Morecambe Offshore Windfarm: Generation Assets

Environmental Statement

Volume 5

Appendix 11.3 Marine Mammal Unexploded Ordnance Assessment (Tracked)

PINS Document Reference: 5.2.11.3.1

APFP Regulation: 5(2)(a)

Rev 02~~1~~

MORECAMBE

Document History

Doc No	MOR001-FLO-CON-ENV-RPT-1113	Rev	0~~1~~2
Alt Doc No	PC1165-RHD-ES-XX-RP-Z-0054		
Document Status	Approved for Use	Doc Date	~~May 2024~~26 November 2024
PINS Doc Ref	5.2.11.3.1	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

Contents

Tables

Glossary of Acronyms

ADD	Acoustic Deterrent Device
ASCOBANS	Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas
BAP	Biodiversity Action Plan
BEIS	Department for Business, Energy and Industrial Strategy[1]
CGNS	Celtic and Greater North Seas
CI	Confidence Interval
CIS	Celtic and Irish Sea
DCO	Development Consent Order
Defra	Department for the Environment, Food and Rural Affairs
DESNZ	Department for Energy Security and Net Zero
EDR	Effective Deterrence Radius
EIA	Environmental Impact Assessment
EPS	European Protected Species
EQT	Effective Quiet Threshold
ES	Environmental Statement
ETG	Expert Topic Groups
FCS	Favourable Conservation Status
HF	High Frequency
IAMMWG	Inter-Agency Marine Mammal Working Group
IS	Irish Sea
JNCC	Joint Nature Conservation Committee
LF	Low Frequency
ML	Marine Licence
MMMP	Marine Mammal Mitigation Protocol
MMO	Marine Management Organisation
MMObs	Marine Mammal Observers
MU	Management Units
NE	Natural England
NEQ	Net Explosive Quantity
NI	Northern Ireland
NPL	National Physical Laboratory

[1] As of February 2023, BEIS is known as the Department for Energy Security and Net Zero (DESNZ)

NW	North-West
OSP	Offshore substation platform
PAM	Passive Acoustic Monitoring
PCW	Phocid Carnivores in Water
PINS	Planning Inspectorate
PTS	Permanent Threshold Shift
RIAA	Report to Inform Appropriate Assessment
RoI	Republic of Ireland
SAC	Special Area of Conservation
SCANS	Small Cetaceans in the European Atlantic and North Sea
SD	Standard Deviation
SEL	Sound Exposure Level
SEL_{cum}	Sound Exposure Level from cumulative exposure
SEL_{ss}	Sound Exposure Level from single strike
SNCBs	Statutory Nature Conservation Bodies
SPL	Sound Pressure Level
SPL_{peak}	peak Sound Pressure Level
SW	South-West
TTS	Temporary Threshold Shift
UK	United Kingdom
UXO	Unexploded Ordnance
VHF	Very High Frequency
WTG	Wind turbine generator

Glossary of Unit Terms

µPa	Micro Pascal
dB re 1 µPa	Underwater dB are referenced to a pressure of 1 microPascal (µPa), which is abbreviated as dB re 1 µPa
dB	Decibel
km	Kilometre
km^2	Kilometre square kilometred
m	Metre
m/s	Metres per second
m^2	Metre square metred
s	Second

Glossary of Terminology

Absolute abundance	The most accurate estimate of population size. In the case of diving birds and mammals, this includes an estimate for the number that are believed to be submerged at the time of survey.
Applicant	Morecambe Offshore Windfarm Ltd.
CAVOK	"Ceiling and Visibility OK" – term used for aviation surface weather observation reports.
Coefficient of Variation *CV (%)*	The coefficient of variation is a standard measure that describes the dispersion of data points around the mean. The lower the CV the more precise the estimate. It is calculated as the SD/mean.
Confidence limit *(CL)*	The upper and lower values that define the range of the 95% confidence interval.
Density estimate *(animals/km^2)*	The average number of animals per square km surveyed.
Evidence Plan Process (EPP)	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 EPP provides a mechanism to agree the information required to be submitted to the Planning Inspectorate (PINS) as part of the Development Consent Order (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.
Expert Topic Group (ETG)	A forum for targeted engagement with regulators and interested stakeholders through the EPP.
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.
Offshore export cables	The cables which would bring electricity from the offshore substation platform to the landfall.
Offshore substation platform(s) (OSP(s))	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.
Platform link cable	An electrical cable which links one or more OSP(s).
Population estimate	The mean number of animals estimated within the survey area.

(number)	
Relative abundance	In the case of diving birds and mammals, this is the estimated population size based on animals recorded on or above the sea surface and does not account for any that may be diving and thus submerged at the time of survey.
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.
Standard deviation *(SD)* of population estimate	The amount of variation or dispersion of a set of values.
Study area	This is an area which is defined for EIA topic, which includes the offshore development area, 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.
Technical stakeholders	Technical stakeholders are organisations with detailed knowledge or experience of the area within which the Project is located and/or receptors which are considered in theEIA 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).
Transmission Assets	The transmission assets refers to Morgan and Morecambe Offshore Wind Farms export cables.
Windfarm site	The area within which the WTGs, inter-array cables, OSP(s) and platform link cables will be present.
Wind turbine generators (WTGs)	A fixed structure located within the windfarm site that converts the kinetic energy of wind into electrical energy.
95% confidence interval *(CI)*	A measure of uncertainty in the mean value. If the analysis was repeated, 95% of the time the mean population estimate would fall within this range. The smaller the CI range the more confident we can be that the mean estimate is an accurate reflection of the true population size.

MORECAMBE

11.3 The future of renewable energy

A leading developer in Offshore Wind Projects

1 Introduction

1. This Appendix provides an indicative assessment of potential auditory injury and disturbance impacts on marine mammals during unexploded ordnance (UXO) clearance at the Project windfarm site. This assessment has been provided with the Environmental Statement (ES) and ultimately the Development Consent Order (DCO) Application for information purposes only. It is intended that a separate Marine Licence (ML) application for UXO clearance will be submitted post-consent, once detailed information on the locations and extent of UXO required to be cleared (if any) is known.

2. This approach was agreed with Natural England (NE) and the Marine Management Organisation (MMO) at the second Expert Topic Group (ETG) meeting in August 2022 and has been reflected in the Scoping Opinion for the Project (Planning Inspectorate (PINS), 2022).

3. The assessment focussed on the following potential effects of underwater noise during UXO clearance on marine mammals:

   - Permanent and temporary auditory injury
   - Behavioural change, such as disturbance to feeding, mating, breeding and resting
   - Changes to prey availability

4. As part of the application for the ML, further assessments of effects for the wider Morecambe development (including the Morecambe and Morgan Offshore Wind Farm: Transmission Assets), and potential cumulative and transboundary effects will be considered if required.

5. For Project-alone, **Section 5.1** assessed the noise impacts using the underwater noise modelling (**Appendix 11.1** (Document Reference 5.2.11.1)) and **Section 5.2** assessed the number of disturbed animals. As a result of the UXO clearance activities changes to prey availability was assessed in **Section 5.3**.

6. The assessment in Section 11.7.3.1 of **Chapter 11 Marine Mammals** (Document Reference 5.1.11) addresses the cumulative effects resulting from two UXO clearances, at the same time as piling at the Project, and other noisy industry activities.

7. The study area for the assessment has been defined on the basis that marine mammals are highly mobile and transitory in nature. It was, therefore, necessary to examine species occurrence, not only within the windfarm site, but also over the wider region.

8. For the marine mammal species included in the assessment (as identified in **Chapter 11 Marine Mammals**), study areas have been defined, based on the

relevant marine mammals 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** (Document Reference 5.2.11.2) and **Chapter 11 Marine Mammals** for further information and maps of the MU and study areas).

2 Worst-case scenario

9. Construction scenarios assumed in the assessment were as set out in Section 11.3.2 of **Chapter 11 Marine Mammals**.

10. **Table 2.1** below, sets out the realistic worst-case scenarios for the marine mammal UXO assessment. These would be refined and clarified as appropriate post-consent during detailed design, which would feed into the UXO assessment for the ML application.

Table 2.1 Realistic worst-case parameters for marine mammal UXO assessment

Parameters	Notes and rationale
Types and sizes of UXO: Worst-case identified by the Project: 18'' British Mark XVII Torpedo (Net Explosive Quantity (NEQ) of 353.6kg). Number of UXO: To be determined – this assessment only considers indicative effects for the worst-case impact range.	Indicative only. Various possible types and sizes of UXO are possible. A detailed UXO survey would be completed prior to construction. The exact type, size and number of possible detonations and duration of UXO clearance operations is therefore unknown at this stage.
Clearance techniques: **Low-order clearance** would be the first and preferred method for UXO that require clearance. As a worst-case, this assessment is based on **high-order clearance** without mitigation, although once ML assessments are completed, if required, high-order detonation with the use of bubble curtain will also be considered.	High-order and low-order clearance have been assessed. High-order clearance would only be undertaken in the event that low-order clearance is not possible or failed to clear the device completely. This is therefore unlikely to be required, however, it is assessed as the potential worst-case.

3 Mitigation

11. Current guidance at the time of application and any relevant updates will be taken into account at the time of the ML application. Recent guidance specific to marine mammals includes Joint Nature Conservation Committee (JNCC) guidelines for minimising the risk of injury to marine mammals from UXO clearance (JNCC, 2010[2]), guidance for the use of Passive Acoustic Monitoring in United Kingdom (UK) waters for minimising the risk of injury to marine mammals from offshore activities (JNCC, 2023a) and the joint interim statement which sets the position on the use of lower noise alternatives to high order detonation of UXOs within the marine environment (Business, Energy and Industrial Strategy (BEIS)) *et al*., 2022).

3.1 UXO clearance mitigation measures

12. The primary mitigation is avoidance of UXO. In the event that UXOs are not able to be avoided, or removed for onshore disposal, the preferred method for UXO clearance would be a low-order clearance method. However, if high-order detonation is required, if for some reason a low-order clearance is not achievable, the following measures are also proposed:

- Only one high-order detonation would be activated at a time during UXO clearance operations at the Project, but potentially more than one UXO clearance could occur in a 24-hour period
- To reduce cumulative noise effects, there would be no UXO high-order clearance (at the Project) at the same time as piling at the Project. Although they may occur in the same day or 24-hour period, they would not occur at exactly the same time

13. The Applicant will consider the following UXO clearance mitigation measures within the production of the Marine Mammal Mitigation Plan (MMMP) which will be produced for UXO clearance (**Table 3.1**). The worst-case assessment in this Appendix did not apply use of these measures. A draft MMMP (Document Reference 6.5) has been provided with the DCO Application and will be updated and finalised during the ML process.

[2] DRAFT guidelines for minimising the risk of injury to marine mammals from unexploded ordnance clearance in the marine environment (2023) are currently issued for consultation and requirements will be updated accordingly once the guidance is finalised (JNCC, 2023b).

