DOGGER BANK D
WIND FARM

Preliminary Environmental Information Report

Volume 2
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Glossary

Term	Definition
Array Area	The area within which the wind turbines, inter-array cables and Offshore Platform(s) will be located.
Development Consent Order (DCO)	A consent required under Section 37 of the Planning Act 2008 to authorise the development of a Nationally Significant Infrastructure Project, which is granted by the relevant Secretary of State following an application to the Planning Inspectorate.
Environmental Impact Assessment (EIA)	A process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information and includes the publication of an Environmental Statement.
Environmental Statement (ES)	A document reporting the findings of the EIA which describes the measures proposed to mitigate any likely significant effects.
Evidence Plan Process (EPP)	A voluntary consultation process with technical stakeholders which includes a Steering Group and Expert Topic Group (ETG) meetings to encourage upfront agreement on the nature, volume and range of supporting evidence required to inform the EIA and HRA process.
Expert Topic Group (ETG)	A forum for targeted technical engagement with relevant stakeholders through the EPP.
Impact	A change resulting from an activity associated with the Project, defined in terms of magnitude.
Inter-Array Cables	Cables which link the wind turbines to the offshore platform(s).
Mitigation	Any action or process designed to avoid, prevent, reduce or, if possible, offset potentially significant adverse effects of a development. All mitigation measures adopted by the Project are provided in the Commitments Register.
Offshore Development Area	The area in which all offshore infrastructure associated with the Project will be located, including any temporary works area during construction, which extends seaward of Mean High Water Springs. There is an overlap with the Onshore Development Area in the intertidal zone.
Offshore Export Cable Corridor (ECC)	The area within which the offshore export cables will be located, extending from the DBD Array Area to Mean High Water Springs at the landfall.
Offshore Export Cables	Cables which bring electricity from the Offshore Platform(s) to the transition joint bays at landfall.

Term	Definition
Offshore Platform(s)	Fixed structures located within the DBD Array Area that contain electrical equipment to aggregate and, where required, convert the power from the wind turbines, into a more suitable voltage for transmission through the export cables to the Onshore Converter Station. Such structures could include (but are not limited to): Offshore Converter Station(s) and an Offshore Switching Station.
The Applicant	SSE Renewables and Equinor acting through 'Doggerbank Offshore Wind Farm Project 4 Projco Limited'.
The Project	Dogger Bank D Offshore Wind Farm Project, also referred to as DBD in this PEIR.

12.4 Unexploded Ordnance Assessment

12.4.1 Introduction

1. This appendix to the Dogger Bank D Offshore Wind Farm (hereafter 'the Project' or 'DBD') Preliminary Environmental Information Report (PEIR) supports **Volume 1, Chapter 12 Marine Mammals.** This appendix forms part of the PEIR for the offshore elements of the Project.

2. This appendix provides an indicative assessment of potential auditory injury and disturbance effects on marine mammals during Unexploded Ordnance (UXO) clearance for the DBD Offshore Development Area. This assessment is provided with the PEIR for information purposes only. A separate Marine Licence (ML) application for UXO clearance would be submitted post-consent, once detailed information on the locations and extent of UXO required to be cleared is known.

3. A Cumulative Effect Assessment (CEA) for UXO clearance at other projects is provided in **Section 12.8** of **Volume 1**, **Chapter 12 Marine Mammals**.

12.4.2 Worst Case Scenario

4. **Table 12.4-1**Error! Reference source not found. presents the worst-case parameters for assessing the impacts from UXO clearance to marine mammals.

Table 12.4-1 Realistic Worse Case Parameters for Marine Mammals UXO Assessment

Parameters	Notes and Rationale
Types and sizes of UXO: Various possible types and sizes of UXO, ranging from 0.25kg to 907kg.	Indicative only. 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 not known at this stage. Therefore, **Table 12.4-3** provides an example of UXO types and sizes from Dogger Bank C data.
Number of UXO requiring clearance: Currently unknown.	
Clearance techniques: Low-order clearance would be the first and preferred method for UXO that require clearance. As a worst-case, assessments are based on high-order clearance.	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 in all cases, however, it is assessed as the worst-case.

12.4.3 DBD Mitigation Measures

5. The Project has committed to the mitigation measures for any UXO clearance, as outlined below in **Table 12.4-2**. Current guidance from the Joint Nature and Conservation Committee (JNCC) guidelines for minimising the risk of injury to marine mammals from using explosives (JNCC 2010[1]) would be used as the basis for the mitigation measures.

[1] DRAFT guidelines for minimising the risk of injury to marine mammals from unexploded ordnance clearance in the marine environment (2023) has been issued for consultation and will be applied once finalised.

Table 12.4-2 UXO Clearance Mitigation and Monitoring Measures

Parameters	Additional Mitigation Measures
Marine Mammal Mitigation Plan (MMMP) for UXO Clearance	A detailed MMMP would be prepared for UXO clearance during the post-consent phase, during the ML application process. The MMMP for UXO clearance would 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 would be developed in the pre-construction period, when there is more detailed information on the UXO clearance which could be required and the most suitable mitigation measures, based upon best available information and methodologies at that time. The MMMP for UXO clearance would be prepared in consultation with the Marine Management Organisation (MMO) and relevant Statutory Nature Conservation Bodies (SNCBs). The MMMP for UXO clearance would include details of all the required mitigation measures to minimise the potential risk of permanent threshold shift (PTS) 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; • Possible use of bubble curtains taking into consideration the environmental and safety limitations; • All UXO clearance to take place in daylight and, when possible, in favourable conditions with good visibility; Establishment of a monitoring area with minimum of 1km radius; • The observation of the monitoring area would be by dedicated and trained marine mammal observers (MMObs) during daylight hours and suitable visibility; • The observation of the monitoring area using Passive Acoustic Monitoring as an additional monitoring tool; • The activation of Acoustic Deterrent Devices (ADDs);

Parameters	**Additional Mitigation Measures**
	• The controlled explosions of the UXO would be undertaken by specialist contractors, using the minimum amount of explosive required in order to achieve safe disposal of the UXO; and • Other UXO clearance techniques, such as avoidance of UXO, or relocation of UXO. UXO is not included in the Development Consent Order (DCO) application, as currently not enough detailed information is available. Therefore, UXO clearance consent would be in a separate ML post-consent. An Outline MMMP will be submitted as part of the DCO application alongside the Environmental Statement (ES). Consultation for this Outline MMMP with the MMO and Natural England will be undertaken prior to the ES submission.
Site Integrity Plan (SIP) for the Southern North Sea Special Area of Conservation (SAC)	A SIP would be developed in the pre-construction period as part of the separate ML process (if deemed to be required) and would be based upon best available information and methodologies at that time, in consultation with the relevant SNCBs and the MMO. The SIP would set out the approach to deliver any mitigation or management measures to reduce the potential for any significant disturbance of harbour porpoise *Phocoena phocoena* in relation to the Southern North Sea SAC Conservation Objectives. The SIP is an adaptive management tool, which can be used to ensure that the most adequate, effective and appropriate measures, if required, are put in place to reduce the significant disturbance of harbour porpoise in the Southern North Sea SAC.

12.4.4 UXO Clearance Techniques

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

7. 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 (NPL 2020a):

   - 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; and
   - Low-order deflagration.

