals, relevant to the coastal and marine environment around the UK. MCCIP Science Review 2020, 420–454.

Evans, P.G.H. and Bjørge, A. (2013). Impacts of climate change on marine mammals. Marine Climate Change Impacts Partnership (MCCIP) Annual Report Card 2011-2012 Scientific Review: 1-34.

Evans, P.G.H., Baines, M. E., Anderwald, P. (2011). Risk assessment of potential conflicts between shipping and cetaceans in the ASCOBANS Region. AC18/Doc.6-04. 18th ASCOBANS Advisory Committee Meeting. Available from: https://www.ascobans.org/sites/default/files/basic_page_documents/AC18_6-04_rev1_ProjectReport_ShipStrikes.pdf (Accessed September 2024)

Faulkner, R.C., Farcas, A. and Merchant, N.D. (2018). Guiding principles for assessing the impact of underwater noise. Journal of Applied Ecology 2018;1–6. DOI: 10.1111/1365-2664.13161: https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/1365-2664.13161(Accessed February 2024)

Felce, T. (2014). Sea Watch Foundation – Isle of Man. Available at: https://www.seawatchfoundation.org.uk/29-isle-of-man/page/155/ (Accessed March 2024)

Fernandez-Betelu, O., Graham, I.M. and Thompson, P.M. (2022). Reef effect of offshore structures on the occurrence and foraging activity of harbour porpoises. Frontiers in Marine Science, 9, p.980388.

Fernandez-Betelu, O., Graham, I.M., Malcher, F., Webster, E., Cheong, S.H., Wang, L., Iorio-Merlo, V., Robinson, S. and Thompson, P.M (2024). Characterising underwater noise and changes in harbour porpoise behaviour during the decommissioning of an oil and gas platform. Marine Pollution Bulletin, 200, p.116083.

Finneran, J.J., Carder, D.A., Schlundt, C.E. and Ridgway, S.H. (2005). Temporary threshold shift in bottlenose dolphins (Tursiops truncatus) exposed to mid-frequency tones. J Acoustic Soc Am 118:2696–705.

Flotation Energy (2023). White Cross Offshore Windfarm Environmental Statement Chapter 12: Marine Mammal and Marine Turtle Ecology. Available at: FLO-WHI-REP-0002-12-Chapter-12-Marine-Mammal-and-Marine-Turtle-Ecology.pdf (Accessed 08th January 2025)

Frankish, C.K., von Benda-Beckmann, A.M., Teilmann, J., Tougaard, J., Dietz, R., Sveegaard, S., Binnerts, B., de Jong, C.A. and Nabe-Nielsen, J., 2023. Ship noise causes tagged harbour porpoises to change direction or dive deeper. *Marine Pollution Bulletin*, *197*, p.115755.

Gaskin, D.E. (1984). The harbour porpoise Phocoena phocoena (L.): regional populations, status and information on direct and indirect catches. Report of International Whaling Commission, 34, pp.569-586.

Gende, S.M., Hendrix, A.N., Harris, K.R., Eichenlaub, B., Nielsen, J. and Pyare, S. (2011). A Bayesian approach for understanding the role of ship speed in whale–ship encounters. Ecological Applications, 21(6), pp.2232-2240.

Gilles, A., Authier, M., Ramirez-Martinez, N.C., Araújo, H., Blanchard, A., Carlström, J., Eira, C., Dorémus, G., Fernández-Maldonado, C., Geelhoed, S.C.V., Kyhn, L., Laran, S., Nachtsheim, D., Panigada, S., Pigeault, R., Sequeira, M., Sveegaard, S.,

Taylor, N.L., Owen, K., Saavedra, C., Vázquez-Bonales, J.A., Unger, B., Hammond, P.S. (2023). Estimates of cetacean abundance in European Atlantic waters in summer 2022 from the SCANS-IV aerial and shipboard surveys. Final report published 29 September 2023. 64 pp. https://tinyurl.com/3ynt6swa (Accessed January 2024)

Hastie, G.D., Lepper, P., McKnight, J.C., Milne, R., Russell, D.J. and Thompson, D., 2021. Acoustic risk balancing by marine mammals: anthropogenic noise can influence the foraging decisions by seals. *Journal of Applied Ecology*, *58*(9), pp.1854-1863.

Godin, O.A. (2008). Sound transmission through water–air interfaces: New insights into an old problem. Contemporary Physics, 49(2), pp.105-123.

Gordon, J., Gillespie, D., Potter, J., Frantzis, A., Simmonds, M.P., Swift, R. and Thompson, D., 2003. A review of the effects of seismic surveys on marine mammals. Marine Technology Society Journal, 37(4), pp.16-34.

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

Graham, I.M., Merchant, N.D., Farcas, A., Barton, T.R., Cheney, B., Bono, S. and Thompson, P.M. (2019). Harbour porpoise responses to pile-driving diminish over time. R. Soc. Open sci. 6: 190335. http://dx.doi.org/10.1098/rsos.190335

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

Graham, I.M., Merchant, N.D., Farcas, A., Barton, T.R., Cheney, B., Bono, S. and Thompson, P.M. (2019). Harbour porpoise responses to pile-driving diminish over

Hammond, P.S., Berggren, P., Benke, H., Borchers, D.L., Collet, A., Heide-Jørgensen, M.P., Heimlich, S., Hiby, A.R., Leopold, M.F. and Øien, N. (2002). Abundance of harbour porpoises and other cetaceans in the North Sea and adjacent waters. J. Appl. Ecol. 39, 361–376.

Hammond, P.S., Lacey, C., Gilles, A., Viquerat, S., Boerjesson, P., Herr, H., Macleod, K., Ridoux, V., Santos, M.B., Scheidat, M., Teilmann, J., Vingada, J. and Øien, N. (2021). Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys. June 2021. Available from: https://synergy.st-andrews.ac.uk/scans3/files/2021/06/SCANS-III_design-based_estimates_final_report_revised_June_2021.pdf (Accessed February 2024)

Hammond, P.S., Macleod, K., Berggren, P., Borchers, D.L., Burt, M.L., Cañadas, A., Desportes, G., Donovan, G.P., Gilles, A., Gillespie, D., Gordon, J., Hedley, S., Hiby, L., Kuklik, I., Leaper, R., Lehnert, K., Leopold, M., Lovell, P., Øien, N., Paxton, C., Ridoux, V., Rogan, E., Samarra, F., Scheidat, M., Sequeira, M., Siebert, U., Skov, H., Swift, R., Tasker, M.L., Teilmann, J., Van Canneyt, O. and Vázquez, J.A. (2013).