Table 3.1 UXO clearance mitigation measures

Parameter	UXO clearance mitigation measures
MMMP for UXO clearance	A detailed MMMP will be prepared for UXO clearance during the pre-construction phase. The MMMP for UXO clearance will ensure there are adequate mitigation measures to minimise the risk of any physical or permanent auditory injury to marine mammals as a result of UXO clearance. The MMMP for UXO clearance will be developed in the pre-construction period, when there is more detailed information available on the type of UXO clearance required, and the most suitable mitigation measures, based upon the best available information and methodologies at that time. The MMMP for UXO clearance will be prepared in consultation with the MMO, relevant Statutory Nature Conservation Bodies (SNCBs) and JNCC (2023) guidance. The MMMP for UXO clearance will include details of all the required mitigation measures to minimise the potential risk of Permanent Threshold Shift (PTS)/Permanent Auditory Injury as a result of underwater noise during UXO clearance. For example, this would consider the options, suitability and effectiveness of mitigation measures such as, but not limited to: ▪ Low-order clearance techniques, such as deflagration ▪ All UXO clearance to take place in daylight and, when possible, in favourable conditions with good visibility (sea state 3 or less) ▪ Establishment of a monitoring area with minimum of 1km radius ▪ The observation of the monitoring area will be by dedicated and trained Marine Mammal Observers (MMObs) during daylight hours and in suitable visibility ▪ Passive Acoustic Monitoring (PAM) may be required to supplement visual observations for species that are difficult to detect visually ▪ The activation of Acoustic Deterrent Device (ADD) ▪ The use of bubble curtains or other approved noise abatement systems if any high-order detonation is required (taking into consideration any environmental limitations) ▪ The controlled explosions of the UXO will be undertaken by specialist contractors, using the minimum amount of explosive required in order to safely render the UXO inert ▪ If more than one high-order detonation is required, other measures such as the use of scare charges; or multiple detonations, if UXO are located in close proximity, will also be considered in consultation with the MMO and SNCBs

4 Impact assessment methodology

14. **Chapter 6 EIA Methodology** (Document Reference 5.1.6) provided a summary of the general impact assessment methodology applied to the Project. The following sections confirm the methodology used to assess the potential impacts on marine mammals.

15. A matrix approach, as used in **Chapter 11 Marine Mammals** (Section 11.4) for all impacts, was used to guide the assessment of impacts following best practice, Environmental Impact Assessment (EIA) guidance, and the approach previously agreed with stakeholders for other recent offshore windfarms (including Sheringham Shoal and Dudgeon Extension, Norfolk Boreas and East Anglia ONE North, East Anglia TWO and East Anglia THREE).

16. In order to enable and facilitate a consistency of approach, a matrix of definitions has been employed to structure the expertise and evidence led assessment of impacts. Receptor sensitivity for an individual from each marine mammal species has been defined within **Chapter 11 Marine Mammals**, following the definitions set out in **Sections 4.1** and **4.2** below.

4.1 Definitions

17. For each impact, the assessment identified receptors sensitive to that impact and implemented a systematic approach to understanding the impact pathways and the level of effect on given receptors. The definitions of receptor sensitivity and impact magnitude for the purpose of the marine mammal assessment are provided in **Table 4.1** and **Table 4.2** respectively.

18. The sensitivity of a marine mammal receptor has been determined through its ability to accommodate change and on its ability to recover if it is negatively affected. The sensitivity level of marine mammals to each type of impact has been justified within the impact assessment and was dependent on the following factors:

- Adaptability – The degree to which a receptor can avoid or adapt to an effect
- Tolerance – The ability of a receptor to accommodate temporary or permanent change without a significant adverse effect
- Recoverability – The temporal scale over and extent to which a receptor will recover following an effect
- Value – A measure of the receptor importance and rarity (as reflected in the species conservation status and legislative importance)

19. The sensitivity of marine mammals to impacts from UXO clearance has been a key concern across the offshore wind sector. The sensitivity to potential impacts of lethality, physical injury, auditory injury or hearing impairment, as well as

behavioural disturbance or auditory masking was considered for each species, using available evidence including published data sources.

Table 4.1 Definition of sensitivity for a marine mammal receptor

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

20. In addition, for some assessments the 'value' of a receptor may also be an element to add to the assessment where relevant – for instance if the receptor is designated or has an economic value.

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

22. In the case of marine mammals, most species are protected by a number of international commitments as well as European and United Kingdom (UK) law and policy. All cetaceans in UK waters represented European Protected Species (EPS) and, therefore, were considered to be internationally important. Harbour porpoise, bottlenose dolphin, grey seal and harbour seals are also afforded international protection through the designation of protected sites. As such, all species of marine mammal were considered to be of high value.

23. **Table 4.2** provides definitions for the value afforded to a receptor based on its legislative importance. The value has been considered, where relevant, as a modifier for the sensitivity assigned to the receptor, based on expert judgement.

Table 4.2 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[3] protected species designated feature of a designated site) and protected species (including EPS) that are not qualifying features of a designated site.
Medium	Regionally important or internationally rare Protected species that are not qualifying features of a designated site but are recognised as a Biodiversity Action Plan (BAP) priority species either alone or under a grouped action plan and are listed on the local action plan relating to the marine mammal study area.
Low	Locally important or nationally rare Protected species that are not qualifying features of a designated site and are occasionally recorded within the study area in low numbers compared to other regions.
Negligible	Not considered to be particularly important or rare 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.

24. The thresholds for defining the potential magnitude that could occur from a particular impact will be determined using expert judgement, current scientific understanding of marine mammal population biology, and Joint Nature Conservation Committee (JNCC) *et al.* (2010) draft guidance on disturbance to EPS. The JNCC *et al.* (2010) EPS draft guidance suggested 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 effects (**Table 4.3**).

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

26. 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. Where the removal of even one individual for a small population with a slow growth rate could be detrimental to the population, the

[3] Species protected under the Habitats Directive.

removal of several to hundred individuals would not result in detriment to a population that is highly abundant.

27. Temporary effects were considered to be of medium magnitude at greater than 5% of the reference population for all species. 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 has been given to uncertainty of the individual consequences of temporary disturbance.

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

29. The magnitude of the potential impacts based on the intensity or degree of impact to the baseline conditions has been categorised into four levels of magnitude: high, medium, low or negligible, as defined in **Table 4.3.**

Table 4.3 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 effect. OR Long-term effect 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 effect. OR Temporary effect (e.g., limited to the construction phase of development) to the exposed receptors or feature(s) of the habitat which are of particular importance to the receptor. Assessment indicates that more than 10% of the reference population are anticipated to be exposed to the effect.
Medium	Permanent irreversible change to exposed receptors or feature(s) of the habitat of particular importance to the receptor. Assessment indicates that greater than 0.01% and below 1% of the reference population anticipated to be exposed to effect. OR Long-term effect for 10 years or more, but not permanent (e.g., limited to operational phase of the Project). Assessment indicates that between 1% and 5% of the reference population are anticipated to be exposed to the effect. OR Temporary effect (e.g., limited to the construction phase of development) to the exposed receptors or feature(s) of the habitat which are of particular importance to the receptor. Assessment indicates that between 5% and 10% of the reference population anticipated to be exposed to effect.
Low	Permanent irreversible change to exposed receptors or feature(s) of the habitat of particular importance to the receptor. Assessment indicates that between 0.001% and 0.01% of the reference population anticipated to be exposed to effect. OR Long-term effect for 10 years or more, but not permanent (e.g., limited to operational phase of the Project). Assessment indicates that between 0.01% and 1% of the reference population are anticipated to be exposed to the effect. OR Intermittent and temporary effect (e.g., limited to the construction phase of development) to the exposed receptors or feature(s) of the habitat which are of particular importance to the receptor. Assessment indicates that between 1% and 5% of the reference population anticipated to be exposed to effect.

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 effect. OR Long-term effect for 10 years or more (but not permanent, e.g., limited to lifetime of the Projects). Assessment indicates that less than 0.01% of the reference population are anticipated to be exposed to the effect. OR Intermittent and temporary effect (limited to the construction phase of development or Project timeframe) to the exposed receptors or feature(s) of the habitat which are of particular importance to the receptor. Assessment indicates that less than 1% of the reference population anticipated to be exposed to effect.

4.2 Significance of effect

30. In basic terms, the potential significance of an impact is a function of the sensitivity of the receptor and the magnitude of the impact (see **Chapter 6 EIA Methodology** for further details). The determination of significance was guided by the use of an impact significance matrix, as shown in **Table 4.4.** Definitions of each level of significance are provided in **Table 4.5**.

31. Potential effects identified within the assessment as major or moderate have been regarded as significant in terms of the EIA Regulations. Appropriate mitigation has been identified, where possible, in consultation with the regulatory authorities and relevant stakeholders. The aim of mitigation measures is to avoid or reduce the overall impact in order to determine a residual impact upon a given receptor.

32. Whilst minor effects (or below) were 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.

Following initial assessment, if the effect did not require additional mitigation (or none was possible), the residual effect remained the same. If, however, additional mitigation has been proposed, there was an assessment of the post-mitigation residual effect.

Table 4.4 Significance of effect matrix

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

Table 4.5 Definition of significance of effect

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

4.3 Existing environment and background

33. The existing environment has been detailed in **Chapter 11 Marine Mammals** and supplemented by **Appendix 11.2**. This included detail of the species, references populations and density estimates used in this assessment.

34. Impulsive noise sources have been described as having a rapid rise time, short duration and high peak pressure. A study into the distance at which underwater noise sources (from offshore windfarm piling and seismic surveys) 'transformed' from an impulsive to a non-impulsive noise revealed that, at a distance of between 2km and 3km, the noise sources no longer contained the characteristics (in particular a high enough peak pressure) to be classed as an impulsive noise (Hastie *et al.*, 2019). However, this study was completed in a shallow water environment, with a relatively flat seabed, and the actual range at which a sound source transforms into a non-impulsive noise was likely to be dependent on a number of environmental variables and other sound source characteristics (Hastie *et al*., 2019).

35. The work by Hastie *et al.* (2019) was preliminary, and Martin *et al*. (2020) suggested that the change in noise characteristics from impulsive to non-impulsive did not make a difference to assessment of injury, because sounds retained impulsive character when Sound Pressure Levels (SPL) were above effective quiet threshold (EQT). However, as outlined in the Hornsea Project Four Environmental Statement Chapter 4 Project Description (Ørsted, 2021), results presented by Martin and Barclay (2019) indicated that some of the piling sound lost its impulsiveness with increasing distance from the piling site, therefore the sound lost its harmful impulsive characteristics with increased distance.

36. All assessments have been based on the worst-case scenario and maximum predicted impact ranges for impulsive thresholds.

37. Low-order clearance techniques, where the ordnance is disposed of or rendered safe without a high-order detonation, is the preferred option for UXO clearance. Examples of low-order clearance techniques include (National Physical Laboratory (NPL), 2020):

- Freezing the munition to render it inactive
- Water abrasive suspension cutting in order to physically disrupt the munition
- Disposal in a Static Detonation Chamber
- Photolytic destruction of the munition
- Low-order deflagration

38. Deflagration is a technique whereby the explosive within the UXO is rapidly burned at subsonic speeds, using plasma from a small-shaped charge, that generates insufficient shock to detonate the UXO (Merchant and Robinson, 2020; NPL 2020). The explosive material inside the UXO reacts with a rapid burning, rather than a chain reaction that would lead to a full explosion (NPL, 2020).

