# Sheringham Shoal and Dudgeon Offshore Wind Farm Extension Projects

## Environmental Statement

**Volume 3**

## Appendix 10.4 - Marine Mammal Unexploded Ordnance (UXO) Assessment

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| **Sheringham Shoal and Dudgeon Offshore Wind Farm Extensions**<br>**Environmental Statement**<br>**Appendix 10.4 Marine Mammal Unexploded Ordnance (UXO) Assessment** | |
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## Glossary of Acronyms

| | |
|---|---|
| µPa | Micro pascal |
| µPa$^2$s | Micro pascal squared second |
| ADD | Acoustic Deterrent Device |
| ASCOBANS | Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas |
| BAP | Biodiversity Action Plan |
| CES | Coastal East Scotland |
| CGNS | Celtic and Greater North Seas |
| dB | Decibel |
| DCO | Development Consent Order |
| Defra | Department for Environment, Food and Rural Affairs |
| DEP | Dudgeon Extension Project |
| EDR | Effective Deterrent Radius |
| EIA | Environmental Impact Assessment |
| EPP | Evidence Plan Process |
| EPS | European Protected Species |
| EQT | Effective Quiet Threshold |
| ES | Environmental Statement |
| ETG | Expert Topic Group |
| FCS | Favourable Conservation Status |
| GNS | Greater North Sea |
| HDD | Horizontal Directional Drilling |
| HF | High Frequency |
| HRA | Habitats Regulations Assessment |
| JNCC | Joint Nature Conservation Committee |
| kg | Kilogram |
| km | Kilometre |
| km$^2$ | Square kilometre |

| | |
|---|---|
| lb | Pound |
| LF | Low Frequency |
| m | Meter |
| ML | Marine Licence |
| MMMP | Marine Mammal Mitigation Plan |
| MMO | Marine Management Organisation |
| MMObs | Marine Mammal Observers |
| m/s | Metres per second |
| MTD | Marine Technical Directorate |
| MU | Management Unit |
| NEQ | Net Explosive Quantity |
| NPL | National Physical Laboratory |
| NS | North Sea |
| OWF | Offshore Wind Farm |
| PCW | Phocid Carnivores in Water |
| PTS | Permanent Threshold Shift/Permanent Auditory Injury |
| RIAA | Report to Inform Appropriate Assessment |
| SAC | Special Area of Conservation |
| SCANS | Small Cetaceans in European Atlantic waters and the North Sea |
| SE | Southeast |
| SEL | Sound Exposure Level |
| $SEL_{ss}$ | Sound Exposure Level from Single Strike |
| SEP | Sheringham Offshore Wind Farm Extension Project |
| SIP | Site Integrity Plan |
| SPL | Sound Pressure Level |
| $SPL_{peak}$ | Peak Sound Pressure Level |
| SNS | Southern North Sea |
| TNT | Trinitrotoluene |
| TTS | Temporary Threshold Shift |

| | |
|---|---|
| UK | United Kingdom |
| UXO | Unexploded Ordnance |
| VHF | Very High Frequency |

## Glossary of Terms

| | |
|---|---|
| Dudgeon Offshore Wind Farm Extension Project (DEP) | The Dudgeon Offshore Wind Farm Extension onshore and offshore sites including all onshore and offshore infrastructure. |
| DEP offshore site | The Dudgeon Offshore Wind Farm Extension consisting of the DEP wind farm site, interlink cable corridors and offshore export cable corridor (up to mean high water springs). |
| DEP wind farm site | The offshore area of DEP within which wind turbines, infield cables and offshore substation platform/s will be located and the adjacent Offshore Temporary Works Area. This is also the collective term for the DEP North and South array areas. |
| Designated site | Sites designated for nature conservation under the Habitats Directive and Birds Directive. This includes candidate Special Areas of Conservation, Sites of Community Importance, Special Areas of Conservation and Special Protection Areas, and is defined in regulation 8 of the Conservation of Habitats and Species Regulations 2017. |
| Evidence Plan Process (EPP) | A voluntary consultation process with specialist stakeholders to agree the approach, and information to support, the EIA and Habitat Regulations Assessment (HRA) for certain topics. |
| Expert Topic Group (ETG) | A forum for targeted engagement with regulators and interested stakeholders through the EPP. |
| Horizontal directional drilling (HDD) zones | The areas within the onshore cable route which would house HDD entry or exit points. |
| Infield cables | Cables which link the wind turbine generators to the offshore substation platforms. |
| Interlink cables | Cables linking two separate project areas. This can be cables linking:<br>1) DEP South array area and DEP North array area<br>2) DEP South array area and SEP<br>3) DEP North array area and SEP |