Cetacean abundance and distribution in European Atlantic shelf waters to inform conservation and management. Biological Conservation 164: 107-122.

Hao, X., Hamel, H., Grandjean, C., Fedutin, I., Wahlberg, M., Frankish, C. and Nabe-Nielsen, J. (2024). Harbour porpoises respond to small boats by speeding up and moving away. *Authorea Preprints*.

Harris, R.E., Miller, G. W. and Richardson, W. J. (2001). Seal responses to air gun sounds during summer seismic surveys in the Alaskan Beaufort Sea. Mar Mam Sci. 17:795-812.

Harwood, J. and King, S. (2014). *The Sensitivity of UK Marine Mammal Populations to Marine Renewables Developments* (Report No. SMRUL-NER-2012-027). Report by SMRU Consulting. Journal of the Acoustical Society of America, 147(6), 3948–3958. https://doi.org/10.1121/10.0001408

Harwood, J., King, S., Schick, R., Donovan, C. & Booth, C. (2013). A Protocol For Implementing The Interim Population Consequences Of Disturbance (PCoD) Approach: Quantifying And Assessing The Effects Of UK Offshore Renewable Energy Developments On Marine Mammal Populations. Report Number SMRUL-TCE-2013-014. Scottish Marine And Freshwater Science, 5(2).

Harwood, J., King, S., Schick, R., Donovan, C. and Booth, C. (2014). A protocol for implementing the interim population consequences of disturbance (PCoD) approach: quantifying and assessing the effects of UK offshore renewable energy developments on marine mammal populations. Report number SMRUL-TCE-2013-014. Scottish Marine and Freshwater Science, 5(2).

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

Hildebrand, J.A., (2009). Anthropogenic and natural sources of ambient noise in the ocean. *Marine Ecology Progress Series*, *395*, pp.5-20.

Hudson, T. (2014). Bottlenose Dolphin (Tursiops truncatus) Responses to Boat Activities in New Quay Bay. Master's Thesis, Bangor University, Anglesey, UK, 2014. Available online: https://www.seawatchfoundation.org.uk/wp-content/uploads/2015/05/Tess-Hudson-MSc-thesis.pdf (Accessed September 2024)

HWDT (2018). Hebridean Marine Mammal Atlas. Part 1: Silurian, 15 years of marine mammal monitoring in the Hebrides. A Hebridean Whale and Dolphin Trust Report

IAMMWG (2015). Management Units for cetaceans in UK waters (January 2015). JNCC Report No. 547, JNCC Peterborough.

IAMMWG (2022). Updated abundance estimates for cetacean Management Units in UK waters. JNCC Report No. 680 (Revised March 2022), JNCC Peterborough, ISSN 0963-8091.

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

Jansen, J.K., Boveng, P.L., Dahle, S.P. and Bengston, J.L. (2010). Reaction of harbor seals to cruise ships. Journal of Wildlife Management,74,1186–1194. https://doi.org/10.1111/j.1937-2817.2010.tb01239.x

JCDP (2022). https://jncc.gov.uk/our-work/joint-cetacean-data-programme/ (Accessed February 2024)

Jitlal, M., Burthe, S., Freeman S. and Daunt, F. (2017) Testing and Validating Metrics of Change Produced by Population Viability Analysis (PVA) Final report to Marine Scotland Science September 2017 Scottish Marine and Freshwater Science Vol 8 No 23JNCC (2010). Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise. August 2010.

JNCC (2019). Article 17 Habitats Directive Report 2019: Species Conservation Status Assessments 2019. Available at: https://jncc.gov.uk/our-work/article-17-habitats-directive-report-2019-species/#regularly-occurring-species-vertebrate-species-mammals-marine (Accessed February 2024)

JNCC (2019). Article 17 Habitats Directive Report 2019: Species Conservation Status Assessments 2019. Available at: https://jncc.gov.uk/our-work/article-17-habitats-directive-report-2019-species/#regularly-occurring-species-vertebrate-species-mammals-marine (Accessed February 2024)

JNCC, DAERA and Natural England (2020). Guidance for assessing the significance of noise disturbance against Conservation Objectives of harbour porpoise SACs (England, Wates and Northern Ireland). Dated June 2020.

JNCC, Natural England and CCW (2010). Draft EPS Guidance - The protection of marine European Protected Species from injury and disturbance. Guidance for the marine area in England and Wales and the UK offshore marine area. Joint Nature Conservation Committee, Natural England and Countryside Council for Wales. October 2010.

JNCC. (2023a) JNCC guidance for the use of Passive Acoustic Monitoring in UK waters for minimising the risk of injury to marine mammals from offshore activities. December 2023.

JNCC. (2023b). UK Marine Noise Registry Disturbance Tool: Description and Output Generation. September 2023.

JNCC (2025). JNCC guidelines for minimising the risk of injury to marine mammals from unexploded ordnance (UXO) clearance in the marine environment. JNCC, Aberdeen. January 2025.

JNCC, Natural England and Cefas (2025). JNCC, Natural England and Cefas position on the use of quieter piling methods and noise abatement systems when installing offshore wind turbine foundations. JNCC, Aberdeen.

Jones, D. and Marten, K. (2016). Dredging sound levels, numerical modelling and EIA. Maritime Solutions for a Changing World, p.21.

Jones, E.L., Hastie, G.D., Smout, S., Onoufriou, J., Merchant, N.D., Brookes, K.L. and Thompson, D. (2017). Seals and shipping: Quantifying Population Risk and Individual Exposure to Vessel Noise. Journal of Applied Ecology, 54(6), pp.1930–1940.

Jones, T.T., Bostrom, B.L., Hastings, M.D., Van Houtan, K.S., Pauly, D. and Jones, D.R. (2012). Resource Requirements of the Pacific Leatherback Turtle Population. PLoS ONE 7(10): e45447. https://doi.org/10.1371/journal.pone.0045447

Kastelein, R.A., Gransier, R., Hoek, L. and Olthuis, J. (2012). Temporary threshold shifts and recovery in a harbor porpoise (Phocoena phocoena) after octave-band noise at 4 kHz. J. Acoust. Soc. Am. 132, 3525–3537.