39. Substantial noise reduction for deflagration over high-order (SPL_{peak} and Sound Exposure Level (SEL) were more than 20 dB lower) and acoustic output for deflagration depended only on the size of the shaped charge (rather than the size of the UXO) (NPL, 2020; Robinson *et al*., 2020).

40. The technique of low-order clearance appears to present a viable option to avoid high-order explosive detonation. Low-order clearance techniques, such as deflagration, are relatively new to civilian applications, but have been used by the UK military since 2005 (Merchant and Robinson, 2020).

41. In the unlikely event that low order clearance was unsuccessful, or deemed unsuitable for a specific UXO (e.g., due to its condition), high-order clearance may be undertaken. Therefore, as a worst-case (**Table 2.1**), high-order detonations have been considered, alongside low-order clearance.

4.4 Potential effects

42. It is important to note that the assessments for UXO clearance have been presented for information only and are not intended to be secured as part of the DCO Application. A separate ML application will be submitted when a detailed UXO survey has been completed prior to construction and a detailed assessment based on the latest available information has been undertaken. Therefore, the number of possible UXO that may require clearance (if any) and the duration of such operations is currently unknown.

43. The potential for UXO clearance would be predominately during the pre-construction phase; it is unlikely that UXO clearance will be undertaken during the construction, operation and decommissioning phases.

44. While any identified UXO could either be avoided, relocated at sea or removed and disposed of onshore in a designated location, there is the potential that underwater detonation could be required where it is necessary and unsafe to move the UXO.

45. For the assessment, an approximated estimate of the UXO charge weights/types has been made, based on the best available information from other offshore wind farm UXO clearance operations nearby, and other published information (more details in **Appendix 11.1**). It is not currently known the size or type of the UXO that could be present, therefore a range of sizes has been assessed, with the maximum charge weight of up to 354kg NEQ anticipated for the Project area.

46. When an item of UXO detonates on the seabed underwater, several effects are generated, most of which are localised at the point of detonation, such as crater formation, movement of sediment and dispersal of nutrients and contaminants. After detonation, there is the rapid expansion of gaseous products known as the “bubble pulse”. Once it reaches the surface, the energy of the bubble is dissipated in a plume of water and the detonation shock front rapidly attenuates at the water/air boundary. Fragmentation (that is shrapnel from the weapon casing and surrounding seabed materials) is also ejected but does not pose a significant hazard beyond 10m from source.

47. The potential effects of underwater explosions on marine mammals include:

   i. Physical injury from direct or indirect blast wave effect of the high amplitude shock waves and sound wave produced by underwater detonation, which could result in immediate or eventual mortality

   ii. Auditory impairment (from exposure to the acoustic wave), resulting in a temporary or permanent loss in hearing sensitivity such as temporary threshold shift (TTS) or PTS

   iii. Behavioural change, such as disturbance to feeding, mating, breeding, and resting (Richardson *et al*., 1995; Ketten, 2004; von Benda-Beckmann *et al*., 2015)

48. The severity of the consequences of UXO detonation will depend on many variables, but principally, on the charge weight and its proximity to the receptor. After detonation, the shock wave will expand spherically outwards and will travel in a straight line (i.e., line of sight), unless the wave is reflected, channelled, or meets an intervening obstruction.

49. There have been limited acoustic measurements for underwater explosions, and there can be large differences in the noise levels, depending on the charge size, as well as water depth, bathymetry, and seabed sediments at the site, which can also influence noise propagation. The water depth in which the explosion

occurred had a significant influence on the effect range for a given charge mass (von Benda-Beckmann *et al*., 2015).

50. It is important to note that assessments set out in this Appendix were based on the worst-case for high-order UXO detonations with no mitigation. This is highly unlikely, as the preferred and first option for any UXO requiring detonation would be a low-order clearance method. If high-order detonation was required, then the mitigation options would be considered as appropriate.

4.5 Sensitivity of marine mammals

51. In this assessment, all species of marine mammal were considered to have **high** sensitivity to UXO detonations if they were within the potential impact ranges for physical injury or PTS. Marine mammals within the potential impact area were considered to have very limited capacity to avoid such effects, and unable to recover from physical injury or auditory injury.

52. The sensitivity of marine mammals to TTS and flee response/likely disturbance as a result of underwater UXO detonations was considered to be **medium** in this assessment as a precautionary approach. This was for animals within the potential TTS and flee response/likely disturbance range, but beyond the potential impact range for PTS. Marine mammals within the potential impact area for TTS and disturbance were considered to have limited capacity to avoid such effects, although any impacts on marine mammals from TTS and disturbance would be temporary and they would be expected to return to the area once the activity had ceased.

4.6 Underwater noise modelling

53. A number of UXOs with a range of charge weights (or quantity of contained explosive) could be located within the Project windfarm site. There is the potential for there to be a variety of explosive types, which will have been subject to degradation and burying over time. Two otherwise identical explosive devices are therefore likely to produce different blasts if one has been subject to different environmental factors.

54. A selection of explosive sizes has been considered in the estimation of the underwater noise levels produced by detonation of UXO (**Table 4.6**). The assessment assumes the worse-case maximum explosive charge of 353.6kg (see **Appendix 11.1**).

Table 4.6 Selection of UXO potentially present at the windfarm site

UXO	NEQ
3" Rocket Projectile (554mm x 152mm)	5.45kg
250 lb Mark VIII Depth Charge (969mm x 279mm)	72.6kg
250lb Mark XI Depth Charge (940mm x 279mm)	103.2kg
18" Mark XII Torpedo (4,953mm x 450mm)	176.0kg
18" Mark XV Torpedo (5,251mm x 450mm	321.1kg
18" Mark XVII Torpedo (5,268mm x 450mm)	353.6kg

55. The noise produced by the detonation of explosives is affected by a number of different elements (e.g., its design, composition, age, position, orientation, whether it is covered by sediment) which are unknown and could not be directly considered in an assessment. This led to a high degree of uncertainty in the estimation of the source noise level (i.e., the noise level at the position of the UXO). A worst-case estimation has therefore been used for calculations, assuming that the UXO to be detonated was not buried, degraded or subject to any other significant attenuation. The consequence of this was that the noise levels produced, particularly by the larger explosives under consideration, were likely to be over-estimated as confirmed UXO often have degraded shell casings, with potential loss to sea over time of some of the explosive material within.

56. The assessment also did not take into account the variation in the noise level at different depths. Where animals are swimming near the surface, the acoustics at the surface cause the noise level, and hence the exposure, to be lower at this position. The risk to animals near the surface may therefore have been lower than indicated by the range estimate and therefore this could be considered conservative in respect of impact at different depths.

57. The potential impact has been assessed based on the latest Southall *et al*. (2019) thresholds and criteria for marine mammals that could be present in the area. The thresholds indicated the onset of PTS, the point at which there was an increase in risk of permanent hearing damage in an underwater receptor (although not all individuals within the maximum PTS range will have permanent hearing damage, this has been assumed as a worst-case scenario).

58. The SEL criteria have been weighted, which took into account the sound level based on the sensitivity of the receiver, for example, harbour porpoise are less sensitive to low frequency sound than minke whales. Southall *et al*. (2019) also included criteria based on peak Sound Pressure Level (SPL_{peak}), which were unweighted and did not take species hearing sensitivity into account.

59. Both SPL_{peak} and SEL values based on the impulsive and non-impulsive criteria have been included in the assessment. However, it is important to note that they are different criteria and as such they should not be compared directly. All decibel SPL values were referenced to 1 μPa and all SEL values were referenced to 1 $\mu Pa^2 s$.

60. Peak noise levels have been difficult to predict accurately in a shallow water environment (von Benda Beckmann *et al.,* 2015) and would tend to be significantly over-estimated by the modelling over increased distances from the source. With increased distance from the source, impulsive noise, such as UXO detonation, noise becomes more of a non-impulsive noise. Unfortunately, it was difficult to determine the distance at which an impulsive noise became more like a non-impulsive noise. Therefore, modelling was conducted using both the impulsive and non-impulsive criteria for PTS weighted SEL to give an indication of the difference between maximum potential impact ranges (see **Appendix 11.1**).

4.6.1 Methodology

61. The range of equivalent charge weights for the potential UXO devices that could be present within the Project windfarm site have been estimated as 5.45kg, 72.6kg, 103.2kg, 176.0kg, 321.1kg and 353.6kg, plus the donor weight to initiate detonation.

62. In addition, low-order clearance (such as deflagration) has been assessed, which assumed that the donor or shaped charge (charge weight of approximately 0.5kg) detonates fully but without the follow-up high-order detonation of the UXO.

63. Estimation of the source noise level for each charge weight has been carried out in accordance with the methodology of Soloway and Dahl (2014), which followed Arons (1954) and Marine Technical Directorate (MTD) (1996) (see **Appendix 11.1**).

64. **Table 4.7** provides the source level used for the underwater noise modelling (further details on how these were calculated is provided in **Appendix 11.1**).

Table 4.7 Source levels (unweighted SPL_{peak} and Sound Exposure Level from single strike (SEL_{ss})) used for UXO modelling

Charge weight (NEQ)	0.5kg	5.45kg + donor charge	72.6kg + donor charge	103.2kg + donor charge	176.0kg + donor charge	321.1kg + donor charge	353.6kg + donor charge
SPL_{peak} source level (dB re 1 µPa @ 1m)	272.1	280.2	288.4	289.5	291.2	293.2	293.5
SEL_{ss} source level (dB re 1 µPa^{2}s @ 1m)	217.1	223.9	230.9	231.9	233.3	235.0	235.3

4.6.2 Results

65. The results of the underwater noise modelling (**Appendix 11.1**) for the range of potential charge weights (NEQ) are presented in **Table 4.8** and **Table 4.9** for PTS and TTS, respectively. The potential impact range has been assessed based on the latest Southall *et al*. (2019) thresholds and criteria. The impact ranges (and areas, based on the area of a circle) have been used to inform the impact assessments.