| | |
|---|---|
| | 1 is relevant if DEP is constructed in isolation or first in a phased development.<br>2 and 3 are relevant where both SEP and DEP are built. |
| Interlink cable corridor | This is the area which will contain the interlink cables between offshore substation platform/s and the adjacent Offshore Temporary Works Area. |
| Landfall | The point at the coastline at which the offshore export cables are brought onshore, connecting to the onshore cables at the transition joint bay above mean high water |
| Offshore cable corridors | This is the area which will contain the offshore export cables or interlink cables, including the adjacent Offshore Temporary Works Area. |
| Offshore export cable corridor | This is the area which will contain the offshore export cables between offshore substation platform/s and landfall, including the adjacent Offshore Temporary Works Area. |
| Offshore export cables | The cables which would bring electricity from the offshore substation platform(s) to the landfall. 220 – 230kV. |
| Offshore scoping area | An area that encompasses all planned offshore infrastructure, including landfall options at both Weybourne and Bacton, and allows sufficient room for receptor identification and environmental surveys. This will be refined following further site selection and consultation. |
| Offshore substation platform | A fixed structure located within the wind farm area, containing electrical equipment to aggregate the power from the wind turbine generators and convert it into a more suitable form for export to shore. |
| Study area | Area where potential impacts from the project could occur, as defined for each individual EIA topic. |
| Sheringham Shoal Offshore Wind Farm Extension Project (SEP) | The Sheringham Shoal Offshore Wind Farm Extension onshore and offshore sites including all onshore and offshore infrastructure. |

| | |
|---|---|
| SEP offshore site | Sheringham Shoal Offshore Wind Farm Extension consisting of the SEP wind farm site and offshore export cable corridor (up to mean high water springs). |
| SEP onshore site | The Sheringham Shoal Wind Farm Extension onshore area consisting of the SEP onshore substation site, onshore cable corridor, construction compounds, temporary working areas and onshore landfall area. |
| SEP wind farm site | The offshore area of SEP within which wind turbines, infield cables and offshore substation platform/s will be located and the adjacent Offshore Temporary Works Area. |
| Static Detonation Chamber (SDC) | The SDC uses thermal destruction technology to process the weapons. Chemical munitions are placed in a feed box, conveyed to the top of the SDC vessel and fed into the electrically heated detonation chamber. The high heat detonates the munition, and the chemical agents and energetics are destroyed by thermal decomposition. |
| The Applicant | Equinor New Energy Limited |

# 10.4 MARINE MAMMAL UNEXPLODED ORDNANCE (UXO) ASSESSMENT

## 10.4.1 Introduction

1. This appendix provides an assessment of potential auditory injury and disturbance impacts on marine mammals during UXO clearance at the Sheringham Offshore Wind Farm Extension Project (SEP) and the Dudgeon Offshore Wind Farm Extension Project (DEP). This assessment is provided with the Development Consent Order (DCO) application for information purposes only. A separate Marine Licence (ML) application for UXO clearance will be submitted post-consent once detailed information on the locations and extent of UXO required to be cleared is known. This was agreed with Natural England and the Marine Management Organisation (MMO) at Expert Topic Group (ETG) meeting 3 on the 20th of July 2021. The cumulative impact assessment for UXO clearance is provided in **Section 10.7.1.2.6** of **Chapter 10 Marine Mammal Ecology**.

## 10.4.2 Worst Case Scenario

2. Construction scenarios are as set out in **Section 10.3.3.2** of the Environmental Statement (ES) chapter however these would be refined and clarified as appropriate post consent during detailed design which would feed into the UXO assessment for the ML application.

3. **Table 10.4.1** sets out the realistic worst-case parameters for the marine mammal UXO assessment.

*Table 10.4.1: Realistic worst-case parameters for marine mammal UXO assessment*

| Parameters | Notes and Rationale |
|---|---|
| Types and Sizes of UXO:<br>Various possible types and sizes of UXO. | Indicative only.<br><br>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. |
| Number of UXO requiring clearance:<br>Currently unknown. | |
| Worst case identified by Sheringham Shoal Offshore Wind Farm (OWF) and Dudgeon OWF:<br>2,000lb (907.2kg) German air dropped bomb (Net Explosive Quantity (NEQ) of 525kg). | Parameters are assumed to be the same for a SEP in isolation, DEP in isolation or a SEP and DEP scenario, in the absence of project specific detail. |
| Clearance techniques:<br>**Low-order clearance** would be the first and preferred method for UXO that require clearance.<br>As a worst-case, assessments are based on **high-order clearance** without bubble curtain, although high-order detonation with | 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 worst-case. |

| Parameters | Notes and Rationale |
|---|---|
| bubble curtain and low-order clearance have also been considered. | |

### 10.4.3 Mitigation

#### 10.4.3.1 Additional Mitigation Measures

4. The Applicant has committed to the following mitigation measures.

*Table 10.4.2: Additional mitigation measures*

| Parameter | Additional Mitigation Measures |
|---|---|
| Marine Mammal Mitigation Plan (MMMP) for UXO Clearance | A detailed MMMP will be prepared for UXO clearance during the pre-construction phase in accordance with the **Draft MMMP** (document reference 9.4) submitted with the DCO application. The MMMP for UXO clearance will ensure there are adequate mitigation measures to minimise the risk of any physical or permanent auditory injury (PTS) to marine mammals as a result of UXO clearance.<br>The MMMP for UXO clearance will be developed in the pre-construction period, when there is more detailed information on the UXO clearance which could be required and the most suitable mitigation measures, based upon best available information and methodologies at that time. The MMMP for UXO clearance will be prepared in consultation with the MMO and relevant SNCBs.<br>The MMMP for UXO clearance will 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:<br>• Low-order clearance techniques, such as deflagration;<br>• The use of bubble curtains if any high-order detonation is required (taking into consideration the environmental limitations);<br>• All UXO clearance to take place in daylight and, when possible, in favourable conditions with good visibility (sea state 3 or less);<br>• 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 suitable visibility;<br>• The activation of Acoustic Deterrent Device (ADD);<br>• The controlled explosions of the UXO will be undertaken by specialist contractors, using the minimum amount of explosive required in order to achieve safe disposal of the UXO; and<br>• Other UXO clearance techniques, such as avoidance of UXO; or relocation of UXO. 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.<br>UXO clearance is not included in the DCO application, as currently not enough detailed information is available. Therefore, UXO clearance will be assessed through a separate Marine Licence (ML) application post consent, as agreed with the MMO and Natural England at ETG 3 on the 20th July 2021. |