Kastelein, R.A., Hardemann, J. and Boer, H. (1997). Food consumption and body weight of harbour porpoises (Phocoena phocoena). In The biology of the harbour porpoise Read, A.J., Wiepkema, P.R., Nachtigall, P.E (1997). Eds. Woerden, The Netherlands: De Spil Publishers. pp. 217–234.

Kastelein, R.A., Helder-Hoek, L., Covi, J. and Gransier, R. (2016). Pile driving playback sounds and temporary threshold shift in harbor porpoises (Phocoena phocoena): Effect of exposure duration. J. Acoust. Soc. Am. 139, 2842–2851.

Kastelein, R.A., Van de Voorde, S. and Jennings, N. (2018). Swimming Speed of a Harbour Porpoise (Phocoena phocoena) During Playbacks of Offshore Pile Driving Sounds. Aquatic Mammals: 44(1):92-99.

Keen, E.M., Mahony, É.O., Nichol, L.M., Wright, B.M., Shine, C., Hendricks, B., Meuter, H., Alidina, H.M. and Wray, J. (2023). Ship-strike forecast and mitigation for whales in Gitga'at First Nation territory. Endangered Species Research, 51, pp.31-58.

Kershaw, J.L., Ramp, C.A., Sears, R., Plourde, S., Brosser, P., Miller, P.J.O. and Hall, A.J. (2020). Declining reproductive success in the Gulf of St. Lawrence's humpback whales (Megaptera novaeangliae) reflects ecosystem shifts on their feeding grounds. Global Change Biology (2020). DOI: 10.1111/gcb.15466.

King, S. L., Schick, R. S., Donovan, C., Booth, C. G., Burgman, M., Thomas, L., and Harwood, J. (2015). An interim framework for assessing the population consequences of disturbance. Methods in Ecology and Evolution, 6, 1150-1158.

Koroza, A. and Evans, P.G.H., 2022. Bottlenose Dolphin Responses to Boat Traffic Affected by Boat Characteristics and Degree of Compliance to Code of Conduct. Sustainability 2022, 14, 5185.

Kroese, M.V., Beckers, L., Bisselink, Y.J.W.M., Brasseur, S., van Tulden, P.W. et al. (2018) Brucella pinnipedialis in grey seals (Halichoerus grypus) and harbour seals (Phoca vitulina) in the Netherlands. Journal of Wildlife Diseases, 54(3), 439–449.

Laist, D.W., Knowlton, A.R. and Pendleton, D. (2014). Effectiveness of mandatory vessel speed limits for protecting North Atlantic right whales. Endangered Species Research, 23(2), pp.133-147.

Laist, D.W., Knowlton, A.R., Mead, J.G., Collet, A.S. and Podesta, M. (2001). Collisions between ships and whales. Marine Mammal Science, 17(1), pp.35-75.

Leaper, R. (2019). The role of slower vessel speeds in reducing greenhouse gas emissions, underwater noise and collision risk to whales. Frontiers in Marine Science, 6, p.505.

Learmonth, J.A., Macleod, C.D., Santos, M.B., Pierce, G.J., Crick, H.Q.P. and Robinson, R.A. (2006). Potential effects of climate change on marine mammals. Oceanography and Marine Biology: An Annual Review 44, 429-462.

Leemans, J.J and & Fijn, R.C. (2023). Observations Of Harbour Porpoises In Offshore Wind Farms. Final report. Report 23-495. Waardenburg Ecology, Culemborg.

Lindeboom, H.J., Kouwenhoven, H.J., Bergman, M.J.N., Bouma, S., Brasseur, S., Daan, Fijn, R.C., de Haan, D., Dirksen, S., van Hal, R, Hille Ris Lambers, R, ter Hofstede, Krijgsveld, R.K.L., Leopold, M. and Scheidat, M. (2011). Short-term ecological effects of an offshore wind farm in the Dutch coastal zone; a compilation. Environ. Res. Lett. 6 (3).

Lonergan, M, Duck, C., Moss, S., Morris, C. and Thompson, D. (2013). Rescaling of aerial survey data with information from small numbers of telemetry tags to estimate the size of a declining harbour seal population. Aquatic Conservation-Marine and Freshwater Ecosystems 23 (1):135-144.

Long, C. 2017. Analysis of the possible displacement of bird and marine mammal species related to the installation and operation of marine energy conversion systems. Scottish Natural Heritage Commissioned Report No. 947

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

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

MacDonald, M.A., Hildebrand, J.A. and Webb, S.C. (1995). Blue and fin whales observed on a seafloor array in the Northeast Pacific. J Acoust Soc Am. 98:712-721.

Machernis, A.F., Powell, J.R., Engleby, L.K. and Spradlin, T.R. (2018). An Updated Literature Review Examining the Impacts of Tourism on Marine Mammals over the Last Fifteen Years (2000-2015) to Inform Research and Management Programs.S. Dept. of Commerce, NOAA. NOAA Technical Memorandum NMFS-SER-7: 66 p.

MacLeod, C.D., Bannon, S.M., Pierce, G.J., Schweder, C., Learmonth, J.A., Herman, J.S. and Reid, R.J. (2005). Climate change and the cetacean community of north-west Scotland. Biological Conservation 124: 477-483.

Madsen, P. T., Wahlberg, M., Tougaard, J., Lucke, K. and Tyack, P. (2006). Wind turbine underwater noise and marine mammals: implications of current knowledge and data needs. Mar Ecol Prog Ser, 309; 279-295.

Malme, C.I., Miles, P.R., Miller, G.W., Richardson, W.J., Roseneau, D.G., Thomson, D.H. and Greene, C.R. (1989). Analysis and ranking of the acoustic disturbance potential of petroleum industry activities and other sources of noise in the environment of marine mammals in Alaska. Final Report No. 6945 to the US Minerals Management Service, Anchorage, AK. BBN Systems and Technologies Corp. Available at: http://www.mms.gov (Accessed December 2023)

Marine Scotland (2012). MS Offshore Renewables Research: Work Package A3: Request for advice about the displacement of marine mammals around operational offshore windfarms. Available at: http://www.gov.scot/Resource/0040/00404921.pdf (Accessed March 2024)

Marmo, B., Roberts, I., Buckingham, M.P., King, S., and Booth, C. (2013). Modelling of Noise Effects of Operational Offshore Wind Turbines including noise transmission through various foundation types. Report to Marine Scotland. 108 pp.