Table 4.8 Potential maximum impact ranges (and areas[4]) of PTS for marine mammals during UXO clearance for high and low order clearance (the maximum potential impact range and area for each species used in assessments are shown in bold)

Potential maximum charge weight (NEQ)	Maximum predicted impact range (km) (and area (km²))		
	PTS SPL_{peak} Unweighted (Impulsive criteria)	PTS Sound Exposure Level from cumulative exposure ($SEL_{peakcum}$) Weighted (Impulsive criteria)	PTS SEL_{ss} Weighted (Non-impulsive criteria)
Harbour porpoise (Very High Frequency (VHF) cetacean)			
	202 dB re 1 µPa	155 dB re 1 µPa²s	173 dB re 1 µPa²s
0.5kg (low-order clearance)	**1.2km (4.52km²)**	0.11km (0.038km²)	<0.05km (<0.008km²)
5.45kg + donor charge	2.8km (24.6km²)	0.32km (0.32km²)	<0.05km (<0.008km²)
72.6kg + donor charge	6.6km (136.8km²)	0.82km (2.11km²)	0.06km (0.011km²)
103.2kg + donor charge	7.4km (172km²)	0.91km (2.60km²)	0.07km (0.015km²)
176.0kg + donor charge	8.8km (243.28km²)	1km (3.14km²)	0.08km (0.02km²)
321.1kg + donor charge	10km (314.16km²)	1.2km (4.52km²)	0.11km (0.038km²)
353.6kg + donor charge	**11km (380.13km²)**	1.3km (5.30km²)	0.11km (0.038km²)
Bottlenose dolphin, Risso's dolphin, common dolphin, and white-beaked dolphin (High Frequency (HF) cetaceans)			
	230 dB re 1 µPa	185 dB re 1 µPa²s	198 dB re 1 µPa²s
0.5kg (low-order clearance)	**0.07km (0.015km²)**	<0.05km (<0.008km²)	<0.05km (<0.008km²)
5.45kg + donor charge	0.16km (0.080km²)	<0.05km (<0.008km²)	<0.05km (<0.008km²)

[4] Based on the area of a circle

Potential maximum charge weight (NEQ)	Maximum predicted impact range (km) (and area (km²)) PTS SPL$_{peak}$ Unweighted (Impulsive criteria)	PTS Sound Exposure Level from cumulative exposure (SEL$_{peak}$~~cum~~) Weighted (Impulsive criteria)	PTS SEL$_{ss}$ Weighted (Non-impulsive criteria)
72.6kg + donor charge	0.38km (0.45km^2)	<0.05km (<0.008km^2)	<0.05km (<0.008km^2)
103.2kg + donor charge	0.42km (0.55km^2)	<0.05km (<0.008km^2)	<0.05km (<0.008km^2)
176.0kg + donor charge	0.51km (0.82km^2)	<0.05km (<0.008km^2)	<0.05km (<0.008km^2)
321.1kg + donor charge	0.62km (1.20km^2)	<0.05km (<0.008km^2)	<0.05km (<0.008km^2)
353.6kg + donor charge	**0.64km (1.29km^2)**	<0.05km (<0.008km^2)	<0.05km (<0.008km^2)
Minke whale (Low Frequency (LF) cetacean)			
	219 dB re 1 µPa	**183 dB re 1 µPa^{2}s**	**199 dB re 1 µPa^{2}s**
0.5kg (low-order clearance)	0.22km (0.15km^2)	**0.32km (0.32km^2)**	<0.05km (<0.008km^2)
5.45kg + donor charge	0.5km (0.79km^2)	1km (3.14km^2)	0.06km (0.01km^2)
72.6kg + donor charge	1.1km (3.80km^2)	3.6km (40.7km^2)	0.21km (0.13km^2)
103.2kg + donor charge	1.3km (5.30km^2)	4.3km (58.08km^2)	0.26km (0.21km^2)
176.0kg + donor charge	1.5km (7.06km^2)	5.6km (98.52km^2)	0.33km (0.34km^2)
321.1kg + donor charge	1.9km (11.34km^2)	7.5km (176.71km^2)	0.45km (0.64km^2)
353.6kg + donor charge	1.9km (11.34km^2)	**7.9km (196.07km^2)**	0.47km (0.70km^2)

Potential maximum charge weight (NEQ)	Maximum predicted impact range (km) (and area (km^2))		
	PTS SPL_{peak} Unweighted (Impulsive criteria)	PTS Sound Exposure Level from cumulative exposure (SEL_{peak}~~$_{cum}$~~) Weighted (Impulsive criteria)	PTS SEL_{ss} Weighted (Non-impulsive criteria)
Grey seal and harbour seal (Phocid Carnivores in Water (PCW))			
	218 dB re 1 μPa	185 dB re 1 μPa^{2}s	201 dB re 1 μPa^{2}s
0.5kg (low-order clearance)	**0.24km (0.18km^2)**	0.06km (0.011km^2)	<0.05km (<0.008km^2)
5.45kg + donor charge	0.56km (0.99 km^2)	0.19km (<0.008km^2)	<0.05km (<0.008km^2)
72.6kg + donor charge	1.2km (4.52km^2)	0.65km (1.33 km^2)	<0.05km (<0.008km^2)
103.2kg + donor charge	1.4km (6.16km^2)	0.77km (1.87km^2)	<0.05km (<0.008km^2)
176.0kg + donor charge	1.7km (9.08 km^2)	1.0km (3.14 km^2)	0.06km (<0.01km^2)
321.1kg + donor charge	2.1km (13.86 km^2)	1.3km (5.30km^2)	0.08km (0.02km^2)
353.6kg + donor charge	**2.1km (13.86 km^2)**	1.4km (6.16km^2)	0.08km (0.02km^2)

Table 4.9 Potential maximum impact ranges (and areas[4]) of TTS for marine mammals during UXO clearance (the maximum potential impact range and area for each species used in assessments are shown in bold)

Potential maximum charge weight (NEQ)	**Maximum predicted impact range (km) (and area (km^2))**		
	TTS SPL_{peak} Unweighted (Impulsive criteria)	**TTS SEL~~sscum~~ Weighted (Impulsive criteria)**	**TTS SEL_{ss} Weighted (Non-impulsive criteria)**
Harbour porpoise (VHF)			
	196 dB re 1 μPa	**140 dB re 1 μPa^{2}s**	**153 dB re 1 μPa^{2}s**
0.5kg (low-order clearance)	**2.3km (16.62 km^2)**	0.93km (2.72km^2)	0.15km (0.071km^2)
5.45kg + donor charge	5.2km (84.95 km^2)	1.8km (10.17 km^2)	0.43km (0.58 km^2)
72.6kg + donor charge	12km (452.39 km^2)	2.9km (26.42 km^2)	1.0km (3.14 km^2)
103.2kg + donor charge	13km (531 km^2)	3.1km (30.2 km^2)	1.1km (3.80 km^2)
176.0.1kg + donor charge	16km (804.25 km^2)	3.4km (36.32 km^2)	1.3km (5.31 km^2)
321.1kg + donor charge	19km (1,134.11 km^2)	3.7km (43 km^2)	1.5km (7.07 km^2)
353.6kg + donor charge	**20km (1,256.64 km^2)**	3.7km (43 km^2)	1.5km (7.07 km^2)
Bottlenose dolphin, Risso's dolphin, common dolphin, and white-beaked dolphin (High Frequency (HF) cetaceans)			
	230 dB re 1 μPa	**170 dB re 1 μPa^{2}s**	**178 dB re 1 μPa^{2}s**
0.5kg (low-order clearance)	**0.13km (0.053km^2)**	<0.05km (0.008km^2)	<0.05km (<0.008km^2)
5.45kg + donor charge	0.3km (0.28 km^2)	0.08km (0.02 km^2)	<0.05km (<0.008km^2)
72.6kg + donor charge	0.7km (1.53 km^2)	0.24km (0.18 km^2)	0.07km (0.02 km^2)
103.2kg + donor charge	0.79km (1.97 km^2)	0.28km (0.25 km^2)	0.08km (0.02 km^2)
176.0.1kg + donor charge	0.94km (2.78 km^2)	0.35km (0.38 km^2)	0.1km (0.03 km^2)

Potential maximum charge weight (NEQ)	Maximum predicted impact range (km) (and area (km^2))		
	TTS SPL$_{peak}$ Unweighted (Impulsive criteria)	TTS SEL$_{sscum}$ Weighted (Impulsive criteria)	TTS SEL$_{ss}$ Weighted (Non-impulsive criteria)
321.1kg + donor charge	1.1km (3.80 km^2)	0.44km (0.61 km^2)	0.13km (0.05 km^2)
353.6kg + donor charge	**1.1km (3.80 km^2)**	0.46km (0.66 km^2)	0.13km (0.05 km^2)
Minke whale (LF)			
	213 dB re 1 μPa	**168 dB re 1 μPa^{2}s**	**179 dB re 1 μPa^{2}s**
0.5kg (low-order clearance)	0.41km (0.53km^2)	**4.5km (63.62km^2)**	0.65km (1.33km^2)
5.45kg + donor charge	0.93km (2.72 km^2)	14km (615.75 km^2)	2.1km (13.85 km^2)
72.6kg + donor charge	2.1km (13.85 km^2)	46km (6,647.61 km^2)	7.4km (172.03 km^2)
103.2kg + donor charge	2.4km (18.10 km^2)	53km (8,824.73 km^2)	8.7km (237.79 km^2)
176.0.1kg + donor charge	2.8km (24.63 km^2)	67km (14,102.61 km^2)	11km (380.13 km^2)
321.1kg + donor charge	3.5km (38.48 km^2)	85km (22,698.01 km^2)	14km (615.75 km^2)
353.6kg + donor charge	3.6km (40.72 km^2)	**89km (24,884.56 km^2)**	15km (706.86 km^2)
Grey seal and harbour seal (PCW)			
	212 dB re 1 μPa	**170 dB re 1 μPa^{2}s**	**181 dB re 1 μPa^{2}s**
0.5kg (low-order clearance)	0.45km (0.64km^2)	**0.8km (2.01km^2)**	0.11km (0.38km^2)
5.45kg + donor charge	1.0km (3.14 km^2)	2.6km (21.24 km^2)	0.38km (0.45 km^2)
72.6kg + donor charge	2.3km (16.62 km^2)	8.5km (226.98 km^2)	1.3km (5.31km^2)
103.2kg + donor charge	2.6km (21.24 km^2)	9.9km (307.91 km^2)	1.5km (7.07 km^2)

Potential maximum charge weight (NEQ)	Maximum predicted impact range (km) (and area (km^2))		
	TTS SPL_{peak} Unweighted (Impulsive criteria)	TTS SEL_{sscum} Weighted (Impulsive criteria)	TTS SEL_{ss} Weighted (Non-impulsive criteria)
176.0.1kg + donor charge	3.2km (32.17 km^2)	12km (452.39 km^2)	2.0km (12.57 km^2)
321.1kg + donor charge	3.9km (47.78 km^2)	16km (804. 25 km^2)	2.6km (21.24 km^2)
353.6kg + donor charge	4.0km (50.27 km^2)	**16km (804.25 km^2)**	2.8km (24.63 km^2)

5 Assessment of effects

5.1 Impact 1: Auditory injury from underwater noise associated with UXO clearance

5.1.1 Magnitude

5.1.1.1 Permanent Auditory Injury (PTS)

66. The number of marine mammal receptors that could potentially be impacted by a high-order UXO detonation and low-order clearance have been estimated for the Project in **Table 5.1**. The assessment was based on the maximum potential PTS impact ranges set out in **Table 4.8**, and the density and population data as presented in Table 11.14 of **Chapter 11 Marine Mammals**.