8. 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 2019; NPL 2020a). The explosive material inside the UXO reacts with a rapid burning rather than a chain reaction that would lead to a full explosion (NPL 2020a).

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

10. The technique of low-order clearance appears to present a viable option to avoid high-order explosive detonation in some cases. 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, 2019). Recent evidence of a successful campaign applying low-order techniques was seen with the Moray West offshore wind farm, where 82 UXOs were able to be cleared using the technique (Ocean Winds, 2024).

11. In the 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, high-order detonations have been considered, alongside low-order clearance.

12.4.5 Potential Effects

12. It is important to note the assessments for UXO clearance are for information only and are not secured as part of the DCO application. A separate ML application would be submitted when a detailed UXO survey has been completed prior to construction, and a detailed assessment based on that latest available information (including potential UXO locations, size, type, and number) has been undertaken.

13. The following assessments are provided for information purposes only and to present the proposed approach to the future assessment.

14. Prior to construction, there is the potential for UXO clearance to be required. While any identified UXO could either be avoided or removed and disposed of onshore in a designated place, if safe to do so, there is the potential that underwater detonation could be required where it is necessary and unsafe to relocate / remove the UXO.

15. A detailed UXO survey would be completed prior to construction. Therefore, the number of possible UXO that may require to cleared and duration of UXO clearance operations are currently unknown. 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 907kg Net Explosive Quantity (NEQ), based on the Dogger Bank C UXO findings (Ordtek, 2022).

16. 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 and 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.

17. The potential effects of underwater UXO detonations on marine mammals include:

- 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.
- 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.

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

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

19. There are 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 occurs has a significant influence on the effect range for a given charge mass (von Benda-Beckmann *et al.* 2015).

20. It is important to note that assessments are based on the worst-case for high-order UXO detonations with no mitigation, which is highly unlikely, as the preferred and first option for any UXO requiring detonation (i.e. those which cannot be avoided, relocated or removed) would be a low-order clearance method.

12.4.6 Underwater Noise Modelling

21. A number of UXOs with a range of charge weights (or quantity of contained explosive) could be located within the Offshore Development Area. There is the potential for there to be a variety of explosive types, which would 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.

22. The Dogger Bank C Offshore Wind Farm UXO risk management report (which included the DBD Array Area at the time of writing) includes detonation of the UXO devices (and sizes) as shown in **Table 12.4-3**.

23. Natural England recommended that one high order detonation of a 750kg UXO is attributed to each scoped-in project at the DCO application stage (Parker *et al.* 2022). Even though there was no expected presence of a 907kg UXO device in the DBD Array Area, it was included in the modelling as a precautionary worst-case due to potential presence in the wider area.

24. A selection of explosive sizes has been considered in the estimation of the underwater noise levels produced by detonation of UXO, these were chosen to give a good spread of what has been identified at similar sites in the North Sea (**Table 12.4-3**). The assessment assumes the maximum explosive charge (see **Appendix 12.3 Underwater Noise Modelling Report**).

Table 12.4-3 Selection of UXO Potentially Present at the Project (data on UXO from Dogger Bank C Offshore Wind Farm is taken from Ordtek, 2022)

UXO devices potentially present	NEQ for UXO sizes potentially present	NEQ for UXO devices included within the following assessment
• German SC-50 Bomb • British 250lb MC Bomb • WWI German IV Mine • British 500lb MC Bomb • WWI U-Boat Torpedo (Multiple Variants) • German SC-250 Bomb • WWI German V Mine • German SC-500 Bomb • British 1000lb MC Bomb • WWII U-Boat Torpedo (Multiple Variants) • British 2000lb MC Bomb • German LMB Mine • German TMB mine • German SC-1000 Bomb • German TMC Mine	• 25kg • 55kg • 82kg • 116kg • 118kg • 130kg • 163kg • 220kg • 239kg • 280kg • 483kg • 554kg • 620kg • 907kg	• 0.25 • 25kg • 55kg • 120kg • 240kg • 525kg • 698kg • 907kg

25. 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.

26. 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.

27. 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).

28. 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 SPL_{peak} which were unweighted and did not take species hearing sensitivity into account.

29. 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 $\mu Pa^2 s$.

30. 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 12.3 Underwater Noise Modelling Report**).

12.4.7 Underwater Noise Modelling Methodology

31. The maximum equivalent charge weight for the potential UXO devices that could be present within the Project has been estimated as 907kg. This has been modelled alongside a range of smaller devices, at charge weights of 25, 55, 120, 240, 525 and 698kg.

32. In addition, low-order clearance (such as deflagration) has been assessed, an additional donor weight of 0.25kg has been included to initiate detonation. 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 follows Arons (1954) and the Marine Technical Directorate Ltd (MTD) (1996) (see **Appendix 12.3 Underwater Noise Modelling Report**).

33. **Table 12.4-4** provides the source level used for the underwater noise modelling (further details on how these were calculated is provided in **Appendix 12.3 Underwater Noise Modelling Report**.

Table 12.4-4 Source Levels (Unweighted SPL_{peak} and SEL_{ss} Used for UXO Modelling)

Charge weight	SPL_{peak} source level (dB re 1 µPa @ 1m)	SEL_{ss} source level (dB re 1 µPa²s @ 1m)
Low order (0.25 kg)	269.8	215.2
25kg + donor	284.9	228.0
55kg + donor	287.5	230.1
120kg + donor	290.0	232.3
240kg + donor	292.3	234.2
525kg + donor	294.8	236.4
698kg + donor	295.7	237.1
907 kg + donor	296.6	237.9

12.4.8 Impact Assessment Methodology

34. The following assessments are undertaken in line with the methodology as set out in **Volume 1**, **Chapter 12 Marine Mammals**, including the definition of effect magnitude levels which can be seen in **Table 12.4-5**.

Table 12.4-5 Definition of Magnitude of Impacts

Severity	Definition	Approximate duration of effect	% of ref pop exposed to the effect
High	Impact has an irreversible adverse effect on the population or the environment. These impacts threaten the long-term viability, health and functioning of the affected population or environment and typically difficult to mitigate.	Permanent	<1%
		Long-term	<5%
		Temporary	<10%
Medium	Impacts are noticeable and measurable but does not exceed the limits in which a population can does not recover or threaten the overall integrity or functioning of the affected environment or population.	Permanent	0.01% and 1%
		Long-term	1% - 5%
		Temporary	5% - 10%
Low	Impacts are detectable, but do not cause significant adverse changes to a population or the habitat the receptors live in. The effects of these impacts are localised and short term in nature without long-term consequences.	Permanent	0.001% - 0.01%
		Long-term	0.01% - 1%
		Temporary	1% - 5%
Negligible	Impacts are so minor that they do not cause any significant changes to the environment or population. These impacts are often undetectable of fall within the natural variability of the system	Permanent	< 0.001%
		Long-term	< 0.01%
		Temporary	< 1%

35. Assessments are carried out using the density and reference populations for harbour porpoise, bottlenose dolphin *Tursiops truncatus*, common dolphin *Delphinus delphis*, white-beaked dolphin *Lagenorhynchus albirostris*, minke whale *Balaenoptera acutorostrata*, grey seal *Halichoerus grypus*, and harbour seal *Phoca vitulina* provided in **Section 12.6.9** of **Volume 1**, **Chapter 12 Marine Mammals**.