McConnell, B., Lonergan, M. and Dietz, R. (2012). Interactions between seals and offshore wind farms. The Crown Estate. ISBN: 978-1-906410-34-5.

McGarry, T., Boisseau, O., Stephenson, S. and Compton, R. (2017). Understanding the Effectiveness of Acoustic Deterrent Devices on Minke Whale (Balaenoptera acutorostrata), a low frequency cetacean. ORJIP Project 4, Phase 2. impact 1 Report EOR0692. Prepared on behalf of The Carbon Trust. November 2017.

McGarry, T., De Silva, R., Canning, S., Mendes, S., Prior, A., Stephenson, S. and Wilson, J. (2020). Evidence base for application of Acoustic Deterrent Devices (ADDs) as marine mammal mitigation (Version 2.0). JNCC Report No. 615, JNCC, Peterborough. ISSN 0963-8091.

McGarry, T., De Silva, R., Canning, S., Mendes, S., Prior, A., Stephenson, S. and Wilson, J. (2020). Evidence base for application of Acoustic Deterrent Devices (ADDs) as marine mammal mitigation (Version 2.0). JNCC Report No. 615, JNCC, Peterborough. ISSN 0963-8091.

Menter Mon Morlais Limited (2019). Morlais Environmental Statement Chapter 12 Marine Mammals Volume 1. Available at: file:///C:/Users/923875/Downloads/ORML1938%20Morlais_ES_Ch12_F3.0_Marine%20Mammals%20(1).pdf (Accessed 08th January 2025).

Mills, E.M.M., Piwetz, S. and Orbach, D.N. (2023). Vessels Disturb Bottlenose Dolphin Behavior and Movement in an Active Ship Channel. *Animals*, 13(22), pp.3441–3441

MMO (2015). Modelled mapping of continuous underwater noise generated by activities. A report produced for the Marine Management Organisation, pp50. MMO Project N. 1097. ISBN 978-1-909452-87-9.

Mona Offshore Wind Limited (2024). Mona Offshore Wind Project - Environmental Statement Volume 2, Chapter 4: Marine mammals. Available at: https://publicregister.naturalresources.wales/ (Accessed 08th January 2025)

Mona Offshore Wind Limited (2024). Morgan Offshore Wind Project - Environmental Statement Volume 2, Chapter 4: Marine mammals. Available at: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010136/EN010136-000151-F2.4_Morgan_Gen_ES_Marine%20mammals.pdf (Accessed 08th January 2025)

Morecambe Offshore Windfarm Ltd (2023). FLO-MOR-REP-0005 Morecambe Offshore Windfarm Generation Assets: Draft Report to Inform the Appropriate Assessment.

Morgan Offshore Wind Limited and Morecambe Offshore Windfarm Limited (2023). Morgan and Morecambe Offshore Wind Farms: Transmission Assets. Preliminary Environmental Information Report. Available at: https://morecambeandmorgan.com/transmission/our-consultation/consultationhub/ (Accessed January 2024)

Morgan Offshore Wind Limited, Morecambe Offshore Windfarm Ltd (2024). Morgan And Morecambe Offshore Wind Farms: Transmission Assets Environmental Statement Volume 2, Chapter 4: Marine mammals. Available at: Transmission Assets ES Volume 2 Chapter 4. (Accessed 08th January 2025)

Morris, C.D. and Duck, C.D. (2019) Aerial thermal-imaging survey of seals in Ireland, 2017 to 2018. Irish Wildlife Manuals, No. 111 National Parks and Wildlife Service,

Nabe-Nielsen, J., van Beest, F.M., Grimm, V., Sibly, R.M., Teilmann, J. and Thompson, P.M. (2018). Predicting the impacts of anthropogenic disturbances on marine populations. Conserv Lett. 2018;e12563. https://doi.org/10.1111/conl.12563.

Natural England (2019). Seal Necropsies in England. Natural England Commissioned Report NECR263

NatureScot (2020a). Conservation and Management Advice – Seas of Hebrides MPA. NatureScot. December 2020.

NatureScot (2020b). Conservation and Management Advice - North-east Lewis MPA. NatureScot. December 2020.

NatureScot (2020c). Conservation and Management Advice -Southern Trench MPA. NatureScot. December 2020.

Nedwell, J.R., Langworthy, J. and Howell, D. (2003). Assessment of subsea noise and vibration from offshore wind turbines and its impact on marine wildlife. Initial measurements of underwater noise during construction of offshore wind farms, and comparisons with background noise. Subacoustech Report No. 544R0423, published by COWRIE, May 2003.

New, L., Pirotta, E., and Lusseau, D. (2020). Dolphins and boats: When is a disturbance, disturbing? *Frontiers in Marine Science*, 7, 353. doi: 10.3389/fmars.2020.00353.

NIRAS Consulting Limited and SMRU Consulting (2019). Reducing Underwater Noise, Report on Behalf of The Crown Estate. Available at: https://opendata-thecrownestate.opendata.arcgis.com/datasets/b07b8b046bb64d4b99c57ad993111c39 (Accessed February 2024)

NMFS (2005). Scoping Report for NMFS EIS for the National Acoustic Guidelines on Marine Mammals. National Marine Fisheries Service

NMFS (National Marine Fisheries Service). (2018). 2018 Revisions to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Dept. of Commer., NOAA. NOAA Technical Memorandum NMFS-OPR-59, 167 p.

NOAA (2021). *Vessel strikes*. Available at: https://www.fisheries.noaa.gov/national/vessel-strikes. (Accessed September 2024)

North Irish Sea Array Windfarm Ltd (2024). North Irish Sea Array Windfarm Environmental Impact Assessment Report. Available at: https://northirishseaarraysid.ie/ (Accessed 10th December 2024)

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

NRW. (2023). PS016 NRW's Position on Assessing the effects of Hearing Injury from Underwater Noise on Marine Mammals. Position statement. May 2023.