| Parameter | Additional Mitigation Measures |
|---|---|
| Site Integrity Plan (SIP) for the Southern North Sea (SNS) Special Area of Conservation (SAC) | In addition to the MMMPs for piling and UXO clearance, a SIP for the SNS SAC will be developed. The SIP will set out the approach to deliver any Project mitigation or management measures to reduce the potential for any significant disturbance of harbour porpoise in relation to the SNS SAC conservation objectives.<br>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 SNS SAC.<br>The SIP will be developed in the pre-construction period and will be based upon best available information and methodologies at that time, in consultation with the relevant SNCBs and the MMO.<br>An **In Principle SIP for the SNS SAC** (document reference 9.6) has been submitted with the DCO application. |

### 10.4.4 Impact Assessment Methodology

5. **Chapter 5 EIA Methodology** provides a summary of the general impact assessment methodology applied to SEP and DEP. The following sections confirm the methodology used to assess the potential impacts on marine mammals.

6. A matrix approach is 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 wind farms (including Norfolk Vanguard, Norfolk Boreas and East Anglia ONE North, East Anglia TWO and East Anglia THREE).

7. In order to enable and facilitate a consistency of approach a matrix of definitions will be employed to structure the expertise and evidence led assessment of impacts. Receptor sensitivity for an individual from each marine mammal species have been defined within the ES, following the definitions set out in **Sections 10.4.4.1** and **10.4.4.2**.

#### 10.4.4.1 Definitions

8. For each effect, the assessment identifies receptors sensitive to that effect and implements a systematic approach to understanding the impact pathways and the level of impacts on given receptors. The definitions of sensitivity and magnitude for the purpose of the marine mammal assessment are provided in **Table 10.4.3** and **Table 10.4.5** respectively.

9. The sensitivity of a receptor is determined through its ability to accommodate change and on its ability to recover if it is affected (**Table 10.4.3**). The sensitivity level of marine mammals to each type of impact is justified within the impact assessment and is dependent on the following factors:

   - Adaptability – The degree to which a receptor can avoid or adapt to an effect;
   - Tolerance – The ability of a receptor to accommodate temporary or permanent change without a significant adverse effect;

- Recoverability – The temporal scale over and extent to which a receptor will recover following an effect; and
- Value – A measure of the receptor importance, rarity and worth.

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

*Table 10.4.3: 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. |

11. 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.

12. The ‘value’ of the receptor forms an important element within the assessment, for instance, if the receptor is a protected species or habitat or has an economic value. 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.

13. 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 are European Protected Species (EPS) and, therefore, are 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 can be considered to be of high value.

14. **Table 10.4.4** provides definitions for the value afforded to a receptor based on its legislative importance. The value will be considered, where relevant, as a modifier for the sensitivity assigned to the receptor, based on expert judgement.

*Table 10.4.4: Definitions of the different value levels for marine mammals*

| Value | Definition |
|---|---|
| High | Internationally or nationally important<br>Internationally protected species that are listed as a qualifying interest feature of an internationally protected site (i.e. Annex II protected species designated feature of a designated site) and protected species (including EPS) that are not qualifying features of a designated site. |
| Medium | Regionally important or internationally rare<br>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<br>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<br>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. |

15. The thresholds for defining the potential magnitude of effect 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 species. The JNCC *et al.* (2010) EPS draft guidance suggests definitions for a 'significant group' of individuals or proportion of the population for EPS species. As such this guidance has been considered in defining the thresholds for magnitude of effects (**Table 10.4.5**).

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

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

18. Permanent effects with a greater than 1% of the reference population being affected within a single year are considered to be high in magnitude in this assessment. This is based on Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS) and 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).

*Table 10.4.5: Definition of magnitude for a marine mammal receptor*

| Magnitude | Definition |
|---|---|
| High | Permanent irreversible change to exposed receptors or feature(s) of the habitat which are of particular importance to the receptor.<br>Assessment indicates that more than 1% of the reference population are anticipated to be exposed to the effect.<br>OR<br>Long-term effect for 10 years or more, but not permanent (e.g. limited to operational phase of the Projects).<br>Assessment indicates that more than 5% of the reference population are anticipated to be exposed to the effect.<br>OR<br>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.<br>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.<br>Assessment indicates that greater than 0.01% and below 1% of the reference population anticipated to be exposed to effect.<br>OR<br>Long-term effect for 10 years or more, but not permanent (e.g. limited to operational phase of the Projects).<br>Assessment indicates that between 1% and 5% of the reference population are anticipated to be exposed to the effect.<br>OR<br>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.<br>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.<br>Assessment indicates that between 0.001% and 0.01% of the reference population anticipated to be exposed to effect.<br>OR<br>Long-term effect for 10 years or more, but not permanent (e.g. limited to operational phase of the Projects).<br>Assessment indicates that between 0.01% and 1% of the reference population are anticipated to be exposed to the effect.<br>OR |