12.4.9 Sensitivity

36. 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.

37. 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.

12.4.10 Results

38. The results of the underwater noise modelling (**Appendix 12.3 Underwater Noise Modelling Report**) for a range of potential charge weights (NEQ) are presented in **Table 12.4-6** for PTS and **Table 12.4-7** for TTS, respectively. The potential effect ranges have been modelled based on the latest Southall *et al.* (2019) thresholds and criteria. The effect ranges (and areas, based on the area of a circle) are used to inform the assessments.

Table 12.4-6 Potential Maximum Impact Ranges (and Areas) of PTS 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 (and area)**		
	PTS SPL_{peak} Unweighted (Impulsive criteria)	PTS SEL Weighted (Impulsive criteria)	PTS SEL 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**
0.25kg (low-order clearance)	**990m (3.1km²)**	80m (0.02km²)	< 50m (0.01km²)
25kg+ donor charge	4.6km (66.5km²)	570m (1.02km²)	< 50m (0.01km²)
55kg + donor charge	6.0km (113.1km²)	740m (1.7km²)	< 50m (0.01km²)
120kg + donor charge	7.8km (191.1km²)	950m (2.8km²)	70m (0.02km²)
240kg + donor charge	9.8km (301.7km²)	1.1km (3.8km²)	100m (0.03km²)
525kg + donor charge	12km (452.4km²)	1.4km (6.2km²)	130m (0.05km²)
698kg + donor charge	13km (530.9km²)	1.5km (7.1km²)	150m (0.07km²)
907kg + donor charge	**15km (706.9km²)**	1.6km (8.04km²)	170m (0.09km²)
Bottlenose 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**
0.25kg (low-order clearance)	**60m (0.01km²)**	< 50m (0.01km²)	< 50m (0.01km²)

Potential maximum charge weight (NEQ)	**Maximum predicted impact range (and area)**		
	PTS SPL_{peak} Unweighted (Impulsive criteria)	PTS SEL Weighted (Impulsive criteria)	PTS SEL Weighted (Non-impulsive criteria)
25kg+ donor charge	260m (0.2km^2)	< 50m (0.01km^2)	< 50m (0.01km^2)
55kg + donor charge	340m (0.4km^2)	< 50m (0.01km^2)	< 50m (0.01km^2)
120kg + donor charge	450m (0.6km^2)	< 50m (0.01km^2)	< 50m (0.01km^2)
240kg + donor charge	560m (0.9km^2)	< 50m (0.01km^2)	< 50m (0.01km^2)
525kg + donor charge	730m (1.7km^2)	50m (0.01km^2)	< 50m (0.01km^2)
698kg + donor charge	810m (2.1km^2)	60m (0.01km^2)	< 50m (0.01km^2)
907kg + donor charge	**880m (2.4km^2)**	70m (0.02km^2)	< 50m (0.01km^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**
0.25kg (low-order clearance)	170m (0.09km^2)	**230m (0.2km^2)**	< 50m (0.01km^2)
25kg+ donor charge	820m (2.1km^2)	2.2km (15.2km^2)	130m (0.05km^2)
55kg + donor charge	1.0km (3.1km^2)	3.2km (32.2km^2)	190m (0.1km^2)
120kg + donor charge	1.3km (5.3km^2)	4.7km (69.4km^2)	280m (0.2km^2)
240kg + donor charge	1.7km (9.1km^2)	6.5km (132.7km^2)	390m (0.5km^2)
525kg + donor charge	2.2km (15.2km^2)	9.5km (283.5km^2)	570m (1.02km^2)

Potential maximum charge weight (NEQ)	Maximum predicted impact range (and area)		
	PTS SPL_{peak} Unweighted (Impulsive criteria)	PTS SEL Weighted (Impulsive criteria)	PTS SEL Weighted (Non-impulsive criteria)
698kg + donor charge	2.4km (18.1km^2)	10km (314.2km^2)	660m (1.4km^2)
907kg + donor charge	2.7km (22.9km^2)	**12km (452.4km^2)**	750m (1.8km^2)
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**
0.25kg (low-order clearance)	**190m (0.1km^2)**	< 50m (0.01km^2)	< 50m (0.01km^2)
25kg+ donor charge	910m (2.6km^2)	390m (0.5km^2)	< 50m (0.01km^2)
55kg + donor charge	1.1km (3.8km^2)	570m (1.02km^2)	< 50m (0.01km^2)
120kg + donor charge	1.5km (7.1km^2)	830m (2.2km^2)	< 50m (0.01km^2)
240kg + donor charge	1.9km (11.3km^2)	1.1km (3.8km^2)	70m (0.02km^2)
525kg + donor charge	2.5km (19.6km^2)	1.6km (8.04km^2)	100m (0.3km^2)
698kg + donor charge	2.7km (22.9km^2)	1.9km (11.3km^2)	110m (0.04km^2)
907kg + donor charge	**3.0km (28.3km^2)**	2.2km (15.2km^2)	130m (0.05km^2)

Table 12.4-7 Potential Maximum Impact Ranges (and Areas) 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 (and area)**		
	TTS SPL_{peak} Unweighted (Impulsive criteria)	TTS SEL Weighted (Impulsive criteria)	TTS SEL Weighted (Non-impulsive criteria)
Harbour porpoise (VHF cetacean)			
	196 dB re 1 µPa	**140 dB re 1 µPa²s**	**153 dB re 1 µPa²s**
0.25kg (low-order clearance)	**1.8km (10.2km²)**	750m (1.8km²)	110m (0.04km²)
25kg+ donor charge	8.5km (227km²)	2.4km (18.1km²)	730m (1.7km²)
55kg + donor charge	11km (380.1km²)	2.8km (24.6km²)	940m (2.8km²)
120kg + donor charge	14km (615.8km²)	3.2km (32.2km²)	1.1km (3.8km²)
240kg + donor charge	18km (1,017.9km²)	3.5km (38.5km²)	1.4km (6.2km²)
525kg + donor charge	23km (1,661.9km²)	4.0km (50.3km²)	1.7km (9.1km²)
698kg + donor charge	25km (1,963.5km²)	4.1km (52.8km²)	1.8km (10.2km²)
907kg + donor charge	**28km (2,463km²)**	4.3km (58.1km²)	1.9km (11.3km²)
Bottlenose dolphin, common dolphin, and white-beaked dolphin (HF cetaceans)			
	224 dB re 1 µPa	**170 dB re 1 µPa²s**	**178 dB re 1 µPa²s**