Nykänen, M., Louis, M., Dillane, E., Alfonsi, E., Berrow, S., O'Brien, J., Brownlow, A., Covelo, P., Dabin, W., Deaville, R. and de Stephanis, R., 2019. Fine-scale population structure and connectivity of bottlenose dolphins, Tursiops truncatus, in European waters and implications for conservation. Aquatic Conservation: Marine and Freshwater Ecosystems, 29, pp.197-211.

Oakley, J.A., Williams, A.Y. and Thomas, T. (2017). Reactions of harbour porpoise (Phocoena phocoena) to vessel traffic in the coastal waters of South West Wales. Ocean and Coastal Management Volume 138, 15 March 2017, Pages 158-169: https://doi.org/10.1016/j.ocecoaman.2017.01.003 (Accessed November 2023)

Onoufriou, J., Jones, E., Hastie, G. and Thompson, D. (2016). Investigations into the interactions between harbour seals (Phoca vitulina) and vessels in the inner Moray Firth. Marine Scotland Science.

Orgeret, F., Thibault, A., Kovacs, K., Lydersen, C., Hindell, M., Thompson, S.A. and Sudeman, W. (2021). Climate change impacts on seabirds and marine mammals: The importance of study duration, thermal tolerance and generation time. Ecology Letters. 2022;25:218-239.

OSPAR (2009). Overview of the impacts of anthropogenic underwater sound in the marine environment. London: OSPAR Commission Biodiversity Series. Publication no. 441/2009. 133 pp.

Otani, S., Naito, T., Kato, A. and Kawamura, A. (2000). Diving behaviour and swimming speed of a free-ranging harbour porpoise (Phocoena phocoena). Marine Mammal Science, Volume 16, Issue 4, pp 811-814, October 2000.

Parker, J., Banks, A., Fawcett, A., Axelsson, M., Rowell, H., Allen, S., Ludgate, C., Humphrey, O., Baker, A. & Copley, V. (2022a). Offshore Wind Marine Environmental Assessments: Best Practice Advice for Evidence and Data Standards. Phase I: Expectations for pre-application baseline data for designated nature conservation and landscape receptors to support offshore wind applications. Natural England. Version 1.1. 79 pp.

Parker, J., Fawcett, A., Banks, A., Rowson, T., Allen, S., Rowell, H., Harwood, A., Ludgate, C., Humphrey, O., Axelsson, M., Baker, A. & Copley, V. (2022c). Offshore Wind Marine Environmental Assessments: Best Practice Advice for Evidence and Data Standards. Phase III: Expectations for data analysis and presentation at examination for offshore wind applications. Natural England. Version 1.2. 140 pp.

Parkwind & ESB (2024). Oriel Wind Farm Project Environmental Impact Assessment Report Chapter 10: Marine Mammals and Megafauna. Available at: https://orielwindfarm-marineplanning.ie/data/files/Environmental%20Documents/Environmental%20Impact%20Assessment%20Report%20(EIAR)/-Volume%202B:%20Chapters%207%20-%2016%20and%20associated%20technical%20appendices/10.%20Marine%20Mammals%20and%20Megafauna.pdf. (Accessed 15th January 2025)

Paterson, W., Russell, D.J.F, Wu, M., McConnell, B.J. and Thompson, D. (2015). Harbour seal haul-out monitoring, Sound of Islay. Scottish Natural Heritage Commissioned Report No. 894.

Paterson, W.D., Russell, D.J.F., Wu, Gi-Mick, McConnell, B.J., Currie, J., McCafferty, D. and Thompson, D. (2019). Post-disturbance haul-out behaviour of harbour seals. Aquatic Conservation: Marine and Freshwater Ecosystems. Doi: 10.1002/aqc.3092.

Paxton, C.G.M., Scott-Hayward, L., Mackenzie, M., Rexstad, E. and Thomas., L. (2016). Revised Phase III Data Analysis of Joint Cetacean Protocol Data Resources. JNCC Report No. 517, ISSN 0963 8901.

Penrose, R.S. and Gander, L.R. (2020). British and Irish Marine Turtle Strandings & Sighting Annual Report 2019. Marine Environmental Monitoring, Cardigan, Wales, UK, 25pp.

Penrose, R.S., Westfield, M.J.B., and Gander, L.R. (2022) British and Irish Marine Turtle Stranding's and Sighting's Annual Report 2021. Available from: https://media.mcsuk.org/documents/2021_Turtle_Strandings_Report_2.pdf (Accessed December 2023)

PINS (2022). SCOPING OPINION: Proposed Morecambe Offshore Wind Farm. Case Reference: EN010121. Available online: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010121/EN010121-000052-MORC%20-%20Scoping%20Opinion%20.pdf (Accessed October 2023)

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

Planning Inspectorate (2018). Advice Note Nine: Rochdale Envelope https://infrastructure.planninginspectorate.gov.uk/wp-content/uploads/2013/05/Advice-note-9.-Rochdale-envelope-web.pdf (Accessed February 2024)

Polacheck, T and Thorpe, L. (1990). The swimming direction of harbour porpoise in relation to a survey vessel. Report of the International Whaling Commission, 40: 463-470.

Popper, A. N., Hawkins, A. D., Fay, R. R., Mann, D. A., Bartol S, Carlson T J, Coombs S, Ellison W T, Gentry R L, Halvorsen M B, Løkkeborg S, Rogers P H, Southall B L, Zeddies D G, Tavolga W N (2014). Sound exposure guidelines for Fishes and Sea Turtles. Springer Briefs in Oceanography, DOI 10.1007/978-3-319-06659-2.

Quick, N. J., Arso Civil, M., Cheney, B., Islas, V., Janik, V., Thompson, P.M. and Hammond, P.S. (2014). The east coast of Scotland bottlenose dolphin population: Improving understanding of ecology outside the Moray Firth SAC. This document was produced as part of the UK Department of Energy and Climate Change's offshore energy Strategic Environmental Assessment programme.

Ransijn, J.M., Booth, C. and Smout, S.C. (2019). A calorific map of harbour porpoise prey in the North Sea. JNCC Report No. 633. JNCC, Peterborough, ISSN 0963 8091.

Reid, J.B., Evans, P.G.H. and Northridge, S.P. (2003). Atlas of cetacean distribution in north-west European waters. Joint Nature Conservation Committee, Peterborough. 76pp.

Richardson, J., Greene, C.R., Malme, C.I. and Thomson, D.H. (1995). Marine Mammals and Noise. San Diego California: Academic Press.