67. For a **high-order detonation** of the worst-case maximum potential UXO (NEQ of 353.6kg plus donor charge), the magnitude for PTS was assessed to be:

- **Medium** for harbour porpoise
- **Medium** (**medium**) for grey seal
- **Medium** (**negligible**) for harbour seal
- **Low** for bottlenose dolphin
- **Negligible** for common dolphin, Risso's dolphin, white-beaked dolphin, and minke whale

68. For **low-order clearance** (0.5kg donor charge for all sizes of UXO) the magnitude for PTS was assessed to be:

- **Medium** for harbour porpoise
- **Low (negligible)** for grey seal
- **Negligible** for minke whale, bottlenose dolphin, white-beaked dolphin, Risso's dolphin, and common dolphin
- **Negligible (negligible)** for harbour seal

Table 5.1 Maximum number of marine mammals potentially at risk of PTS during UXO clearance

Species	Maximum impact range (and area)	Maximum number of individuals	% of reference population	Magnitude (permanent impact)
Harbour porpoise	High-order detonation (353.6kg (NEQ) + donor charge) 11km (380.13km^2)	616 (1.621/km^2 based on the site-specific survey density)	0.986% of the Celtic and Irish Sea (CIS) MU	Medium
	Low-order clearance (0.5kg (NEQ)) 1.2km (4.52km^2)	7 (1.621/km^2 based on the site-specific survey density)	0.012% of the CIS MU	Medium
Bottlenose dolphin	High-order detonation (353.6kg (NEQ) + donor charge) 0.64km (1.29km^2)	0.013 Small Cetaceans in the European Atlantic and North Sea (SCANS)-IV density of 0.0104/km^2)	0.00457% of the Irish Sea (IS) MU	Low
	Low-order clearance (0.5kg (NEQ)) 0.07km (0.015km^2)	0.0002 (SCANS-IV density of 0.0104/km^2)	0.00005% of the IS MU	Negligible
White-beaked dolphin	High-order detonation (353.6kg (NEQ) + donor charge) 0.64km (1.29km^2)	0.01 (Waggitt *et al*. (2019) density of 0.007/km^2)	0.000020% of the Celtic and Greater North Seas (CGNS) MU	Negligible
	Low-order clearance (0.5kg (NEQ)) 0.07km (0.015km^2)	0.0001 (Waggitt *et al*. (2019) density of 0.007/km^2)	0.0000002% of the CGNS MU	Negligible
Risso's dolphin	High-order detonation (353.6kg (NEQ) + donor charge) 0.64km (1.29km^2)	0.004 (Evans & Waggitt (2023) density of 0.003/km^2)	0.00003% of the CGNS MU	Negligible

Species	Maximum impact range (and area)	Maximum number of individuals	% of reference population	Magnitude (permanent impact)
	Low-order clearance (0.5kg (NEQ)) 0.07km (0.015km^2)	0.004 (Evans & Waggitt (2023) density of 0.003/km^2)	0.0000004% of the CGNS MU	Negligible
Common dolphin	High-order detonation (353.6kg (NEQ) + donor charge) 0.64km (1.29km^2)	0.0004 (Waggitt *et al*. (2019) density of 0.028/km^2)	0.0000002% of the CGNS MU	Negligible
	Low-order clearance (0.5kg (NEQ)) 0.07km (0.015km^2)	0.04 (Waggitt *et al*. (2019) density of 0.028/km^2)	0.00004% of the CGNS MU	Negligible
Minke whale	High-order detonation (353.6kg (NEQ) + donor charge) 7.9km (196.06km^2)*	0.01 (SCANS-IV density of 0.0088/km^2)	0.0005% of the CGNS MU	Negligible
	Low-order clearance (0.5kg (NEQ)) 0.32km (0.322km^2)*	0.001 (SCANS-IV density of 0.0088/km^2)	0.000007% of the CGNS MU	Negligible
Grey seal	High-order detonation (353.6kg (NEQ) + donor charge) 2.1km (13.85km^2)	1 (based on the worst-case array area density of 0.100/km^2)	0.1% of the combined MUs (0.01% of the wider ref pop)	Medium (medium)**
	Low-order clearance (0.5kg (NEQ)) 0.24km (0.18km2)	0.02 (based on the worst-case array area density of 0.100/km^2)	0.001% of the combined MUs (0.0001% of the wider ref pop)	Low (negligible)**
Harbour seal	High-order detonation (353.6kg (NEQ) + donor charge) 2.1km (13.85km^2)	0.002 (based on the worst-case array area density of 0.00012/km^2)	0.02% of the North-West (NW) MUs (0.0001% of the wider ref pop)	Medium (negligible)**

Species	Maximum impact range (and area)	Maximum number of individuals	% of reference population	Magnitude (permanent impact)
	Low-order clearance (0.5kg (NEQ)) 0.24km (0.18km^2)	0.00002 (based on the worst-case array area density of 0.00012/km^2)	0.0003% of the NW MUs (0.000002% of the wider ref pop)	Negligible (negligible)**

*Based on the PTS SEL range as worst case

** Magnitude in brackets is for the wider reference population for grey seals (incl. Wales, South West (SW) Scotland, Northern Ireland (NI) and Republic of Ireland (RoI) and harbour seal (including NI)

5.1.1.2 Temporary Auditory Injury (TTS)

69. The number of marine mammal receptors that could potentially be impacted by a high-order UXO detonation (up to 353.6kg NEQ) and low-order clearance (0.5kg) have been estimated for the Project in **Table 5.2**. The assessment was based on the maximum potential TTS impact ranges set out in **Table 4.9**, and the density and population data as presented in Table 11-14 of the **Chapter 11 Marine Mammals**.

70. For low-order clearance (0.5kg donor charge for all sizes of UXO) the magnitude for TTS was assessed to be:

- **Negligible** for all species

71. For the **high-order detonation** of the worst-case maximum potential UXO (NEQ of 353.6kg plus donor charge), the magnitude for TTS was assessed (**Table 5.2**) to be:

- **Low** for harbour porpoise
- **Negligible** for minke whale, bottlenose dolphin, white-beaked dolphin, Risso's dolphin, and common dolphin
- **Negligible (negligible)** for grey seal and harbour seal

Table 5.2 Maximum number of marine mammals potentially at risk of TTS during UXO clearance

Species	Maximum impact range (and area)	Maximum number of individuals	% of reference population	Magnitude (temporary impact)
Harbour porpoise	High-order detonation (353.6kg (NEQ) + donor charge) 20km (1,256.64 km2)	2037 (based on the site-specific survey density 1.621/km^2)	3.3% of the CIS MU	Low
	Low-order clearance (0.5kg (NEQ)) 2.3km (16.62km^2)	27 (based on the site-specific survey density 1.621/km^2)	0.04% of the CIS MU	Negligible
Bottlenose dolphin	High-order detonation (353.6kg (NEQ) + donor charge) 1.1km (3.80km^2)	0.04 (based on SCANS-IV density of 0.0104/km^2)	0.01% of the IS MU	Negligible
	Low-order clearance (0.5kg (NEQ)) 0.13km (0.053km^2)	0.001 (based on SCANS-IV density of 0.0104/km^2)	0.0002% the IS MU	Negligible
White-beaked dolphin	High-order detonation (353.6kg (NEQ) + donor charge) 1.1km (3.80km^2)	0.03 (based on Waggitt *et al.* (2019) density of 0.007/km^2)	0.00006% of the CGNS MU	Negligible
	Low-order clearance (0.5kg (NEQ)) 0.13km (0.053km^2)	0.0004 (based on Waggitt *et al.* (2019) density of 0.007/km^2)	0.000001% of the CGNS MU	Negligible
Common dolphin	High-order detonation (353.6kg (NEQ) + donor charge) 1.1km (3.80km^2)	0.0004 (based on Waggitt *et al.* (2019) density of 0.028/km^2)	0.0001%of the CGNS MU	Negligible
	Low-order clearance (0.5kg (NEQ)) 0.13km (0.053km^2)	0.04 (based on Waggitt *et al.* (2019) density of 0.028/km^2)	0.000001% of the CGNS MU	Negligible

Species	Maximum impact range (and area)	Maximum number of individuals	% of reference population	Magnitude (temporary impact)
Risso's dolphin	High-order detonation (353.6kg (NEQ) + donor charge) 1.1km (3.80km^2)	0.01 (based on Evans & Waggitt (2023) density of 0.003/km^2)	0.0001% of the CGNS MU	Negligible
	Low-order clearance (0.5kg (NEQ)) 0.13km (0.053km^2)	0.0002 (based on Evans & Waggitt (2023) density of 0.003/km^2)	0.000001% of the CGNS MU	Negligible
Minke whale	High-order detonation (353.6kg (NEQ) + donor charge) 89km (24,884km^2)*	0.4 (based on SCANS-IV density of 0.0088/km^2)	0.002% of the CGNS MU	Negligible
	Low-order clearance (0.5kg (NEQ)) 4.5km (63.62km^2)*	0.005 (based on SCANS-IV density of 0.0088/km^2)	0.00002% of the CGNS MU	Negligible
Grey seal	High-order detonation (353.6kg (NEQ) + donor charge) 16km (804.25km^2)*	5 (based on the worst-case array area density of 0.100/km^2)	0.3% of the combined MUs (0.03% of the wider ref pop)	Negligible (negligible)
	Low-order clearance (0.5kg (NEQ)) 0.8km (2.01km^2)*	0.06 (based on the worst-case array area density of 0.100/km^2)	0.004% of the combined MUs (0.0005% of the wider ref pop)	Negligible (negligible)
Harbour seal	High-order detonation (353.6kg (NEQ) + donor charge) 16km (804.25km^2)*	0.006 (based on the worst-case array area density of 0.00012/km^2)	0.09% of the NW MU (0.0004% of the wider ref pop)	Negligible (negligible)
	Low-order clearance (0.5kg (NEQ)) 0.8km (2.01km^2)*	0.0001 (based on the worst-case array area density of 0.00012/km^2)	0.001% of the NW MU (0.00001% of the wider ref pop)	Negligible (negligible)

*Based on the weighted TTS SEL range as worst case

5.1.2 Significance of effect

72. Taking into account the high sensitivity for all species to PTS from UXO clearance, the significance of effect, for a high-order detonation without mitigation, has been assessed as **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 (**Table 5.3**) .

73. For low-order clearance, without mitigation measures, and based on a very precautionary high sensitivity for all marine mammals to PTS from low-order clearance, the significance of effect has been assessed as **major adverse** (significant in EIA terms) for harbour porpoise (the percentage of animals at risk was marginal to be of low magnitude and thus a moderate adverse effect significance); **moderate** (significant in EIA terms) to **minor adverse** (not significant in EIA terms) for grey seal; and **minor adverse** (not significant in EIA terms) for all other species.

74. For TTS, taking into account the medium sensitivity for all species to UXO clearance, the significance of effect, for a high-order detonation without mitigation, has been assessed as **minor adverse** (not significant in EIA terms) for all species (**Table 5.3**). For low-order clearance, the significance of effect was **minor adverse** (not significant in EIA terms) for TTS in all species (not significant in EIA terms).