0.25kg (low-order clearance)	**100m (0.03km^2)**	< 50m (0.01km^2)	< 50m (0.01km^2)
25kg+ donor charge	490m (0.8km^2)	150m (0.07km^2)	< 50m (0.01km^2)
55kg + donor charge	640m (1.3km^2)	210m (0.1km^2)	60m (0.01km^2)
120kg + donor charge	830m (2.2km^2)	300m (0.3km^2)	80m (0.02km^2)
240kg + donor charge	1.0km (3.1km^2)	390m (0.5km^2)	110m (0.04km^2)
525kg + donor charge	1.3km (5.3km^2)	530m (0.9km^2)	160m (0.08km^2)
698kg + donor charge	1.4km (6.2km^2)	590m (1.1km^2)	180m (0.1km^2)
907kg + donor charge	**1.6km (8.04km^2)**	650m (1.3km^2)	200m (0.1km^2)
Minke whale (LF cetacean)			
	213 dB re 1 μPa	**168 dB re 1 μPa^{2}s**	**179 dB re 1 μPa^{2}s**
0.25kg (low-order clearance)	320m (0.3km^2)	**3.2km (32.2km^2)**	460m (0.7km^2)
25kg+ donor charge	1.5km (7.1km^2)	29km (2,642.1km^2)	4.4km (60.8km^2)
55kg + donor charge	1.9km (11.3km^2)	41km (5,281.02km^2)	6.4km (128.7km^2)
120kg + donor charge	2.5km (19.6km^2)	57km (10,207.04km^2)	9.4km (277.6km^2)
240kg + donor charge	3.2km (32.2km^2)	76km (18,145.8km^2)	13km (530.9km^2)
525kg + donor charge	4.1km (52.8km^2)	100km (31,416km^2)	18km (1,017.9km^2)

698kg + donor charge	4.5km (63.6km^2)	110km (38,013.3km^2)	21km (1,385.4km^2)
907kg + donor charge	4.9km (75.4km^2)	**120km (45,239km^2)**	24km (1,809.6km^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**
0.25kg (low-order clearance)	360m (0.4km^2)	**570m (1.02km^2)**	80m (0.02km^2)
25kg+ donor charge	1.6km (8.04km^2)	5.2km (84.9km^2)	790m (2.0km^2)
55kg + donor charge	2.1km (13.9km^2)	7.5km (176.7km^2)	1.1km (3.8km^2)
120kg + donor charge	2.8km (24.6km^2)	10km (314.2km^2)	1.6km (8.04km^2)
240kg + donor charge	3.5km (38.5km^2)	14km (615.8km^2)	2.3km (16.6km^2)
525kg + donor charge	4.6km (66.5km^2)	19km (1,134.1km^2)	3.3km (34.2km^2)
698kg + donor charge	5.0km (78.5km^2)	22km (1,520.5km^2)	3.8km (45.4km^2)
907kg + donor charge	5.5km (95.03km^2)	**24km (1,809.6km^2)**	4.3km (58.1km^2)

12.4.11 Assessment of Effects

39. The density and population estimates used for the assessments are as those presented in **Section 12.6.9** of **Volume 1**, **Chapter 12 Marine Mammals**. The worst-case density estimate used for each species are shown in **Table 12.4-8**.

Table 12.4-8 Worst Case Density Estimates used for UXO Assessments

Species	Offshore component	Density (animals/km^2)	Source
Harbour porpoise	Array Area	0.842	Project survey data
Bottlenose dolphin	Offshore Export Cable Corridor (ECC)	0.0419	SCANS-IV
Common dolphin	Offshore ECC	0.017	Waggitt *et al.* 2019
White-beaked dolphin	Offshore ECC	0.034	Waggitt *et al.* 2019
Minke whale	Array Area	0.0153	SCANS-IV
Grey seal	Offshore ECC	0.274	Carter *et al.* 2022
Harbour seal	Offshore ECC	0.0008	Carter *et al.* 2022

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

12.4.11.1.1 Magnitude

12.4.11.1.1.1.Permanent Auditory Injury (PTS)

40. 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 12.4-9**Table 12.4-9 Maximum Number of Marine Mammals Potentially at Risk of PTS During High and Low Order UXO Clearance

41. The assessment was based on the maximum potential PTS impact ranges set out in **Table 12.4-6**.

42. For a high-order detonation of the worst-case maximum potential UXO (NEQ of 907kg plus donor charge), the magnitude for PTS was assessed to be:

- Medium for harbour porpoise, minke whale and grey seal;

- Low to medium for bottlenose dolphin; and
- Negligible for white-beaked dolphin, common dolphin and harbour seal.

43. For low-order clearance (NEQ of 0.25kg) the magnitude for PTS was assessed to be negligible for all marine mammal species assessed as seen in **Table 12.4-9**.

Table 12.4-9 Maximum Number of Marine Mammals Potentially at Risk of PTS During High and Low Order UXO Clearance

Species	Criteria	Maximum effect range (and area)	Maximum number of individuals	% of reference population	Magnitude (permanent impact)
Harbour porpoise	PTS SPL_{peak} Unweighted (Impulsive criteria)	High-order clearance (907kg + donor) 15km (706.9km^2)	596	0.18% of the North Sea (NS) Assessment Unit (AU)	**Medium**
		Low-order clearance (0.25kg NEQ) 990m (3.1km^2)	3	0.0009% of the NS AU	**Negligible**
Bottlenose dolphin	PTS SPL_{peak} Unweighted (Impulsive criteria)	High-order clearance (907kg + donor) 880m (2.4km^2)	0.1	0.005% of the Greater North Sea (GNS) Management Unit (MU) or 0.05% of the CES MU	**Low to Medium**
		Low-order clearance (0.25kg NEQ) 60m (0.01km^2)	0.0005	0.00002% of the GNS MU or 0.0002% of the CES MU	**Negligible**
Common dolphin	PTS SPL_{peak} Unweighted (Impulsive criteria)	High-order clearance (907kg + donor) 880m (2.4km^2)	0.04	0.0004% of the Celtic and Greater North Seas (CGNS) MU	**Negligible**
		Low-order clearance (0.25kg NEQ) 60m (0.01km^2)	0.0002	0.0000002% of the CGNS MU	**Negligible**
	PTS SPL_{peak}	High-order clearance (907kg + donor)	0.08	0.0002% of the CGNS MU	**Negligible**

Species	Criteria	Maximum effect range (and area)	Maximum number of individuals	% of reference population	Magnitude (permanent impact)
White-beaked dolphin	Unweighted (Impulsive criteria)	880m (2.4km^2)			
		Low-order clearance (0.25kg NEQ) 60m (0.01km^2)	0.0004	0.00000001% of the CGNS MU	**Negligible**
Minke whale	PTS SEL Weighted (Impulsive criteria)	High-order clearance (907kg + donor) 12km (452.4km^2)	7	0.03% of the CGNS MU	**Medium**
		Low-order clearance (0.25kg NEQ) 230m (0.2km^2)	0.003	0.00001% of the CGNS MU	**Negligible**
Grey seal	PTS SPL_{peak} Unweighted (Impulsive criteria)	High-order clearance (907kg + donor) 3km (28.3km^2)	8	0.01% of the South East (SE) and North East (NE) MU	**Medium**
		Low-order clearance (0.25kg NEQ) 190m (0.1km^2)	0.03	0.0000006% of the SE and NE MU	**Negligible**
Harbour seal	PTS SPL_{peak} Unweighted (Impulsive criteria)	High-order clearance (907kg + donor) 3km (28.3km^2)	0.02	0.0005% of the SE and NE MU	**Negligible**
		Low-order clearance (0.25kg NEQ)	0.00009	0.00000002% of the SE and NE MU	**Negligible**

Species	Criteria	Maximum effect range (and area)	Maximum number of individuals	% of reference population	Magnitude (permanent impact)
		190m (0.1km^2)			

12.4.11.1.1.2.Temporary Auditory Injury (TTS)

44. The number of marine mammal receptors that could potentially be impacted by a high-order UXO detonation (up to 907kg + donor NEQ) and low-order clearance (0.25kg) have been estimated for the Project in **Table 12.4-10**. The assessment was based on the maximum potential TTS impact ranges set out in **Table 12.4-7**, and the density and population data as presented in **Section 12.6.9** of **Volume 1**, **Chapter 12 Marine Mammals**. The worst-case density estimate used for each species are shown in **Table 12.4-8**.