| Magnitude | Definition |
|---|---|
| | 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.<br>Assessment indicates that between 1% and 5% of the reference population anticipated to be exposed to effect. |
| Negligible | Permanent irreversible change to exposed receptors or feature(s) of the habitat of particular importance to the receptor.<br>Assessment indicates that less than 0.001% of the reference population anticipated to be exposed to effect.<br>OR<br>Long-term effect for 10 years or more (but not permanent, e.g. limited to lifetime of the Projects).<br>Assessment indicates that less than 0.01% of the reference population are anticipated to be exposed to the effect.<br>OR<br>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.<br>Assessment indicates that less than 1% of the reference population anticipated to be exposed to effect. |

#### 10.4.4.2 Impact Significance

19. 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 5 EIA Methodology** for further details). The determination of significance is guided by the use of an impact significance matrix, as shown in **Table 10.4.6**. Definitions of each level of significance are provided in **Table 10.4.7**.

20. Potential impacts identified within the assessment as major or moderate are 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.

*Table 10.4.6: Impact significance 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 10.4.7: Definition of impact significance*

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

### 10.4.5 Impact 1: Auditory Injury from Underwater Noise Associated with UXO Clearance

21. 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 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.

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

23. A detailed UXO survey will 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.

24. For the assessment, a conservative estimate has been made, based on the best available information from other offshore wind farm UXO clearance operations nearby, and other published information. 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 525kg Net Explosive Quantity (NEQ) for a 2,000lb (907.2kg) UXO.

25. At the Sheringham Shoal Offshore Wind Farm, just one UXO was found, out of a potential 52 targets investigated, that was required to be cleared prior to construction; a German air dropped bomb of 250lbs (113.4kg) (Scira Offshore Energy, 2010). For Dudgeon Offshore Wind Farm, a total of 243 targets were identified as potential UXO targets for further investigation. Of those, 20 were identified were identified as UXO requiring clearance, in addition to three partial UXO that would also require clearance. The UXO cleared at Dudgeon Offshore Wind Farm included one 2,000lb (907.2kg), three 1,000lb (453.6kg), six 500lb (226.8kg), and two 250lb (113.4kg) German air dropped bombs, seven 6 inch projectiles (of 45kg), one Mk17 mine, and two mine sinkers (Statoil, 2015). At Hornsea Project Two, similar UXO to those found at Dudgeon Offshore Wind Farm were identified, with a total of 38 UXO were confirmed within project area, ranging from 2,000lb (907.2kg), 1,000lb (453.6kg), 500lb (226.8kg), and 50kg air-delivered bombs, Mk17 mines, 12 inch projectiles, and German land mines (Orsted, 2019). UXO weights have been converted from lb to kg for consistency, however, this is not the same as the NEQ or Trinitrotoluene (TNT) equivalent weights used in the underwater noise modelling in **Table 10.4.8**.

26. When an item of UXO detonates on the sea bed 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 sea bed materials) is also ejected but does not pose a significant hazard beyond 10m from source.

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

28. 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.

29. 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 sea bed 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).

30. 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 would be a low-order clearance method. Or if high-order detonation was required, then a bubble curtain would be used.

#### 10.4.5.1 Sensitivity of Marine Mammals

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

32. The sensitivity of marine mammals to TTS and flee response / likely disturbance as a result of underwater UXO detonations is considered to be medium in this assessment as a precautionary approach. This is 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 are considered to have limited capacity to avoid such effects, although any impacts on marine mammals would be temporary and they would be expected to return to the area once the activity had ceased.

#### 10.4.5.2 Underwater Noise Modelling

33. A number of UXOs with a range of charge weights (or quantity of contained explosive) could be located within SEP, DEP and / or the export cable corridor. 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.

34. A selection of explosive sizes has been considered in the estimation of the underwater noise levels produced by detonation of UXO (**Table 10.4.8**). The assessment assumes the maximum explosive charge (see **Appendix 10.2**).

*Table 10.4.8: Selection of UXO potentially present at SEP and DEP and their NEQ*

| UXO | NEQ |
|---|---|
| German 50 kg bomb | 25kg |
| Air-delivered 1,000 lb (453.6kg) bomb | 240kg |
| Air-delivered 2,000 lb (907.2kg) bomb | 525kg |

35. 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 cannot be directly considered in an assessment. This leads 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 is not buried, degraded or subject to any other significant attenuation. The consequence of this is that the noise levels produced, particularly by the larger explosives under consideration, are likely to be over-estimated as they are likely to be covered by sediment and degraded.

36. The assessment also does 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 be lower than indicated by the range estimate and therefore this can be considered conservative in respect of impact at different depths.

37. 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 indicate the onset of PTS, the point at which there is 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 is assumed as a worst case scenario).

38. The Sound Exposure Level (SEL) criteria are weighted, which takes 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 includes criteria based on peak Sound Pressure Level ($SPL_{peak}$), which are unweighted and do not take species hearing sensitivity into account.