75. It should be noted that the conclusion of **major** or **moderate adverse** (significant in EIA terms) for PTS for some species was very precautionary, as the assessment was based on the worst-case scenario with no mitigation measures applied (this also applied to TTS).

5.1.3 Mitigation options

76. As outlined in **Section 3**, a final MMMP for UXO clearance will be produced post-consent in consultation with the MMO and relevant SNCBs if required. A draft MMMP (Document Reference 6.5) with a high level consideration of UXO clearances has been provided with the DCO Application. The final MMMP for UXO clearance will be based on the latest scientific understanding and guidance, pre-construction UXO surveys at the Project windfarm site, as well as detailed Project design. The implementation of the mitigation measures within the MMMP for UXO clearance would reduce the risk of any PTS during UXO clearance. The mitigation measures would also reduce the risk of TTS.

77. The proposed mitigation measures for consideration in the MMMP for UXO clearance include the use of low-order clearance techniques such as deflagration, potential use of bubble curtains, establishing a monitoring zone and

surveying prior to UXO clearance (MMObs and potentially PAMs), and the use of ADDs.

78. A marine wildlife licence application, if required, will be submitted post-consent for any proposed UXO clearance activities. At this time, pre-construction UXO investigation surveys would have been conducted, and full consideration will have been given to any necessary mitigation measures that may be required following the development of the MMMP for UXO clearance.

5.1.4 Residual significance of effect

79. The residual effect of the potential risk of physical injury and permanent or temporary auditory injury (PTS or TTS) to marine mammals as a result of any underwater UXO clearance was reduced to a **negligible adverse** magnitude for all species, by implementing the proposed mitigation (to be confirmed in the final UXO clearance MMMP, to be submitted with any required UXO clearance ML application).

80. There would be only one potential high-order UXO detonation at a time during Project UXO clearance operation, i.e., there would be no simultaneous high-order UXO detonations. Although, more than one UXO clearance could occur in a 24-hour period.

81. Therefore, with high sensitivity for any physical injury or permanent auditory injury (PTS) and medium sensitivity for TTS/fleeing response, the potential significance of effect was reduced to **minor adverse** for all species (not significant in EIA terms) (**Table 5.3**).

Table 5.3 Assessment of significance of effect UXO clearance (Auditory injury)

Impact	Species	Sensitivity	Magnitude	Significance of effect	Mitigation	Residual significance of effect
PTS during underwater UXO clearance (for high-order detonation)	Harbour porpoise	High	Medium	Significant (Major adverse)	MMMP for UXO clearance (including a combination of options such as low-order clearance, bubble curtain deployment, monitoring zone and ADD activation)	Not Significant (Minor adverse)
	Bottlenose dolphin	High	Low	Significant (Moderate adverse)		Not Significant (Minor adverse)
	White-beaked dolphin	High	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Common dolphin	High	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Risso's dolphin	High	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Minke whale	High	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Grey seal	High	Medium	Significant (Major adverse)		Not Significant (Minor adverse)
	Harbour seal	High	Medium to Negligible	Significant (Major to Minor adverse)		Not Significant (Minor adverse)

Impact	Species	Sensitivity	Magnitude	Significance of effect	Mitigation	Residual significance of effect
TTS during underwater UXO clearance (for high-order detonation)	Harbour porpoise	Medium	Low	Not Significant (Minor adverse)	MMMP for UXO clearance may indirectly reduce the potential for TTS. Low order clearance and/or bubble curtains could be used in case any significant TTS (or disturbance) effects are anticipated.	Not Significant (Minor adverse)
	Bottlenose dolphin	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	White-beaked 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)
	Minke whale	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Grey seal	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	Harbour seal	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)

5.2 Impact 2: Disturbance from underwater noise associated with UXO clearance

82. There were no agreed thresholds or criteria for the behavioural response and disturbance of marine mammals available to use for the assessment, therefore it was not possible to conduct underwater noise modelling to predict impact ranges.

83. For marine mammals a fleeing response has been assumed to occur at the same noise levels as TTS for high-order UXO detonation. As outlined in Southall *et al.* (2007) the onset of behavioural disturbance was proposed to occur at the lowest level of noise exposure that had a measurable transient effect on hearing (i.e., TTS). Although, as Southall *et al.* (2007) recognised, this was not a behavioural effect per se, and exposures to lower noise levels from a single pulse were not expected to cause disturbance. However, any compromise, even temporarily, to hearing functions could have the potential to affect behaviour.

84. The use of the TTS threshold was appropriate for UXO disturbance because the noise from the UXO explosion would be only fleetingly in the environment. Therefore, the assumption was that although noise levels lower than TTS threshold may startle an individual, this would have no lasting effect. TTS would result in a temporary reduction in hearing ability, and therefore may affect the individuals' fitness temporarily (as recommended in Southall *et al*. (2007) for a single pulse) (NRW, 2023).

85. As outlined in Southall *et al*. (2021) thresholds that attempt to relate single noise exposure parameters (e.g., received noise level) and behavioural response across broad taxonomic grouping and sound types could lead to severe errors in predicting effects. Differences between species, individuals, exposure, situational context, the temporal and spatial scales over which they occur, and the potential interacting effects of multiple stressors could lead to inherent variability in the probability and severity of behavioural responses.

86. The assessments for TTS/fleeing response have therefore been used to calculate the potential disturbance ranges for UXO high-order detonation. Therefore, the potential range and areas for TTS presented in **Table 4.9**, along with the estimated number and percentage of the reference populations that could be impacted (as assessed in **Section 5.1**) provided an indication of possible fleeing response by the marine mammal receptors.

87. The most recent SNCBs advice recommended that a potential disturbance range based on an Effective Deterrent Radius (EDR) of 26km around UXO high-order detonations should be used to assess harbour porpoise disturbance in designated Special Areas of Conservation (SAC) (JNCC *et al*., 2020). The Project is not located in close proximity to these sites, however, this approach has been used for the EIA (as well as the Report to Inform Appropriate Assessment (RIAA)) for the assessment of harbour porpoise. The assessment

for the potential disturbance for high order detonation, therefore, also included the maximum number of harbour porpoise based on maximum potential impact area for the 26km EDR (an area of 2,124km^2).

88. The 5km (78.54km^2) potential disturbance range for low-order clearance (the first option and preferred method) is based on disturbance in harbour porpoise SACs (JNCC, 2023c) and includes vessels associated with the activity.

89. Modelling of the impacts of UXO detonation charges up to 700kg in the Moray Firth suggested that behavioural responses may occur up to 1.5km and 4.4km from the source for bottlenose dolphin and minke whale respectively (Marine Scotland, 2018). While behavioural disturbance from UXOs has not been described for grey seal, an 800kg detonation charge may cause PTS in grey seal up to 2.7km from the source, implying that individuals may be disturbed at even greater distances (BEIS, 2020). The 5km disturbance range has been based on the latest JNCC guidance (JNCC, 2023c), based on estimated disturbance from vessels (see also Benhemma-Le Gall *et al*., 2021) and low-order deflagration. As a worst-case, marine mammals could be temporarily disturbed from this area for UXO low-order clearances.

90. In addition, the MMMP for UXO clearance will include ADD activation prior to all UXO clearances, to ensure marine mammals are beyond the maximum potential impact range for PTS. The duration for ADD activation will depend on the clearance method and will vary for low-order clearance, high-order detonation, size of UXO (NEQ) and location (e.g., marine mammal species that could be present in nearshore and offshore areas).

91. The required duration of ADD activation will be determined for the final MMMP for UXO clearance. The most suitable mitigation measures that may be required will be informed by the best available information and methodologies at that time in consultation with the MMO and relevant SNCBs. Assessments have been provided for information only and will be reviewed and updated for the ML and marine wildlife licence application prior to UXO clearance.

5.2.1 Magnitude

92. As per **Section 5.1**, a high-order detonation of the maximum potential UXO (NEQ of 353.6kg plus donor charge) was used to assess the magnitude for TTS/fleeing response, as a worst-case (**Table 5.3**). The magnitude was assessed for each species, whilst the magnitude in brackets is for the wider reference population for grey seal (including Wales, SW Scotland, NI and RoI) and harbour seal (including NI):

- **Low** for harbour porpoise
- **Negligible** for minke whale, bottlenose dolphin, white-beaked dolphin, Risso’s dolphin and common dolphin

- **Negligible (negligible)** for grey seal and harbour seal

93. For low-order clearance (0.5kg donor charge for all sizes of UXO) the magnitude for TTS/fleeing response was assessed to be:

- **Negligible** for harbour porpoise, bottlenose dolphin, common dolphin, Risso's dolphin, white-beaked dolphin and minke whale
- **Negligible (negligible)** for grey seal and harbour seal

94. The maximum number of harbour porpoise that could potentially be disturbed in a 26km radius of a high-order UXO detonation without mitigation has been estimated. The resulting magnitude was assessed to be **medium** (**Table 5.4**).

95. There would be only one high-order UXO detonation at a time during UXO clearance operation, i.e., there would be no simultaneous high-order UXO detonations. Although, more than one UXO clearance could occur in a 24-hour period.

Table 5.4 Estimated number of harbour porpoise that could potentially be disturbed during UXO clearance based on 26km EDR for high-order detonation with no mitigation

Species	Maximum impact area	Maximum number of individuals	%of reference population	Magnitude (temporary impact)
Harbour porpoise	2,123.72km^2	3,443 (1.621/km^2 based on the site-specific survey density)	5.51% CIS MU	Medium

96. Based on an estimated worst-case of a 5km disturbance range (78.54km^2) including vessels for low-order clearance (such as deflagration), the magnitude of impact has been assessed as **negligible** for all marine mammal species (**Table 5.5**).

Table 5.5 Estimated number of marine mammals that could potentially be disturbed during low-order UXO clearance based on 5km disturbance range

Species	Maximum impact area	Maximum number of individuals	% of reference population	Magnitude (temporary impact)
Harbour porpoise	78.54km^2	122.5 (1.621/km^2 based on the site-specific survey density)	0.20% CIS MU	Negligible
Bottlenose dolphin	78.54km^2	0.8 (SCANS-IV density of 0.0104/km^2)	0.28% IS MU	Negligible
White-beaked dolphin	78.54km^2	0.6 (Waggitt *et al*. (2019) density of 0.007 /km^2)	0.001% CGNS MU	Negligible
Common dolphin	78.54km^2	2 (Waggitt *et al*. (2019) density of 0.028/km^2)	0.002% CGNS MU	Negligible
Risso's dolphin	78.54km^2	0.002 based on Evans & Waggitt (2023) density of 0.003/km^2)	0.002% CGNS MU	Negligible
Minke whale	78.54km^2	0.02 (based on SCANS-IV density of 0.0088/km^2)	0.003% CGNS MU	Negligible
Grey seal	78.54km^2	8 (based on the worst-case array area density of 0.100/km^2)	0.5% of the combined MUs (0.06% of the wider reference population)	Negligible (negligible)
Harbour seal	78.54km^2	0.009 (based on the worst-case array area density of 0.00012/km^2)	0.01% of the NW MUs 0.001% of the wider reference population)	Negligible (negligible)

5.2.1.1 ADD Activation

97. For high-order clearance, an ADD would need to be activated for 123 minutes, during which harbour porpoise, grey seal, and harbour seal would move at least 11km away, based on a precautionary swimming speed of 1.5m/s (Otani *et al*., 2000). Minke whale would move 24km away, based on a swimming speed of 3.25m/s (Blix and Folkow, 1995). The ADD activation time was calculated based on the highest PTS effect range of 11km for harbour porpoise and would cover the highest PTS effect range for minke whale (of 7.9km), and 2.1km for grey seal and harbour seal.