45. For the high-order detonation of the worst-case maximum potential UXO (NEQ of 907kg plus donor charge), the magnitude for TTS was assessed to be:

- Negligible for harbour porpoise, bottlenose dolphin, white-beaked dolphin, common dolphin, grey seal and harbour seal; and
- Low for minke whale.

46. For low-order clearance (0.25kg donor charge) the magnitude for TTS was assessed to be negligible for all species assessed.

Table 12.4-10 Maximum Number of Marine Mammals Potentially at Risk of TTS During High and Low Order UXO Clearance

Species	Criteria	Maximum effect range (and area)	Maximum number of individuals	% of reference population	Magnitude (permanent impact)
Harbour porpoise	TTS SPL_{peak} Unweighted (Impulsive criteria)	High-order clearance (907kg + donor) 28km (2,463km^2)	2,074	0.61% of the NS AU	**Negligible**
		Low-order clearance (0.25kg NEQ) 1.8km (10.2km^2)	9	0.003% of the NS AU	**Negligible**
Bottlenose dolphin	TTS SPL_{peak} Unweighted (Impulsive criteria)	High-order clearance (907kg + donor) 1.6km (8.04km^2)	0.3	0.02% of the GNS MU or 0.15% of the CES MU	**Negligible**
		Low-order clearance (0.25kg NEQ) 100m (0.03km^2)	0.0013	0.00007% of the GNS MU or 0.0006%of the CES MU	**Negligible**
Common dolphin	TTS SPL_{peak} Unweighted (Impulsive criteria)	High-order clearance (907kg + donor) 1.6km (8.04km^2)	0.1	0.0001% of the CGNS MU	**Negligible**
		Low-order clearance (0.25kg NEQ) 100m (0.03km^2)	0.0005	0.0000005% of the CGNS MU	**Negligible**
White-beaked dolphin	TTS SPL_{peak} Unweighted (Impulsive criteria)	High-order clearance (907kg + donor) 1.6km (8.04km^2)	0.3	0.0006% of the CGNS MU	**Negligible**
		Low-order clearance (0.25kg NEQ) 100m (0.03km^2)	0.001	0.000002% of the CGNS MU	**Negligible**
	TTS SEL	High-order clearance (907kg + donor)	693	3.44% of the CGNS MU	**Low**

Species	Criteria	Maximum effect range (and area)	Maximum number of individuals	% of reference population	Magnitude (permanent impact)
Minke whale	Weighted (Impulsive criteria)	120km (45,239km^2)			
		Low-order clearance (0.25kg NEQ) 3.2km (32.2km^2)	0.5	0.002% of the CGNS MU	**Negligible**
Grey seal	TTS SEL Weighted (Impulsive criteria)	High-order clearance (907kg + donor) 24km (1,809.6km^2)	496	0.88% of the SE and NE MU	**Negligible**
		Low-order clearance (0.25kg NEQ) 570m (1.02km^2)	0.3	0.0005% of the SE and NE MU	**Negligible**
Harbour seal	TTS SEL Weighted (Impulsive criteria)	High-order clearance (907kg + donor) 24km (1,809.6km^2)	2	0.04% of the SE and NE MU	**Negligible**
		Low-order clearance (0.25kg NEQ) 570m (1.02km^2)	0.0008	0.00002% of the SE and NE MU	**Negligible**

12.4.11.1.2 Effect Significance

47. Taking into account the high sensitivity for all species to PTS from UXO clearance. The effect significance, for a high-order detonation without mitigation, has been assessed as **major adverse** (**significant in EIA terms**) for harbour porpoise, bottlenose dolphin (for the CES MU population), minke whale and grey seal, **moderate adverse** (**significant in EIA terms**) for bottlenose dolphin (for the GNS MU population), and minor adverse for common dolphin, white-beaked dolphin and harbour seal (**Table 12.4-11**) (based on impact methodology in **Volume 1**, **Chapter 12 Marine Mammals**, **Section 12.5.3**).

48. For low-order clearance, without mitigation measures, and based on a high sensitivity for all marine mammals to PTS, the effect significance has been assessed as **minor adverse** (**not significant in EIA terms**) for all marine mammal species (**Table 12.4-11**).

49. With mitigation measures (**Section 12.4.11.1.3**), the residual effect significance would be **minor adverse** (not significant) for the potential for PTS in all marine mammal species for both high-order and low-order clearance.

50. For TTS, taking into account the medium sensitivity for all species to UXO clearance, the effect significance, for both a high-order detonation and low-order detonation, without mitigation, has been assessed as **negligible adverse** (**not significant in EIA terms**) for all marine mammal species except for a high-order clearance for minke whale which was assessed as **minor adverse** (**not significant in EIA terms**) (**Table 12.4-11**).

51. It should be noted that the conclusion of **moderate** or **major adverse** (**significant in EIA terms**) without mitigation for PTS is very precautionary, as the assessment is based on the worst-case scenario of the largest possible UXO device as a high-order detonation.

Table 12.4-11 Assessment of Effect Significance for Auditory Injury from UXO Clearance

Species	Sensitivity	Magnitude*	Effect significance*	Mitigation	Residual effect significance
PTS during high-order UXO clearance					
Harbour porpoise	High	Medium	Major adverse	MMMP for UXO clearance.	Minor adverse
Bottlenose dolphin	High	Low (medium)	Moderate adverse (major adverse)		Minor adverse
Common dolphin	High	Negligible	Minor adverse		Minor adverse
White-beaked dolphin	High	Negligible	Minor adverse		Minor adverse
Minke whale	High	Medium	Major adverse		Minor adverse
Grey seal	High	Medium	Major adverse		Minor adverse
Harbour seal	High	Negligible	Minor adverse		Minor adverse
PTS during low-order UXO clearance					
Harbour porpoise	High	Negligible	Minor adverse	None required, but MMMP for UXO clearance would reduce potential for effect.	Minor adverse
Bottlenose dolphin	High	Negligible	Minor adverse		Minor adverse
Common dolphin	High	Negligible	Minor adverse		Minor adverse
White-beaked dolphin	High	Negligible	Minor adverse		Minor adverse