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

40. Peak noise levels are 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 is currently difficult to determine the distance at which an impulsive noise becomes 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 10.2**).

41. Impulsive noise sources are 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 wind farm piling and seismic surveys) 'transformed' from an impulsive to a non-impulsive noise revealed that, at a distance of between 2 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 sea bed, and the actual range at which a sound source transforms into a non-impulsive noise is likely to be dependent on a number of environmental variables and other sound source characteristics (Hastie *et al*., 2019). The work by Hastie *et al.* (2019) is preliminary work and Martin *et al*. (2020) suggest that the change in noise characteristics from impulsive to non-impulsive does not make a difference to assessment of injury because sounds retain impulsive character when SPLs are above effective quiet threshold (EQT). However, as outlined in the Hornsea Project Four ES Chapter 4 (Orsted, 2021), some of the results presented by Martine *et al*. (2019), indicate that some of the piling sound loses its impulsiveness with increasing distance from the piling site, therefore the sound loses its harmful impulsive characteristics with increased distance.

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

43. 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, 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; and
- Low-order deflagration.

44. 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).

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

46. 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).

47. 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, high-order detonations with and without bubble curtains have been considered, alongside low-order clearance.

48. If a high-order detonation is required bubble curtains will be used to reduce underwater noise impacts from the explosion. Bubble curtains are a flexible system of tubes fitted with special nozzle openings which can be installed on the sea bed at a sufficient radius around the UXO. A specialist vessel that is designed specifically for the launch and recovery of the bubble curtain will be used and fitted with large hose reels and a number of air compressors. Compressed air will be discharged via the hose nozzles prior to and during the detonation, causing a curtain of continually rising air bubbles that surround the water column around the UXO location. This process changes the physical condition of the water column with regard to underwater acoustics and upon detonation, acoustic waves are repeatedly broken, theoretically limiting their spatial extent.

49. It is important to consider the environment that the bubble curtains will be deployed in prior to deployment, to ensure that they are effective. Key considerations are water depth, current speeds and wave height. In line with current guidance, bubble curtains will be deployed for UXO detonation under the following scenarios:

- Where the UXO is larger than 50kg charge weight;
- Where water depths are between approximately 5m and 40m;
- Where significant wave heights are less than 1m (maximum wave height);
- Where the maximum wind speed is less than 8 m/s; and
- Where there is a deployment window of current speeds less than 1.5 knots.

50. As a worst-case, assessments are based on high-order detonation without bubble curtain, although high-order detonation with bubble curtain and low-order clearance have also been considered.

#### *10.4.5.2.1 Methodology*

51. The range of equivalent charge weights for the potential UXO devices that could be present within the SEP and DEP site boundaries have been estimated as 25kg, 55kg, 120kg, 240kg and 525kg, plus the donor weight of 0.5kg to initiate detonation.

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

53. The underwater noise modelling for UXO has also been undertaken with the inclusion of a bubble curtain as mitigation, reducing source levels by 10 dB. This reduction is an estimate of the attenuation performance of bubble curtains typically used at offshore wind farm sites (Verfuss *et al*., 2019). 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 Marine Technical Directorate (MTD) (1996) (see **Appendix 10.2**).

54. **Table 10.4.9** provides the source level used for the underwater noise modelling (further details on how these were calculated is provided in **Appendix 10.2**).

*Table 10.4.9: Source levels (unweighted $SPL_{peak}$ and $SEL_{ss}$) used for UXO modelling*

| Charge weight (NEQ) | 0.5kg | 25kg + donor charge | 55kg + donor charge | 120kg + donor charge | 240kg + donor charge | 525kg + donor charge |
|---|---|---|---|---|---|---|
| $SPL_{peak}$ source level (dB re 1 µPa @ 1m) | 272.1 | 284.9 | 287.4 | 290.0 | 292.2 | 294.8 |
| $SEL_{ss}$ source level (dB re 1 $\mu Pa^2s$ @ 1m) | 217.1 | 227.9 | 230.1 | 232.3 | 234.2 | 236.4 |

#### *10.4.5.2.2 Results*

55. The results of the underwater noise modelling (**Appendix 10.2**) for a range of potential charge weights (NEQ) with and without bubble curtain are presented in **Table 10.4.10** and **Table 10.4.11**, for PTS and TTS, respectively. The potential impact 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) are used to inform the impact assessments.

*Table 10.4.10: Potential maximum impact ranges (and areas) of PTS for marine mammals during UXO clearance with and without bubble curtain (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 ($km^2$))** | | |
|---|---|---|---|
| | **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 $\mu Pa^2s$** | **173 dB re 1 $\mu Pa^2s$** |
| **0.5kg (low-order clearance)** | **1.2km (4.52$km^2$)** | 0.11km (0.038$km^2$) | <0.05km (<0.008$km^2$) |
| 0.5kg + bubble curtain | 0.45km (0.64$km^2$) | <0.05km (<0.008$km^2$) | <0.05km (<0.008$km^2$) |
| 25kg + donor charge | 4.6km (66.48$km^2$) | 0.57km (1.02$km^2$) | <0.05km (<0.008$km^2$) |
| 25kg + donor charge + bubble curtain | 1.6km (8.04$km^2$) | 0.12km (0.045$km^2$) | <0.05km (<0.008$km^2$) |
| 55kg + donor charge | 6.0km (113.10$km^2$) | 0.74km (1.72$km^2$) | <0.05km (<0.008$km^2$) |
| 55kg + donor charge + bubble curtain | 2.1km (13.85$km^2$) | 0.18km (0.10$km^2$) | <0.05km (<0.008$km^2$) |
| 120kg + donor charge | 7.8km (191.13$km^2$) | 0.95km (2.84$km^2$) | 0.07km (0.02$km^2$) |
| 120kg + donor charge + bubble curtain | 2.8km (24.63$km^2$) | 0.25km (0.20$km^2$) | <0.05km (<0.008$km^2$) |
| 240kg + donor charge | 9.8km (301.72$km^2$) | 1.1km (3.80$km^2$) | 0.1km (0.03$km^2$) |