Richardson, W. J., Miller, G. W., & Greene, C. R., Jr. (1999). Displacement of migrating bowhead whales by sounds from seismic surveys in shallow waters of the Beaufort Sea. Journal of the Acoustical Society of America, 106, 2281.

Risch, D., Castellote, M., Clark, C.W., Davis, G.E., Dugan, P.J., Hodge, L.E., Kumar, A., Lucke, K., Mellinger, D.K., Nieukirk, S.L. and Popescu, C.M. (2014). Seasonal migrations of North Atlantic minke whales: novel insights from large-scale passive acoustic monitoring networks. Movement ecology, 2(1), pp.1-17.

Risch, D., Favill, G., Marmo, B., vanGeel, N., Benjamins, S., Thompson, P, Wittich, A., & Wilson, B. (2023). Characterisation of underwater operational noise of two types of floating offshore wind turbines. Available at: https://supergen-ore.net/uploads/resources/Fortune_Report_Final.pdf (Accessed March 2024).

Robinson, K.P., O'Brien, J., Berrow, S., Cheney, B., Costa, M., Elsfield, S.M., Haberlin, D., Mandleberg, L., O'donovan, M., Oudejans, M.G. and O'Connor, I. (2012). Discrete or not so discrete: Long distance movements by coastal bottlenose dolphins in UK and Irish waters. Journal of Cetacean Research and Management 12: 365–371.

Robinson, N.J., Sanfelix, M.M., Blanco, G.S., Clyde-Brockway, C., Hill, J.E., Paladino, F.V., Tomás and Tomillo, P.S. (2022). Effect of water temperature on the duration of the internesting interval across sea turtle species. Journal of Thermal Biology Volume 110, December 2022. Available from: https://doi.org/10.1016/j.jtherbio.2022.103342 (Accessed November 2023).

Robinson, S.P., Theobald, P.D., Hayman, G., Wang, L.S., Lepper, P.A., Humphrey, V. and Mumford, S. (2011). Measurement of underwater noise arising from marine aggregate dredging operations. Marine Aggregate Levy Sustainability Fund MEPF report 09/P108.

Russel, D.J.F (2016). Movements of grey seal that haul out on the UK coast of the southern North Sea. Report for the Department of Energy and Climate Change (OESEA-14-47).

Russell, D.J.F. and McConnell, B.J. (2014). Seal at-sea distribution, movements and behavior. Report to DECC. URN: 14D/085. March 2014 (final revision).

Russell, D.J.F., Duck, C., Morris, C. and Thompson, D. (2016). Independent estimates of grey seal population size: 2008 and 2014. SCOS Briefing paper, 16(3).

RWE (2023). Awel y Môr Offshore Wind Farm - Environmental Statement Volume2, Chapter 7: Marine Mammals. Available at: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010112/EN010112-001560-8.66_D8_AyM_ES_Volume_2_Chapter_7_Marine_Mammals_RevD.pdf. (Accessed 08th January 2025)

Salfordacoustics (2023). Sound science for schools and colleges- Decibel Scale. Available at: https://salfordacoustics.co.uk/sound-waves/waves-transverse-introduction/decibel-#:~:text=It%20makes%20things%20easier%20if,an%20increase%20in%2010%20dB (Accessed March 2024).

SCANS-II (2008). Small cetaceans in the European Atlantic and North Sea. Final Report submitted to the European Commission under project LIFE04NAT/GB/000245, SMRU, St Andrews.

Scheidat, M., Tougaard, J., Brasseur, S., Carstensen, J., van Polanen Petel, T., Teilmann, J., and Reijnders, P. (2011). Harbour porpoise (Phocoena phocoena) and wind farms: a case study in the Dutch North Sea. Environ. Res. Lett. 6 (April-June 2011) 025102.

Schoeman, R.P., Patterson-Abrolat, C. and Plön, S. (2020). A global review of vessel collisions with marine animals. *Frontiers in Marine Science*, 7, p.292.

SCOS (2020). Scientific Advice on Matters Related to the Management of Seal Populations: 2020. Available at: http://www.smru.st-andrews.ac.uk/research-policy/scos/ (Accessed November 2023)

SCOS (2021). Scientific Advice on Matters Related to the Management of Seal Populations: 2021. Available at: http://www.smru.st-andrews.ac.uk/files/2022/08/SCOS-2021.pdf (Accessed December 2023)

SCOS (2022). Scientific Advice on Matters Related to the Management of Seal Populations: 2022. Available at: http://www.smru.st-andrews.ac.uk/files/2023/09/SCOS-2022.pdf (Accessed March 2024)

Scottish and Southern Energy (2020) EPS and Protected Sites and Species Risk Assessment – North Coast and Orkney Islands. Produced by Xodus Group Document Number: A-302244-S02-REPT-001

Sigray, P., and Andersson, M. H. (2011). Particle motion measured at an operational wind turbine in relation to hearing sensitivity in fish. The Journal of the Acoustical Society of America 130, 200-207. https://doi.org/10.1121/1.3596464 (Accessed January 2024)

Silber, G.K., Slutsky, J. and Bettridge, S., 2010. Hydrodynamics of a ship/whale collision. *Journal of Experimental Marine Biology and Ecology*, *391*(1-2), pp.10-19.

Sinclair, R. R., Kazer, S., Ryder, M., New, P. and Verfuss, U. K. (2023). Review and recommendations on assessment of noise disturbance for marine mammals. Natural Resources Wales

Sinclair, R., Booth, C., Harwood, J. & Sparling, C. (2019). Helpfile for the interim PCoD v5 model. March 2019.

Sinclair, R.R. (2024). Phase 1 Irish offshore wind farms: cumulative iPCoD modelling for NISA, Codling, Dublin Array, and Oriel (and Codling).

SMRU Limited (Sea Mammal Research Unit Limited) (2010). Approaches to Marine Mammal Monitoring at Marine Renewable Energy Developments. Final Report on behalf of The Crown Estate.

Southall, B.L., Bowles, A.E., Ellison, W.T., Finneran, J.J., Gentry, R.L., Greene Jr., C.R., Kastak, D., Ketten, D.R., Miller, J.H., Nachtigall, P.E., Richardson, W.J., Thomas, J.A., and Tyack, P.L. (2007). Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. Aquatic Mammals, 33 (4), pp. 411-509.