98. There is a knowledge gap regarding the ranges at which ADDs become less effective and would no longer cause a marine mammal to flee. As per ADD review in the JNCC report No. 615 (McGarry *et al*., 2022), the ranges of deterrence distances can vary significantly from only a few meters to several kilometres (approximately 6km for VHF cetacean); these differed between devices and dependent on the acoustic properties of the environment (Rosemeyer *et al*., 2021). A report from Marine Scotland noted the increase of previously known effect ranges from 3.5km to up to 7.5km for porpoises (Coram *et al*., 2014). It was unknown whether the effects were beyond these ranges. To cover the ranges of 6km or 7.5km, assuming a 1.5m/s swimming speed, the ADD would need to be activated for 66 - 83 minutes.

99. The lack of evidence that ADDs are effective for VHF cetaceans beyond the effect ranges discussed above, implied that prolonged activation time would introduce additional noise to the environment. The JNCC report (McGarry *et al*., 2022) presented concerns regarding the potential for hearing damage (PTS) from some of the ADD devices, but stated that the risk of injury from ADD deployment was likely to be low, unless the animals remained in the vicinity of the device.

100. Following this, the ADD would be activated for approximately 80 minutes, during which harbour porpoise, grey seal, and harbour seal would move at least 7.2km away, and minke whale would move 15.6km away. This would be less than the highest PTS effect range of 11km for harbour porpoise, but higher than the highest PTS effect range for minke whale (of 7.9km), and 2.1km for grey seal and harbour seal.

101. An ADD activation period of 80 minutes would deter harbour porpoise outwith the potential PTS effect range for a high-order UXO clearance of up to 72.6kg NEQ, while high-order clearance for UXO heavier than 72.6kg NEQ would result in potential PTS ranges that exceed the predicted ADD deterrence range for 80 minutes of ADD activation.

102. There was therefore the potential for injury to occur for harbour porpoise for a high-order clearance of UXO heavier than 72.6kg NEQ. Should this be required, alternative mitigation or noise reduction options would be required (e.g. bubble

curtains or other approved noise abatement systems, low-order clearance or scare charges) to avoid injury to this EPS. If it were not possible to wholly mitigate the potential for auditory injury, an EPS licence for injury would need to be secured prior to the start of UXO clearance works.

103. The effects of ADD activation were assessed using the estimated maximum ADD activation prior to UXO clearance. This estimation was on the maximum predicted impact range: 1.2km for low-order clearance for harbour porpoise, and 11km for high-order clearance (detonation) for harbour porpoise (**Table 5.6**).

104. The maximum number of marine mammals that could be disturbed as a result of ADD activation prior to UXO clearance has been estimated based on the maximum density estimate for each species (**Table 5.6**).

105. As noted above, for high-order clearance, an ADD would be activated for a maximum of 80 minutes, during which harbour porpoise, grey seal, and harbour seal would move at least 7.2km away, based on precautionary swimming speed of 1.5m/s (Otani *et al.,* 2000). Minke whale would move 15.6km, based on swimming speed of 3.25m/s (Blix and Folkow, 1995).

106. For low-order clearance, ADD would be activated for 15 minutes, during which harbour porpoise, bottlenose dolphin, white-beaked dolphin, grey and harbour seal would move at least 1.35km away, based on precautionary swimming speed of 1.5m/s (Otani *et al*., 2000) and minke whale would move 2.93km, based on swimming speed of 3.25m/s (Blix and Folkow, 1995).

107. The magnitude of impact for ADD activation prior to UXO clearance has been assessed as **negligible** for all marine mammal species (**Table 5.6**).

108. ADD would only be activated for the minimum time required to ensure effective mitigation. Disturbance as a result of ADD activation would be within the maximum impact range assessed for TTS/disturbance from UXO clearance and would therefore not be an additive effect to the overall area of potential disturbance.

Table 5.6 Estimated number of marine mammals that could potentially be disturbed during ADD activation for UXO clearance and impact magnitude

Species	Low-order clearance Up to 15 minutes	High-order detonation Up to 80 minutes
Harbour porpoise	9 (0.01% CIS MU) Negligible	264 (0.4% CIS MU) Negligible
Bottlenose dolphin	0.06 (0.02% IS MU) Negligible	2 (0.6% IS MU) Negligible
White-beaked dolphin	0.04 (0.0001% CGNS MU) Negligible	1 (0.003% CGNS MU) Negligible
Common dolphin	0.02 (0.00002% CGNS MU) Negligible	5 (0.004% CGNS MU) Negligible
Risso's dolphin	0.02 (0.0001% CGNS MU) Negligible	0.02 (0.0001% CGNS MU) Negligible
Minke whale	0.02 (0.00001% CGNS MU) Negligible	7 (0.0003% CGNS MU) Negligible
Grey seal	16.9 (1.22% of the combined MUs; 0.16% of the wider ref pop) Low (negligible)	16 (1.02% of the combined MUs; 0.12% of the wider ref pop) Low (negligible)
Harbour seal	0.0007 (0.01% of the NW MU; 0.00005% of the wider ref pop) Negligible (negligible)	0.02 (0.3% of the NW MU; 0.001% of the wider ref pop)) Negligible (negligible)

5.2.2 Significance of effect

109. Taking into account the medium sensitivity of marine mammals to disturbance from UXO clearance activities (including the potential disturbance from ADD) and the magnitude of impact defined above, the temporary disturbance of marine mammals has been assessed as **minor adverse** (not significant in EIA terms) for a low-order UXO clearance (**Table 5.7**). For harbour porpoise the magnitude of impact based on EDRs was assessed as medium, with an effect of **moderate**

adverse (significant in EIA terms) for a high-order UXO clearance without mitigation.

5.2.3 Mitigation options

110. Mitigation techniques such as bubble curtains, other approved noise abatement system deployment, low-order clearance and a monitoring zone for high-order detonation would reduce the potential disturbance of marine mammals during UXO clearance (**Section 3**) and would be defined in any UXO clearance MMMP. Further mitigation measures would also be considered if appropriate and required.

5.2.4 Residual significance of effect

111. The residual effect of the potential disturbance of marine mammals as a result of underwater noise during UXO clearance activities at the Project windfarm site with mitigation was **minor adverse** (not significant in EIA terms) (**Table 5.7**).

Table 5.7 Assessment of significance of effect for disturbance of marine mammals during UXO clearance

Impact	Species	Sensitivity	Magnitude	Significance of effect	Mitigation	Residual significance of effect
TTS/ fleeing response	See **Table 4.9**					
26km EDR	Harbour porpoise	Medium	Medium	Moderate adverse	MMMP (including options such as low-order clearance, monitoring zone for high-order detonation) may indirectly reduce the potential for TTS (or disturbance).	Minor adverse
5km disturbance for low-order clearance	Harbour porpoise	Medium	Negligible	Minor adverse		Minor adverse
	Bottlenose dolphin	Medium	Negligible	Minor adverse		Minor adverse
	White-beaked dolphin	Medium	Negligible	Minor adverse		Minor adverse
	Common dolphin	Medium	Negligible	Minor adverse		Minor adverse
	Risso's dolphin	Medium	Negligible	Minor adverse		Minor adverse
	Minke whale	Medium	Negligible	Minor adverse		Minor adverse
	Grey seal	Medium	Negligible	Minor adverse		Minor adverse
	Harbour seal	Medium	Negligible	Minor adverse		Minor adverse
ADD activation	Harbour porpoise	Medium	Negligible	Minor adverse		Minor adverse

Impact	Species	Sensitivity	Magnitude	Significance of effect	Mitigation	Residual significance of effect
	Bottlenose dolphin	Medium	Negligible	Minor adverse		Minor adverse
	White-beaked dolphin	Medium	Negligible	Minor adverse		Minor adverse
	Minke whale	Medium	Negligible	Minor adverse		Minor adverse
	Common dolphin	Medium	Negligible	Minor adverse		Minor adverse
	Risso's dolphin	Medium	Negligible	Minor adverse		Minor adverse
	Grey seal	Medium	Low (negligible)	Minor adverse		Minor adverse
	Harbour seal	Medium	Negligible	Minor adverse		Minor adverse

5.3 Impact 3: Changes to prey availability as a result of underwater noise from UXO clearance activities

5.3.1 Sensitivity of marine mammals

112. 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 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.

113. Bottlenose dolphin, common dolphin, and white-beaked dolphin are opportunistic feeders, feeding on wide range of prey species and have large foraging ranges (see **Appendix 11.2**) and were therefore considered to have **low** sensitivity to changes in prey resources.

114. Risso's dolphin are highly migratory, inhabit and forage in deeper waters, primarily feeding on squid, cuttlefish, shrimp, and other fish species. Risso's dolphin were considered to have a **low** sensitivity to changes in prey resources.

115. Minke whale feed on a variety of prey species, but in some areas, they have been found to prey upon specific species at the population level (see **Appendix 11.2**). Therefore, minke whale were considered to have a **low** to **medium** sensitivity to changes in prey resource.

116. Grey and harbour seal feed on a variety of prey species, both are considered to be opportunistic feeders, feeding on wide range of prey species and they are able to forage in other areas and have relatively large foraging ranges (see **Appendix 11.2**). Grey seal and harbour seal were therefore considered to have **low** sensitivity to changes in prey resources.

5.3.2 Magnitude

117. UXO clearance has potential to produce high levels of underwater noise and therefore has the potential to result in adverse impacts on fish.

118. 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) impacts on fish species.

119. Underwater noise modelling (**Appendix 11.1**) assessed the following fish groups (based on Popper *et al*., 2014):

- No swim bladder (e.g., sole, plaice, lemon sole, mackerel and sandeels)
- Swim bladder not involved in hearing (e.g., sea bass, salmon and sea trout)
- Swim bladder which is involved in hearing (e.g., cod, whiting, sprat and herring)

120. The underwater noise modelling results (**Appendix 11.1**) indicated that fish species in which the swim bladder is involved in hearing were the most sensitive to the impact of underwater noise.