| Potential maximum charge weight (NEQ) | Maximum predicted impact range (km) (and area ($km^2$)) | | |
|---|---|---|---|
| | **PTS $SPL_{peak}$ Unweighted (Impulsive criteria)** | **PTS SEL Weighted (Impulsive criteria)** | **PTS SEL Weighted (Non-impulsive criteria)** |
| 240kg + donor charge + bubble curtain | 3.5km (38.48$km^2$) | 0.34km (0.36$km^2$) | <0.05km (<0.008$km^2$) |
| **525kg + donor charge** | **13.0km (530.93$km^2$)** | 1.4km (6.16$km^2$) | 0.13km (0.05$km^2$) |
| **525kg + donor charge + bubble curtain** | **4.6km (66.48$km^2$)** | 0.46km (0.66$km^2$) | <0.05km (<0.008$km^2$) |
| **Bottlenose dolphin and white-beaked dolphin (High Frequency (HF) cetaceans)** | | | |
| | **230 dB re 1 µPa** | **185 dB re 1 $µPa^2s$** | **198 dB re 1 $µPa^2s$** |
| **0.5kg (low-order clearance)** | **0.07km (0.015$km^2$)** | <0.05km (<0.008$km^2$) | <0.05km (<0.008$km^2$) |
| 0.5kg + bubble curtain | <0.05km (<0.008$km^2$) | <0.05km (<0.008$km^2$) | <0.05km (<0.008$km^2$) |
| 25kg + donor charge | 0.26km (0.21$km^2$) | <0.05km (<0.008$km^2$) | <0.05km (<0.008$km^2$) |
| 25kg + donor charge + bubble curtain | 0.1km (0.031$km^2$) | <0.05km (<0.008$km^2$) | <0.05km (<0.008$km^2$) |
| 55kg + donor charge | 0.34km (0.36$km^2$) | <0.05km (<0.008$km^2$) | <0.05km (<0.008$km^2$) |
| 55kg + donor charge + bubble curtain | 0.12km (0.045$km^2$) | <0.05km (<0.008$km^2$) | <0.05km (<0.008$km^2$) |

| Potential maximum charge weight (NEQ) | Maximum predicted impact range (km) (and area ($km^2$)) | | |
|---|---|---|---|
| | **PTS $SPL_{peak}$ Unweighted (Impulsive criteria)** | **PTS SEL Weighted (Impulsive criteria)** | **PTS SEL Weighted (Non-impulsive criteria)** |
| 120kg + donor charge | 0.45km (0.64$km^2$) | <0.05km (<0.008$km^2$) | <0.05km (<0.008$km^2$) |
| 120kg + donor charge + bubble curtain | 0.16km (0.08$km^2$) | <0.05km (<0.008$km^2$) | <0.05km (<0.008$km^2$) |
| 240kg + donor charge | 0.56km (0.99$km^2$) | <0.05km (<0.008$km^2$) | <0.05km (<0.008$km^2$) |
| 240kg + donor charge + bubble curtain | 0.20km (0.13$km^2$) | <0.05km (<0.008$km^2$) | <0.05km (<0.008$km^2$) |
| **525kg + donor charge** | **0.73km (1.67$km^2$)** | 0.05km (0.008$km^2$) | <0.05km (<0.008$km^2$) |
| **525kg + donor charge + bubble curtain** | **0.26km (0.21$km^2$)** | <0.05km (<0.008$km^2$) | <0.05km (<0.008$km^2$) |
| **Minke whale (Low Frequency (LF) cetacean)** | | | |
| | **219 dB re 1 µPa** | **183 dB re 1 $µPa^2s$** | **199 dB re 1 $µPa^2s$** |
| **0.5kg (low-order clearance)** | **0.22km (0.15$km^2$)** | 0.06km (0.011$km^2$) | <0.05km (<0.008$km^2$) |
| 0.5kg + bubble curtain | 0.08km (0.02$km^2$) | 0.32km (0.32$km^2$) | <0.05km (<0.008$km^2$) |