Southall, B.L., Finneran, J.J., Reichmuth, C., Nachtigall, P.E., Ketten, D.R., Bowles, A.E., Ellison, W.T., Nowacek, D.P. and Tyack, P.L. (2019). Marine mammal noise exposure criteria: updated scientific recommendations for residual hearing effects. Aquatic Mammals, 45(2), pp.125-232.

Southall, B.L., Nowacek, D.P., Bowles, A.E., Senigaglia, V., Bejder, L. and Tyack, P.L. (2021). Marine mammal noise exposure criteria: assessing the severity of marine mammal behavioral responses to human noise. Aquatic Mammals, 47(5), pp.421-464. DOI 10.1578/AM.47.5.2021.421.

Sparling, C., Sams, C., Stephenson, S., Joy, R., Wood, J., Gordon, J., Thompson, D., Plunkett, R., Miller, B. and Götz, T. (2015). The use of Acoustic Deterrents for the mitigation of Evidence base for application of Acoustic Deterrent Devices (ADDs) as marine mammal mitigation injury to marine mammals during pile driving for offshore wind farm construction. ORJIP Project 4, Stage 1 of Phase 2. Final Report.

SSE Renewables (2024). Arklow Bank Wind Park 2 -Environmental Impact Assessment Report. Available at: Arklow Bank Wind Park 2. (Accessed 20th December 2024).

Stöber, U. and Thomsen, F. (2021). How could operational underwater sound from future offshore wind turbines impact marine life? The Journal of the Acoustical Society of America, 149(3), pp.1791-1795. Available online at: PubMed.

Strong, P. and Morris, S.R. (2010). Grey seal (Halichoerus grypus) disturbance, ecotourism and the Pembrokeshire Marine Code around Ramsey Island. J. Ecotourism 9(2): 117–132.

Taormina, B., Bald, J., Want, A., Thouzeau, G., Lejart, M., Desroy, N. & Carlier, A. (2018). A review of potential impacts of submarine power cables on the marine environment: Knowledge gaps, recommendations and future directions. Renewable and Sustainable Energy Reviews, vol. 96, pp. 380-391.

Teilmann, J., Larsen, F. and Desportes, G. (2007). Time allocation and diving behaviour of harbour porpoises (Phocoena phocoena) in Danish and adjacent waters. Journal of Cetacean Research and Management 9(3): 201-210.

Teilmann, J., Carstensen, J., Dietz, R., Edrén, S. and Andersen, S. (2006). Final report on aerial monitoring of seals near Nysted Offshore Wind Farm Technical report to Energi E2 A/S. Ministry of the Environment Denmark.

Teilmann, J., Christiansen, C.T., Kjellerup, S., Dietz, R. and Nachman, G. (2013). Geographic, seasonal, and diurnal surface behavior of harbor porpoises. Marine mammal science, 29(2), pp.E60-E76.

Theobald, P.D., Robinson, S.P., Lepper, P.A., Hayman, G., Humphrey, V.F., Wang, L. and Mumford, S.E. (2011). The measurement of underwater noise radiated by dredging vessels during aggregate extraction operations. 4th International Conference and Exhibition on Underwater Acoustic Measurements: Technologies & Results.

Thompson, P.M., Brookes, K.L., Graham, I.M., Barton, T.R., Needham, K., Bradbury, G. and Merchant, N.D. (2013). Short-term disturbance by a commercial two-dimensional seismic survey does not lead to long-term displacement of harbour porpoises. Proceedings of the Royal Society B: Biological Sciences, 280(1771), p.20132001.

Thompson, P.M., Graham, I.M., Cheney, B., Barton, T.R., Farcas, A. and Merchant, N.D. (2020). Balancing risks of injury and disturbance to marine mammals when pile driving at offshore windfarms. Ecological Solutions and Evidence, 1(2), p.e12034. Available online at: Ecological Solutions and Evidence (Accessed February 2024).

Thompson, P.M., Hastie, G.D., Nedwell, J., Barham, R., Brookes, K., Cordes, L., Bailey, H. and McLean, N. (2012). Framework for assessing the impacts of pile-driving noise from offshore windfarm construction on the Moray Firth harbour seal population. Seal assessment Framework Technical Summary, 6th June 2012.

Thomsen, F., Lüdemann, K., Kafemann, R. and Piper, W. (2006). Effects of offshore windfarm noise on marine mammals and fish, on behalf of COWRIE Limited.

Todd, V.L.G., Todd, I.B., Gardiner, J.C., Morrin, E.C.N., MacPherson, N.A., DiMarzio, N.A. and Thomsen, F. (2014). A review of impacts of marine dredging activities on marine mammals. – International Council for the Exploration of the Sea (ICES) Journal of Marine Science, doi: 10.1093/icesjms/fsu187.

Tougaard, J. (2015). Underwater Noise from a Wave Energy Converter Is Unlikely to Affect Marine Mammals. PLoS ONE 10(7): e0132391. doi:10.1371/journal.pone.0132391.

Tougaard, J., Carstensen, J. and Teilmann, J. (2009a). Pile driving zone of responsiveness extends beyond 20km for harbour porpoises (Phocoena phocoena (L.)). J. Acoust. Soc. Am., 126, pp. 11-14.

Tougaard, J., Carstensen, J. and Teilmann, J. (2009b). Pile driving zone of responsiveness extends beyond 20km for harbour porpoises (Phocoena phocoena (L.)). J. Acoust. Soc. Am., 126, pp. 11-14.

Tougaard, J., Carstensen, J., Teilmann, J., Bech, N.I., Skov, H. and Henriksen, O.D. (2005). Effects of the Nysted Offshore wind farm on harbour porpoises. Annual status report for the T-POD monitoring program.

Tougaard, J., Carstensen, J., Wisch, M.S., Teilmann, J., Bech, N., Skov, H. and Henriksen, O.D. (2005). Harbour porpoises on Horns reef—effects of the Horns Reef Wind farm. Annual Status Report 2004 to Elsam. NERI, Roskilde. Available at: www.hornsrev.dk (Accessed January 2024).

Tougaard, J., Henriksen, O.D. and Miller, L.A. (2009a). Underwater noise from three types of offshore wind turbines: estimation of impact zones for harbour porpoise and harbour seals. Journal of the Acoustic Society of America 125(6): 3766.