Species	Sensitivity	Magnitude*	Effect significance*	Mitigation	Residual effect significance
Minke whale	High	Negligible	Minor adverse		Minor adverse
Grey seal	High	Negligible	Minor adverse		Minor adverse
Harbour seal	High	Negligible	Minor adverse		Minor adverse
TTS during high-order UXO clearance					
Harbour porpoise	Medium	Negligible	Negligible adverse	None required, but MMMP for UXO clearance would reduce potential for effect.	Negligible adverse
Bottlenose dolphin	Medium	Negligible	Negligible adverse		Negligible adverse
Common dolphin	Medium	Negligible	Negligible adverse		Negligible adverse
White-beaked dolphin	Medium	Negligible	Negligible adverse		Negligible adverse
Minke whale	Medium	Low	Minor adverse		Minor adverse
Grey seal	Medium	Negligible	Negligible adverse		Negligible adverse
Harbour seal	Medium	Negligible	Negligible adverse		Negligible adverse
TTS during low-order UXO clearance					
Harbour porpoise	Medium	Negligible	Negligible adverse	None required, but MMMP for UXO clearance would reduce potential for effect.	Negligible adverse
Bottlenose dolphin	Medium	Negligible	Negligible adverse		Negligible adverse
Common dolphin	Medium	Negligible	Negligible adverse		Negligible adverse

Species	Sensitivity	Magnitude*	Effect significance*	Mitigation	Residual effect significance
White-beaked dolphin	Medium	Negligible	Negligible adverse		Negligible adverse
Minke whale	Medium	Negligible	Negligible adverse		Negligible adverse
Grey seal	Medium	Negligible	Negligible adverse		Negligible adverse
Harbour seal	Medium	Negligible	Negligible adverse		Negligible adverse

** Magnitudes and significance given in brackets are for the secondary MU assessed for the Coastal East Scotland (CES) MU for bottlenose dolphin*

12.4.11.1.3 Mitigation

52. As outlined in **Section 12.4.3**, a MMMP for UXO clearance would be produced post- consent in consultation with the MMO and relevant SNCBs. The final MMMP for UXO clearance would be based on the latest scientific understanding and guidance, pre-construction UXO surveys in the offshore project area, as well as detailed project design.

53. The proposed mitigation measures for consideration in the **Outline MMMP** for UXO clearance could include, the use of low-order clearance techniques, such as deflagration, establishing a monitoring zone and surveying prior to UXO clearance, and the use of ADDs to ensure the potential PTS range has been cleared.

54. For high-order clearance, an ADD would be required to be activated for a maximum of 80 minutes, during which harbour porpoise, bottlenose dolphin, common dolphin, white-beaked dolphin, grey seal, and harbour seal would move at least 7.2km away, based on a precautionary swimming speed of 1.5m/s (Otani *et al.* 2000), and minke whale would move 15.6km, based on a swimming speed of 3.25m/s (Blix and Folkow, 1995).

55. This is less than the highest PTS effect range of 15km for harbour porpoise. Alternative mitigation such as noise reduction options could be required (e.g. bubble curtains) to avoid injury to this European Protected Species (EPS). If not possible to wholly mitigate the potential for auditory injury, a marine wildlife EPS licence for injury would be applied for, at the time of the ML application. An updated assessment would be undertaken for the ML application based on the actual type, weight, and number of UXO identified for clearance.

56. The implementation of the mitigation measures within the final MMMP for UXO clearance would reduce the risk of any PTS during UXO clearance. The mitigation measure would also reduce the risk of TTS.

12.4.11.2 Impact 2: Disturbance from Underwater Noise Associated with UXO Clearance

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

58. For marine mammals, a fleeing response is 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 is proposed to occur at the lowest level of noise exposure that has a measurable transient effect on hearing (i.e. TTS). Although, as Southall *et al.* (2007) recognised that this is not a behavioural effect per se, sound exposures to lower noise levels from a single pulse are not expected to cause disturbance. However, any compromise, even temporarily, to hearing functions could have the potential to affect behaviour.

59. The use of the TTS threshold is appropriate for UXO disturbance because the noise from the UXO explosion is only fleetingly in the environment. Therefore, the assumption is that although noise levels lower than TTS threshold may startle the individual, this has no lasting effect. TTS results 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).

60. 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 can 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 can lead to inherent variability in the probability and severity of behavioural responses.

61. The SNCBs currently recommend that a potential disturbance range based on an Effective Deterrent Radius (EDR) of 26km around UXO high-order detonations is used to assess harbour porpoise disturbance in SACs (JNCC *et al.* 2020); the offshore project area lies within the Southern North Sea SAC. The assessment for the potential disturbance for high-order detonation, therefore, also includes the maximum number of harbour porpoise based on maximum potential impact area for 26km EDR (an area of 2,123.7km^2).

62. For harbour porpoise, minke whale and seal, the potential effect area during a UXO clearance event was determined using the modelled worst-case effect ranges for TTS / fleeing response (weighted SEL). The TTS ranges for high-order clearance for harbour porpoise and minke whale, at 28km (=2,463km^2) and 120km (=45,239km^2) respectively, exceeded the 26km EDR (JNCC, 2023b), and is therefore considered a worst-case. For seals, the 24km TTS range (=1,810km^2), was taken forward for the assessments.

63. The potential impact area for dolphins was determined to be based on the 26km EDR (=2,124km^2) for high-order UXO detonation (unmitigated), following the current JNCC (2023b) guidance, and has been applied to dolphins as a precautionary approach, due to the lack of information on the potential disturbance of dolphin species to UXO clearance. In addition, while TTS ranges are available for dolphin species, they are significantly smaller and may not adequately represent the potential for dolphin disturbance. This is however a precautionary approach and is likely to overestimate the potential for disturbance of dolphin species.

64. The assessments for TTS / fleeing response have therefore been used for assessing the potential disturbance ranges for UXO high-order detonation for those species where no further information is currently available for potential disturbance ranges due to UXO clearances. Therefore, the potential ranges and areas for TTS presented in **Section 12.4.11**, with the estimated number and percentage of reference populations that could be affected provides an indication of possible fleeing response.

65. The potential disturbance for low-order clearance (the first option and preferred method) is currently unknown, however, as a precautionary approach, it has been assumed that there could be an estimated worst-case of 5km disturbance range (78.54km^2) including vessels (JNCC, 2023b). As a worst-case assessment, it has been assumed that marine mammals could be temporarily disturbed from this area for UXO low-order clearances.

66. In addition, the MMMP for UXO clearance would include ADD activation prior to all UXO clearance, to ensure marine mammals are beyond the maximum potential effect ranges for PTS. The duration for ADD activation would depend on the clearance method, and would 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).

67. The duration of ADD activation required would be determined for the final MMMP for UXO clearance, based on detailed information on the UXO clearance which could be required and the most suitable mitigation measures, based upon best available information and methodologies at that time, in consultation with the MMO and relevant SNCBs. Therefore, assessments provided are for information only and would be reviewed and updated for the ML and marine wildlife licence application prior to UXO clearance in line with the latest guidance at the time of submission.

12.4.11.2.1 Magnitude

68. As assessed in **Section 0** a high-order detonation of the maximum potential UXO (NEQ of 907kg plus donor charge) was used to assess the magnitude for TTS / fleeing response, as a worst-case. The magnitude was assessed for each species:

- Negligible for harbour porpoise, bottlenose dolphin, common dolphin, white-beaked dolphin, grey seal and harbour seal; and
- Low for minke whale.

69. For low-order clearance (0.25kg donor charge for all sizes of UXO) the magnitude for TTS / fleeing response is assessed to be negligible for all marine mammal species.