| Potential maximum charge weight (NEQ) | Maximum predicted impact range (km) (and area ($km^2$)) | | |
|---|---|---|---|
| | **PTS $SPL_{peak}$ Unweighted (Impulsive criteria)** | **PTS SEL Weighted (Impulsive criteria)** | **PTS SEL Weighted (Non-impulsive criteria)** |
| 25kg + donor charge | 0.82km (2.11$km^2$) | 2.2km (15.21$km^2$) | 0.13km (0.053$km^2$) |
| 25kg + donor charge + bubble curtain | 0.29km (0.26$km^2$) | 0.37km (0.43$km^2$) | <0.05km (<0.008$km^2$) |
| 55kg + donor charge | 1.0km (3.14$km^2$) | 3.2km (32.17$km^2$) | 0.19km (0.11$km^2$) |
| 55kg + donor charge + bubble curtain | 0.38km (0.45$km^2$) | 0.55km (0.95$km^2$) | <0.05km (<0.008$km^2$) |
| 120kg + donor charge | 1.3km (5.31$km^2$) | 4.7km (69.4$km^2$) | 0.28km (0.25$km^2$) |
| 120kg + donor charge + bubble curtain | 0.49km (0.75$km^2$) | 0.81km (2.06$km^2$) | <0.05km (<0.008$km^2$) |
| 240kg + donor charge | 1.7km (9.08$km^2$) | 6.5km (132.73$km^2$) | 0.39km (0.48$km^2$) |
| 240kg + donor charge + bubble curtain | 0.62km (1.21$km^2$) | 1.1km (3.80$km^2$) | 0.07km (0.015$km^2$) |
| **525kg + donor charge** | 2.2km (15.21$km^2$) | **9.5km (283.53$km^2$)** | 0.57km (1.02$km^2$) |
| **525kg + donor charge + bubble curtain** | 0.81km (2.06$km^2$) | **1.6km (8.04$km^2$)** | 0.1km (0.031$km^2$) |

| Potential maximum charge weight (NEQ) | Maximum predicted impact range (km) (and area ($km^2$)) | | |
|---|---|---|---|
| | **PTS $SPL_{peak}$ Unweighted (Impulsive criteria)** | **PTS SEL Weighted (Impulsive criteria)** | **PTS SEL Weighted (Non-impulsive criteria)** |
| **Grey seal and harbour seal (Phocid Carnivores in Water (PCW))** | | | |
| | **218 dB re 1 µPa** | **185 dB re 1 $µPa^2s$** | **201 dB re 1 $µPa^2s$** |
| **0.5kg (low-order clearance)** | **0.24km (0.18$km^2$)** | 0.06km (0.011$km^2$) | <0.05km (<0.008$km^2$) |
| 0.5kg + bubble curtain | 0.09km (0.025$km^2$) | <0.05km (<0.008$km^2$) | <0.05km (<0.008$km^2$) |
| 25kg + donor charge | 0.91km (2.60$km^2$) | 0.39km (0.48$km^2$) | <0.05km (<0.008$km^2$) |
| 25kg + donor charge + bubble curtain | 0.32km (0.32$km^2$) | 0.07km (0.015$km^2$) | <0.05km (<0.008$km^2$) |
| 55kg + donor charge | 1.1km (3.80$km^2$) | 0.57km (1.02$km^2$) | <0.05km (<0.008$km^2$) |
| 55kg + donor charge + bubble curtain | 0.42km (0.55$km^2$) | 0.1km (0.031$km^2$) | <0.05km (<0.008$km^2$) |
| 120kg + donor charge | 1.5km (7.07$km^2$) | 0.83km (2.16$km^2$) | <0.05km (<0.008$km^2$) |
| 120kg + donor charge + bubble curtain | 0.55km (0.95$km^2$) | 0.14km (0.062$km^2$) | <0.05km (<0.008$km^2$) |
| 240kg + donor charge | 1.9km (11.34$km^2$) | 1.1km (3.80$km^2$) | 0.07km (0.015$km^2$) |

| Potential maximum charge weight (NEQ) | Maximum predicted impact range (km) (and area ($km^2$)) | | |
|---|---|---|---|
| | **PTS $SPL_{peak}$ Unweighted (Impulsive criteria)** | **PTS SEL Weighted (Impulsive criteria)** | **PTS SEL Weighted (Non-impulsive criteria)** |
| 240kg + donor charge + bubble curtain | 0.69km (1.50$km^2$) | 0.2km (0.13$km^2$) | <0.05km (<0.008$km^2$) |
| **525kg + donor charge** | **2.5km (19.63$km^2$)** | 1.6km (8.04$km^2$) | 0.1km (0.03$km^2$) |
| **525kg + donor charge + bubble curtain** | **0.9km (2.54$km^2$)** | 0.29km (0.26$km^2$) | <0.05km (<0.008$km^2$) |

*Table 10.4.11: Potential maximum impact ranges (and areas) of TTS for marine mammals during UXO clearance with and without bubble curtain (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 Weighted (Impulsive criteria)** | **TTS SEL Weighted (Non-impulsive criteria)** |
| **Harbour porpoise (VHF)** | | | |
| | **196 dB re 1 µPa** | **140 dB re 1 $µPa^2s$** | **153 dB re 1 $µPa^2s$** |
| **0.5kg (low-order clearance)** | **2.3km (16.62$km^2$)** | 0.93km (2.72$km^2$) | 0.15km (0.071$km^2$) |
| 0.5kg + bubble curtain | 0.83km (2.16$km^2$) | 0.24km (0.18$km^2$) | <0.05km (<0.008$km^2$) |