121. **Table 5.8** summarises the maximum impact ranges for fish species during UXO clearance. Whilst mortality is most likely to occur at a SPL of 234dB, the potential for mortal injury is slightly less at a SPL of 229dB. With a maximum impact range of up to 710m, this was considerably less than the 11km PTS impact range for harbour porpoise, based on the unweighted SPL_{peak} criteria (**Appendix 11.1**). Therefore, there would be no additional impacts as a result of any changes in prey availability during UXO clearance besides the direct impacts to marine mammals as a result of underwater noise assessed in **Sections 5** and **5.2.**

122. The magnitude of any potential changes to prey availability as a result of UXO clearance was assessed as **negligible** for marine mammals, as any impacts on prey would be less than the direct impacts on marine mammals.

Table 5.8 Summary of the impact ranges for UXO detonation using the unweighted SPL_{peak} explosion noise criteria from Popper et al. (2014) for fish species

Potential Impact	0.5kg	5.45kg + donor charge	72.6kg + donor charge	103.2kg + donor charge	176.0kg + donor charge	321.1kg + donor charge	353.6kg + donor charge
234 dB (Mortality and potential mortal injury)	<50m	110m	250m	280m	340m	410m	430m
229 dB (Mortality and potential mortal injury)	80m	180m	420m	470m	560m	690m	710m

5.3.3 Significance of effect

123. Taking into account the low to medium sensitivity and the negligible magnitude, the significance of effect on marine mammals due to changes in prey availability has been assessed as **negligible** to **minor adverse** (not significant in EIA terms).

5.3.4 Mitigation

124. Mitigation techniques outlined in the MMMP (**Section 3**) would also reduce impacts to fish.

5.3.5 Residual significance of effect

125. The residual effect to marine mammals due to changes in prey availability as a result of underwater noise during UXO clearance at the Project windfarm site remained **negligible** to **minor adverse** (not significant in EIA terms).

6 Assessment summary

126. The potential impacts on marine mammals from UXO clearance at the Project windfarm site are summarised in **Table 6.1.**

Table 6.1 Summary of potential effects associated with UXO clearance

Potential impact	Receptor	Sensitivity	Magnitude	Significance of effect	UXO clearance mitigation measures proposed	Residual significance of effect
Impact 1: Auditory injury from underwater noise associated with UXO clearance						
PTS for UXO high-order detonation with no mitigation	Harbour porpoise	High	Medium	Significant (Major adverse)	MMMP for UXO clearance (including options such as bubble curtain deployment, low-order clearance, monitoring zone and ADD activation)	Not Significant (Minor adverse)
	Grey seal	High	Medium (medium)	Significant (Major adverse)		
	Harbour seal	High	Medium (Negligible)	Significant (Major) to not significant (minor adverse)		
	Bottlenose dolphin	High	Low	Significant (Moderate adverse)		
	White-beaked dolphin, common dolphin, Risso's dolphin and minke whale	High	Negligible	Not Significant (Minor adverse)		
TTS for UXO high-order detonation with no mitigation	Harbour porpoise	Medium	Low	Not Significant (Minor adverse)	MMMP for UXO clearance	Not Significant (Minor adverse)
	All other species	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)

Potential impact	Receptor	Sensitivity	Magnitude	Significance of effect	UXO clearance mitigation measures proposed	Residual significance of effect
Impact 2: Disturbance from underwater noise associated with UXO clearance						
TTS/fleeing response	All species	Medium	Low to Negligible	Not Significant (Minor adverse)	MMMP (approved noise abatement system deployment, low-order clearance, monitoring zone for high-order detonation)	Not Significant (Minor adverse)
Disturbance (26km EDR)	Harbour porpoise	Medium	Medium	Significant (Moderate adverse)		Not Significant (Minor adverse)
Low-ordnance clearance (5km)	All species	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
ADD activation for UXO clearance	Grey seal	Medium	Low (negligible)	Not Significant (Minor adverse)		Not Significant (Minor adverse)
	All other species	Medium	Negligible	Not Significant (Minor adverse)		Not Significant (Minor adverse)
Impact 3: Changes to prey availability as a result of underwater noise from UXO clearance activities						
Changes to prey	Harbour porpoise and minke whale	Low to medium	Negligible	Not Significant (Minor adverse)	NA	Not Significant (Minor adverse)
	All other species	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)

7 References

Arons, A. B. (1954). Underwater explosion shock wave parameters at large distances from the charge. J. Acoust. Soc. Am. 26, 343–346.

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

BEIS. 2020. ION Southern North Sea Seismic Survey.

Benhemma-Le Gall, A., Graham, I.M., Merchant, N.D. and Thompson, P.M. (2021). Broad-Scale Responses of Harbor Porpoises to Pile-Driving and Vessel Activities During Offshore Windfarm Construction. Front. Mar. Sci. 8:664724. doi: 10.3389/fmars.2021.664724

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

Coram, A., Gordon, J., Thompson, D., & Northridge, S. (2014). Evaluating and assessing the relative effectiveness of acoustic deterrent devices and other non-lethal measures on marine mammals. Scottish Government, 1–145.

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

Evans, P.G.H. and Waggitt, J.J. (2023). Modelled Distribution and Abundance of Cetaceans and Seabirds in Wales and Surrounding Waters. NRW Evidence Report, Report No: 646, 354 pp. Natural Resources Wales, Bangor.

Hastie, G., Merchant, N.D., Götz, T., Russell, D.J., Thompson, P. and Janik, V.M. (2019). Effects of impulsive noise on marine mammals: investigating range-dependent risk. Ecological Applications, p.e01906. Available from: https://research-repository.st-andrews.ac.uk/bitstream/handle/10023/17882/Hastie_2019_EA_Impulsivenoise_AAM.pdf?sequence=1&isAllowed= (Accessed: December 2023)

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

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. https://data.jncc.gov.uk/data/fb7d345b-ec24-4c60-aba2-894e50375e33/jncc-pam-guidance-in-uk-waters.pdf (Accessed: January 2024)

JNCC (2023b). DRAFT JNCC guidelines for minimising the risk of injury to marine mammals from unexploded ordnance clearance use in the marine environment. October 2023.

JNCC (2023c). Marine Noise Registry Help and Guidance. November 2023. Available at: https://mnr.jncc.gov.uk/assets/mnr/documents/marine_noise_registry_helpguide_2023_v1.1.pdf (Accessed: January 2023)

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.

Joint Nature Conservation Committee (JNCC) (2010). Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise. August 2010.

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.

Ketten, D.R. (2004). Experimental measures of blast and acoustic trauma in marine mammals (ONR Final Report N000149711030).

Marine Scotland. 2018. UXO Clearance Cetacean Risk Assessment

Martin, S.B. and Barclay, D.R. (2019). Determining the dependence of marine pile driving sound levels on strike energy, pile penetration, and propagation effects using a linear mixed model based on damped cylindrical spreading. The Journal of the Acoustical Society of America, 146(1), pp.109-121.

Martin, S.B., Lucke, K. and Barclay, D.R. (2020). Techniques for distinguishing between impulsive and non-impulsive sound in the context of regulating sound exposure for marine mammals. Journal of the Acoustical Society of America, 147, pp. 2159-2176. Available online at: https://www.semanticscholar.org/paper/Techniques-for-distinguishing-between-impulsive-and-MartinLucke/5772c8af067f696393e6d1cf24582a082b7cc6a5?p2df (Accessed: February 2023)

McGarry, T., De Silva, R., Canning, S., Mendes, S., Prior, A., Stephenson, S. & Wilson, J. 2022. Evidence base for application of Acoustic Deterrent Devices (ADDs) as marine mammal mitigation (Version 4). JNCC Report No. 615. JNCC, Peterborough. ISSN 0963-8091

Merchant, N.D., and Robinson, S.P. (2020). Abatement of underwater noise pollution from pile-driving and explosions in UK waters. Report of the UKAN workshop held on Tuesday 12 November 2019 at The Royal Society, London. 31pp. doi: https://dx.doi.org/10.6084/m9.figshare.11815449. (Accessed: February 2024)

MTD (Marine Technical Directorate Ltd). (1996). Guidelines for the safe use of explosives underwater. MTD Publication 96/101. ISBN 1 870553 23 3

Natural Resources Wales NRW (2023). NRW's Position on Assessing Behavioural disturbance of Harbour Porpoise (*Phocoena phocoena*) from underwater noise. Available at: https://cdn.cyfoethnaturiol.cymru/media/696755/ps017-nrws-position-on-assessing-behavioural-disturbance-of-harbour-porpoise-phocoena-phocoena-from-underwater-noise-30.pdfhttps://cdn.cyfoethnaturiol.cymru/media/696755/ps017-nrws-position-on-assessing-behavioural-disturbance-of-harbour-porpoise-phocoena-phocoena-from-underwater-noise-30.pdf (Accessed: September 2023).

NPL (National Physical Laboratory). 2020. Final Report: Characterisation of Acoustic Fields Generated by UXO Removal – Phase 2 (BEIS offshore energy SEA sub-contract OESEA-19-107). NPL Report AC 19 June 2020. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/893773/NPL_2020_-_Characterisation_of_Acoustic_Fields_Generated_by_UXO_Removal.pdf (Accessed: December 2023)

Ørsted (2021). Hornsea Project Four: Environmental Statement (ES) Chapter 4: Marine Mammals. PINS Document Reference: A2.4. APFP Regulation: 5(2)(a).

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

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 January 2024)

Popper, A.N., Hawkins, A.D., Fay, R.R., Mann, D.A., Bartol, S., Carlson, T.J., Coombs, S., Ellison, W.T., Gentry, R.L., Halvorsen, M.B. and Løkkeborg, S., (2014). ASA S3/SC1. 4 TR-2014 Sound exposure guidelines for fishes and sea turtles: A technical report prepared by ANSI-Accredited standards committee S3/SC1 and registered with ANSI. Springer

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

Robinson, S.P., Wang, L., Cheong, S-H., Lepper, P.A., Marubini, F. and Hartley, J.P. (2020). Underwater acoustic characterisation of unexploded ordnance disposal using deflagration. Mar. Poll. Bull. 160, 111646.

Rosemeyer, M., Matuschek, R., Bellmann, M.A., Brinkmann, J. (2021). Cross project evaluation of FaunaGuard operation before pile-driving for German offshore wind farms. Technical Report- Part 1: Underwater noise conditions of FaunaGuard during operation. Technical report on behalfof the Federal Maritime and Hydrographic Agency (BSH). Available under: https://marinears.bsh.de and https://bioconsult-sh.de/ (Accessed: February 2023)

Soloway, A.G. and Dahl, P.H. (2014). Peak sound pressure and sound exposure level from underwater explosions in shallow water. The Journal of the Acoustical Society of America, 136(3), EL219 – EL223. http://dx.doi.org/10.1121/1.4892668 (Accessed: December 2023)

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.

von Benda-Beckmann, A.M., Aarts, G., Özkan Sertlek, H., Lucke, K., Verboom W.C., Kastelein, R.A., Ketten, D.R., van Bemmelen, R., Lam, F,A., Kirkwood, R.J. and Ainslie, M.A. (2015). Assessing the Impact of Underwater Clearance of Unexploded Ordnance on Harbour Porpoises (Phocoena phocoena) in the Southern North Sea. Aquatic Mammals 2015, 41(4), 503-523.

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.