70. The maximum number of harbour porpoise and dolphin species that could potentially be disturbed in a 26km radius of a high-order UXO detonation without mitigation has been estimated as 1,788 individuals. The resulting magnitude is assessed to be negligible for harbour porpoise, common dolphin and white-beaked dolphin, and low to high for bottlenose dolphin (**Table 12.4-12**).

71. 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 (low order) could occur in a 24-hour period.

Table 12.4-12 Estimated Number of Harbour Porpoise and Dolphins that Could Potentially be Disturbed During UXO Clearance Based on 26km EDR for High-Order Detonation with No Mitigation

Species	Maximum effect area	Maximum number of individuals	% of reference population	Magnitude (temporary effect)
Harbour porpoise	2,123.72km^2	1,789	0.53% of NS AU	Negligible
Bottlenose dolphin		89	4.40% of the GNS MU or 39.37% of the CES MU	Low to High
Common dolphin		37	0.04% of the CGNS MU	Negligible
White-beaked dolphin		73	0.16% of the CGNS MU	Negligible

72. Based on an estimated worst-case of 5km disturbance range (78.54km^2) including vessels for low-order clearance (such as deflagration), the magnitude of effect has been assessed as negligible for all marine mammal species except bottlenose dolphin, with a magnitude of negligible to low (**Table 12.4-13**).

Table 12.4-13 Estimated Number of Marine Mammals that Could Potentially be Disturbed During Low-Order UXO Clearance based on 5km Disturbance Ranges with a Maximum Area of Effect of 78.54km^2

Species	Maximum impact area	Maximum number of individuals and of reference population	Magnitude (temporary effect)
Harbour porpoise	78.54km^2	67 (0.02% of NS AU)	Negligible
Bottlenose dolphin	78.54km^2	4 (0.16% of GNS MU; 1.77% of CES MU)	Negligible to Low
Common dolphin	78.54km^2	2 (0.002% of CGNS MU)	Negligible
White-beaked dolphin	78.54km^2	3 (0.007% of CGNS MU)	Negligible
Minke whale	78.54km^2	2 (0.01% of CGNS MU)	Negligible
Grey seal	78.54km^2	22 (0.04% of SE and NE MU)	Negligible
Harbour seal	78.54km^2	0.06 (0.001% of SE and NE MU)	Negligible

12.4.11.2.1.1.ADD Activation

73. For high-order clearance (for a worst-case 907kg + donor charge weight) without mitigation, an ADD would need to be activated for 167 minutes, during which harbour porpoise, bottlenose dolphin, common dolphin, white-beaked dolphin, grey seal, and harbour seal would move at least 15km away, based on a precautionary swimming speed of 1.5m/s (Otani *et al.* 2000). Minke whale would move 32.57km 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 15km for harbour porpoise and would cover the highest PTS effect range for all dolphins (of 880m) minke whale (of 12km), and grey seal and harbour seal (for 3km).

74. 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.

75. 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.

76. Following this, the ADD would be activated for a maximum of 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 15km for harbour porpoise, but higher than the highest PTS effect range for minke whale (of 12km), all dolphins of 880m and 3km for grey seal and harbour seal.

77. 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 55kg NEQ (based on NEQs modelled), while high-order clearance for UXO heavier than 55kg NEQ would result in potential PTS ranges that exceed the predicted ADD deterrence range for 80 minutes of ADD activation.

78. There was therefore the potential for injury to occur for harbour porpoise for a high-order clearance of UXO heavier than 55kg 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.

79. 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: 990m for low-order clearance for harbour porpoise, and 15km for high-order clearance (detonation) for harbour porpoise (**Table12.4-14**).

80. 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 (**Table12.4-14**).

81. 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 a precautionary swimming speed of 1.5m/s (Otani *et al.*, 2000). Minke whale would move 15.6km, based on a swimming speed of 3.25m/s (Blix and Folkow 1995).

82. For low-order clearance, ADD would be activated for 11 minutes, during which harbour porpoise, bottlenose dolphin, common dolphin, white-beaked dolphin, grey and harbour seal would move at least 990m away, based on a precautionary swimming speed of 1.5m/s (Otani *et al.*, 2000) and minke whale would move 2.15km, based on a swimming speed of 3.25m/s (Blix and Folkow 1995).

83. The magnitude of impact for ADD activation prior to UXO clearance has been assessed as negligible for all marine mammal species, apart from the bottlenose dolphin CES MU population which has been assessed as low (**Table12.4-14**).

84. 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.

Table12.4-14 Estimated Number of Marine Mammals that Could Potentially be Disturbed During ADD Activation for UXO Clearance

Species (Highest density)	Low-order clearance up to 11 minutes		High-order clearance up to a maximum to 80 minutes	
	Number of individuals potentially disturbed (% of reference population)	**Magnitude of effect**	**Number of individuals potentially disturbed (% of reference population)**	**Magnitude of effect***
Harbour porpoise	3 (0.0009% of the NS AU)	Negligible	138 (0.04% of the NS AU)	Negligible
Bottlenose dolphin	0.13 (0.006% of the GNS MU; 0.06% of the CES MU)	Negligible	7 (0.35% of the GNS MU; 3.1% of the CES MU)	Negligible to Low
Common dolphin	0.05 (0.00005% of the CGNS MU)	Negligible	3 (0.003% of the CGNS MU)	Negligible
White-beaked dolphin	0.1 (0.0002% of the CGNS MU)	Negligible	6 (0.01% of the CGNS MU)	Negligible
Minke whale	0.3 (0.001% of the CGNS MU)	Negligible	14 (0.07% of the CGNS MU)	Negligible
Grey seal	0.8 (0.001% of the SE and NE MU)	Negligible	45 (0.08% of the SE and NE MU)	Negligible
Harbour seal	0.002 (0.00005% of the SE and NE MU)	Negligible	0.1 (0.003% of the SE and NE MU)	Negligible

12.4.11.2.2 Effect Significance

85. 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 **negligible adverse** (**not significant in EIA terms**) for a low-order UXO clearance, with the exception of bottlenose dolphin of the CES MU, with an effect significance of **minor adverse (not significant in EIA terms)**.

86. For harbour porpoise, common dolphin and white-beaked dolphin, the magnitude of impact based on EDRs (for a high-order clearance with no mitigation) was assessed as negligible, with an effect of **negligible adverse** (**not significant in EIA terms**). For bottlenose dolphin of the GNS MU, a high-order clearance with no mitigation would lead to a **minor adverse (which is not significant in EIA terms)** effect. For bottlenose dolphin of the CES MU, a high-order clearance with no mitigation would lead to a **major adverse (which is significant in EIA terms)** effect.

87. The disturbance effect from ADD activation (for high-order clearance) has been assessed as **minor adverse** (**not significant in EIA terms**) for the CES MU bottlenose dolphin population. For all other species (for both low-order and high-order), the overall effect has been assessed as **negligible adverse (which is not significant in EIA terms)**.

12.4.11.2.3 Mitigation options

88. 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 and would be defined in any UXO clearance MMMP. Further mitigation measures would also be considered if appropriate and required.

12.4.11.2.4 Residual Effect Significance

89. The residual effect to marine mammals due to disturbance effects as a result of underwater noise during UXO clearance at the Project wind farm site remained **negligible adverse** (**not significant in EIA terms**).