Tougaard, J., Henriksen, O.D. and Miller, L.A. (2009b). Underwater noise from three types of offshore wind turbines: estimation of impact zones for harbour porpoise and harbour seals. Journal of the Acoustic Society of America 125(6): 3766.

Tougaard, J., Hermannsen, L. and Madsen, P.T. (2020). How loud is the underwater noise from operating offshore wind turbines? J. Acoust. Soc. Am. 148 (5). doi.org/10.1121/10.0002453.

Trigg, L.E., Chen, F., Shpiro, G/I., Ingram, S.N., Vincent, C., Thompson, D., Russell, D.J.F., Carter, M.I.D. and Embling, C.B. (2020). Predicting the exposure of diving grey seals to shipping noise. The Journal of the Acoustical Society of America 148, 1014 (2020); doi: 10.1121/10.0001727. Accessed January 2024.

UK Government (2010). The Marine Strategy Regulations 2010. 15th July 2010. Available from: UK Legislation.

UK Government (2011). Marine Policy Statement. Available at: UK Government. (Accessed March 2024).

UK Government, Defra, MMO, JNCC, NE, OPRED, DAERA, Nature Scot, Marine Scotland, NRW, BEIS and DESNZ (2025). Policy Paper. Marine Environment: Unexploded Ordnance Clearance Joint Position Statement. Available at: UK Government. (Accessed February 2025).

van der Molen, J., Smith, H.C., Lepper, P., Limpenny, S. and Rees, J. (2014). Predicting the large-scale consequences of offshore wind turbine array development on a North Sea ecosystem. Continental shelf research, 85, pp.60-72.

Van Waerebeek, K.O.E.N., Baker, A.N., Félix, F., Gedamke, J., Iñiguez, M., Sanino, G.P., Secchi, E., Sutaria, D., van Helden, A. and Wang, Y. (2007). Vessel collisions with small cetaceans worldwide and with large whales in the Southern Hemisphere, an initial assessment. Latin American Journal of Aquatic Mammals, pp.43-69.

Vanderlaan, A.S.M. and Taggart, C.T. (2007). Vessel Collisions with Whales: the Probability of Lethal Injury Based on Vessel Speed. Marine Mammal Science, 23(1), pp.144–156.

Verfuss, U.K., Plunkett, R., Booth, C.G. & Harwood, J. (2016). Assessing the benefit of noise reduction measures during offshore wind farm construction on harbour porpoises. WWF-UK.

Verfuss, U.K., Sinclair, R.R. and Sparling, C.E. (2019). A review of noise abatement systems for offshore wind farm construction noise, and the potential for their application in Scottish waters. Scottish Natural Heritage Research Report No. 1070.

Waggitt, J.J., Evans, P.G., Andrade, J., Banks, A.N., Boisseau, O., Bolton, M., Bradbury, G., Brereton, T., Camphuysen, C.J., Durinck, J. and Felce, T. (2019). Distribution maps of cetacean and seabird populations in the North-East Atlantic. Journal of Applied Ecology, 57(2), pp.253-269.

Wallace, B. et al. (2023). Marine turtle regional management units 2.0: an updated framework for conservation and research of wide-ranging megafauna species. Available from: PLOS ONE. (Accessed December 2023).

Wartzok, D., Popper, A., Gordon, J. and Merrill, J. (2003). Factors Affecting the Responses of Marine Mammals to Acoustic Disturbance. Marine Technology Society Journal, 37, pp.6-15. doi: 10.4031/002533203787537041.

Watson, A.P. and Gaskin, D.E. (1983). Observations on the ventilation cycle of the harbour porpoise (L.) in coastal waters of the Bay of Fundy. Canadian Journal of Zoology, Vol. 61, No. 1: pp. 126-132. Accessed December 2023.

Wenz, G. M. (1962). Acoustic ambient noise in the ocean: Spectra and sources. J. Acoust. Soc. Am. 34, 1936-1956.

WGMME (2016). Report of the Working Group on Marine Mammal Ecology (WGMME), 8-11 February 2016, Madrid, Spain. ICES CM 2016/ACOM: 26.

Whyte, K.F., Russell, D.J.F., Sparling, C.E., Binnerts, B. and Hastie, G.D. (2020). Estimating the effects of pile driving sounds on seals: Pitfalls and possibilities. The Journal of the Acoustical Society of America, 147(6), 3948–3958. https://doi.org/10.1121/10.0001408 (Accessed December 2023)

Williams, R., Lusseau, D. and Hammond, P.S., 2006. Estimating relative energetic costs of human disturbance to killer whales (Orcinus orca). *Biological conservation*, 133(3), pp.301-311.

Williamson, L.D., Scott, B.E., Laxton, M.R., Bachl, F.E., Illian, J.B., Brookes, K.L. and Thompson, P.M., (2022). Spatiotemporal variation in harbor porpoise distribution and foraging across a landscape of fear. *Marine Mammal Science*, *38*(1), pp.42-57.

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

Wilson, B. Batty, R. S., Daunt, F. and Carter, C. (2007). Collision risks between marine renewable energy devices and mammals, fish and diving birds. Report to the Scottish Executive. Scottish Association for Marine Science, Oban, Scotland, PA37 1QA.

Winkler, C., Panigada, S., Murphy, S. and Ritter, F. (2020). Global numbers of ship strikes: an assessment of collisions between vessels and cetaceans using available data in the IWC ship strike database. IWC B, 68.

Winkler, C., Panigada, S., Murphy, S. and Ritter, F. (2020). Global numbers of ship strikes: an assessment of collisions between vessels and cetaceans using available data in the IWC ship strike database. IWC B, 68.

Wisniewska, D.M., Johnson, M., Teilmann, J., Siebert, U., Galatius, A., Dietz, R. and Madsen, P.T., 2018. High rates of vessel noise disrupt foraging in wild harbour porpoises (Phocoena phocoena). *Proceedings of the Royal Society B: Biological Sciences*, *285*(1872), p.20172314.

Yang, C.M., Liu, Z.W., Lü, L.G., Yang, G.B., Huang, L.F. and Jiang, Y. (2018) May. Measurement and Characterization of Underwater Noise from Operational Offshore Wind Turbines in Shanghai Donghai Bridge. In 2018 OCEANS-MTS/IEEE Kobe Techno-Oceans (OTO) (pp. 1-5). IEEE.