12.4.11.3 Impact 3: Changes To Prey Availability as a Result of Underwater Noise from UXO Clearance Activities

12.4.11.3.1 Sensitivity

90. As outlined in **Appendix 12.2 Marine Mammal Technical Report**, 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 are therefore considered to have low to medium sensitivity to changes in prey resources.

91. Bottlenose dolphin are opportunistic feeders and take a wide variety of fish and invertebrate species. Benthic and pelagic fish (both solitary and schooling species), however, they are selective opportunists and although they may have preference for a type of prey, their diet seems to be determined largely by prey availability (see **Appendix 12.2 Marine Mammal Technical Report**). Therefore, bottlenose dolphin are considered to have a low sensitivity to changes in prey resource.

92. Common dolphin are cooperative feeders, working within a pod to capture prey and have a varied diet (see **Appendix 12.2 Marine Mammal Technical Report**). Therefore, common dolphin are considered to have a low sensitivity to changes in prey resource.

93. White-beaked dolphin have a varied diet (see **Appendix 12.2 Marine Mammal Technical Report**). Therefore, common dolphin are considered to have a low sensitivity to changes in prey resource.

94. 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 12.2 Marine Mammal Technical Report**). Therefore, minke whale are considered to have a low to medium sensitivity to changes in prey resource.

95. 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 12.2 Marine Mammal Technical Report**). Grey seal and harbour seal are therefore considered to have low sensitivity to changes in prey resources.

12.4.11.3.2 Magnitude

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

97. 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.

98. Underwater noise modelling (**Appendix 12.3 Underwater Noise Modelling Report**) 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); and
- Swim bladder which is involved in hearing (e.g. cod, whiting, sprat and herring).

99. The underwater noise modelling results (**Appendix 12.3 Underwater Noise Modelling Report**) indicated that fish species in which the swim bladder is involved in hearing were the most sensitive to the impact of underwater noise.

100. **Table 12.4-15** 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 970m, this was considerably less than the 15km PTS impact range for harbour porpoise, based on the unweighted SPL_{peak} criteria (**Appendix 12.3 Underwater Noise Modelling Report**). 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.

101. 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 12.4-15 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	0.25kg	25kg + donor charge	55kg + donor charge	120kg + donor charge	240kg + donor charge	525kg + donor charge	698kg + donor charge	907kg + donor charge
234 dB (Mortality and potential mortal injury)	< 50m	170m	230m	300m	370m	490m	530m	580m
229 dB (Mortality and potential mortal injury)	60m	290m	380m	490m	620m	810m	890m	970m

12.4.11.3.3 Effect Significance

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

12.4.11.3.4 Mitigation

103. Mitigation techniques outlined in the MMMP would also reduce impacts to fish.

12.4.11.3.5 Residual Effect Significance

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

12.4.12 Assessment Summary

105. The potential effects on marine mammals from UXO clearance at the Offshore Development Area are summarised in **Table 12.4-16**.

Table 12.4-16 Summary of Potential Effects to Marine Mammals due to UXO Clearance

Potential Impact	Receptor	Sensitivity	Magnitude	Pre-mitigation effect	Mitigation measures	Residual effect
Impact 1: Auditory injury from underwater noise associated with UXO clearance						
PTS for UXO high-order detonation with no mitigation	Harbour porpoise, minke whale and grey seal	High	Medium	Major adverse	MMMP for UXO clearance.	Minor adverse
	Bottlenose dolphin	High	Low to medium	Moderate to major adverse		Minor adverse
	Common dolphin, white-beaked dolphin and harbour seal	High	Negligible	Minor adverse		Minor adverse
PTS for UXO low-order detonation with no mitigation	All marine mammals	High	Negligible	Minor adverse	None required, but MMMP for UXO clearance would reduce potential for effect.	Minor adverse
TTS for UXO high-order detonation with no mitigation	Harbour porpoise, bottlenose dolphin, common dolphin, white-beaked dolphin, grey seal and harbour seal	Medium	Negligible	Negligible adverse		Negligible adverse
	Minke whale	Medium	Low	Minor adverse		Minor adverse

Potential Impact	Receptor	Sensitivity	Magnitude	Pre-mitigation effect	Mitigation measures	Residual effect
TTS for UXO low order detonation with no mitigation	All marine mammals	Medium	Negligible	Negligible adverse		Negligible adverse
Impact 2: Disturbance from underwater noise associated with UXO clearance						
Disturbance from high order UXO detonation with no mitigation	Harbour porpoise, common dolphin, white-beaked dolphin, grey seal and harbour seal	Medium	Negligible	Negligible adverse	MMMP for UXO clearance would reduce potential for effect. Low order clearance preferred method in all cases; high order only used where low order is not possible (or safe). Any high order clearance to be undertaken with noise reduction.	Negligible adverse
	Bottlenose dolphin	Medium	Low to High	Minor to Major adverse		Minor adverse
	Minke whale	Medium	Low	Minor adverse		Minor adverse
Disturbance from low order UXO detonation	All marine mammals	Medium	Negligible	Negligible adverse		Negligible adverse
Disturbance from ADD activation	Harbour porpoise, common dolphin, white-beaked dolphin, minke whale, grey seal and harbour seal	Medium	Negligible	Negligible adverse		Negligible adverse

Potential Impact	Receptor	Sensitivity	Magnitude	Pre-mitigation effect	Mitigation measures	Residual effect
	Bottlenose dolphin	Medium	Negligible to low	Negligible to minor adverse		Negligible adverse
Impact 3: Changes to prey resources						
Changes to prey availability as a result of underwater noise from UXO clearance activities	Harbour porpoise and minke whale	Low to Medium	Negligible	Negligible adverse	None required, but MMMP for UXO clearance would reduce potential for effect.	Negligible adverse
	Bottlenose dolphin, common dolphin, white-beaked dolphin, grey seal and harbour seal	Low	Negligible	Negligible adverse		Negligible adverse

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List of Acronyms

Acronym	Definition
ADD	Acoustic Deterrent Device
AU	Assessment Unit
CEA	Cumulative Effect Assessment
CES	Coastal East Scotland
CGNS	Celtic and Greater North Seas
DBD	Dogger Bank D Offshore Wind Farm
DCO	Development Consent Order
ECC	Export Cable Corridor
EDR	Effective Deterrent Radius
EIA	Environmental Impact Assessment
EPS	European Protection Species
ES	Environmental Statement
GNS	Greater North Sea
HF	High Frequency
JNCC	Joint Nature Conservation Committee
LF	Low Frequency
ML	Marine Licence
MMMP	Marine Mammal Mitigation Plan
MMO	Marine Management Organisation
MMOb	Marine Mammal Observer
MTD	Marine Technical Directorate
MU	Management Unit
NE	North East
NEQ	Net Explosive Quantity

Acronym	Definition
NPL	National Physical Laboratory
NS	North Sea
PCW	Phocid Carnivores in Water
PEIR	Preliminary Environmental Information Report
PTS	Permanent Threshold Shift
SAC	Special Area of Conservation
SE	South East
SEL	Sound Exposure Level
SIP	Site Integrity Plan
SNCB	Statutory Nature Conservation Body
SPL_{peak}	Sound Pressure Level
TTS	Temporary Threshold Shift
UXO	Unexploded Ordnance
VHF	Very High Frequency