| Potential maximum charge weight (NEQ) | Maximum predicted impact range (km) (and area ($km^2$)) | | |
|---|---|---|---|
| | **TTS $SPL_{peak}$ Unweighted (Impulsive criteria)** | **TTS SEL Weighted (Impulsive criteria)** | **TTS SEL Weighted (Non-impulsive criteria)** |
| 25kg + donor charge | 8.5km (226.98$km^2$) | 2.4km (18.10$km^2$) | 0.73km (1.67$km^2$) |
| 25kg + donor charge + bubble curtain | 3.1km (30.19$km^2$) | 1.0km (3.14$km^2$) | 0.17km (0.091$km^2$) |
| 55kg + donor charge | 11km (380.13$km^2$) | 2.8km (24.63$km^2$) | 0.94km (2.78$km^2$) |
| 55kg + donor charge + bubble curtain | 4km (50.27$km^2$) | 1.2km (4.52$km^2$) | 0.25km (0.20$km^2$) |
| 120kg + donor charge | 14km (615.75$km^2$) | 3.2km (32.17$km^2$) | 1.1km (3.80$km^2$) |
| 120kg + donor charge + bubble curtain | 5.1km (18.71$km^2$) | 1.5km (7.07$km^2$) | 0.34km (0.36$km^2$) |
| 240kg + donor charge | 18km (1,017.88$km^2$) | 3.5km (38.48$km^2$) | 1.4km (6.16$km^2$) |
| 240kg + donor charge + bubble curtain | 6.5km (132.73$km^2$) | 1.8km (10.18$km^2$) | 0.45km (0.64$km^2$) |
| **525kg + donor charge** | **23km (1,661.90$km^2$)** | 4km (50.27$km^2$) | 1.7km (9.08$km^2$) |
| **525kg + donor charge + bubble curtain** | **8.4km (221.67$km^2$)** | 2.1km (13.85$km^2$) | 0.6km (1.13$km^2$) |

| Potential maximum charge weight (NEQ) | Maximum predicted impact range (km) (and area ($km^2$)) | | |
|---|---|---|---|
| | **TTS $SPL_{peak}$ Unweighted (Impulsive criteria)** | **TTS SEL Weighted (Impulsive criteria)** | **TTS SEL Weighted (Non-impulsive criteria)** |
| **Bottlenose dolphin and white-beaked dolphin (HF)** | | | |
| | **224 dB re 1 µPa** | **170 dB re 1 $µPa^2s$** | **178 dB re 1 $µPa^2s$** |
| **0.5kg (low-order clearance)** | 0.13km (0.053$km^2$) | **<0.54km (0.92$km^2$)** | <0.05km (<0.008$km^2$) |
| 0.5kg + bubble curtain | <0.05km (<0.008$km^2$) | <0.05km (<0.008$km^2$) | <0.05km (<0.008$km^2$) |
| 25kg + donor charge | 0.49km (0.75$km^2$) | 0.15km (0.07$km^2$) | <0.05km (<0.008$km^2$) |
| 25kg + donor charge + bubble curtain | 0.17km (0.09$km^2$) | <0.05km (<0.008$km^2$) | <0.05km (<0.008$km^2$) |
| 55kg + donor charge | 0.64km (1.29$km^2$) | 0.21km (0.14$km^2$) | 0.06km (0.01$km^2$) |
| 55kg + donor charge + bubble curtain | 0.23km (0.17$km^2$) | <0.05km (<0.008$km^2$) | <0.05km (<0.008$km^2$) |
| 120kg + donor charge | 0.83km (2.16$km^2$) | 0.3km (0.28$km^2$) | 0.08km (0.02$km^2$) |
| 120kg + donor charge + bubble curtain | 0.3km (0.28$km^2$) | 0.06km (0.01$km^2$) | <0.05km (<0.008$km^2$) |
| 240kg + donor charge | 1km (3.14$km^2$) | 0.39km (0.48$km^2$) | 0.11km (0.04$km^2$) |

| Potential maximum charge weight (NEQ) | Maximum predicted impact range (km) (and area ($km^2$)) | | |
|---|---|---|---|
| | **TTS $SPL_{peak}$ Unweighted (Impulsive criteria)** | **TTS SEL Weighted (Impulsive criteria)** | **TTS SEL Weighted (Non-impulsive criteria)** |
| 240kg + donor charge + bubble curtain | 0.37km (0.43$km^2$) | 0.08km (0.02$km^2$) | <0.05km (<0.008$km^2$) |
| **525kg + donor charge** | **1.3km (5.31$km^2$)** | 0.53km (0.88$km^2$) | 0.16km (0.08$km^2$) |
| **525kg + donor charge + bubble curtain** | **0.49km (0.75$km^2$)** | 0.11km (0.04$km^2$) | <0.05km (<0.008$km^2$) |
| **Minke whale (LF)** | | | |
| | **213 dB re 1 µPa** | **168 dB re 1 $µPa^2s$** | **179 dB re 1 $µPa^2s$** |
| **0.5kg (low-order clearance)** | 0.41km (0.53$km^2$) | **4.5km (63.62$km^2$)** | 0.65km (1.33$km^2$) |
| 0.5kg + bubble curtain | 0.14km (0.06$km^2$) | 0.78km (1.91$km^2$) | 0.11km (0.04$km^2$) |
| 25kg + donor charge | 1.5km (7.07$km^2$) | 29km (2,642.08$km^2$) | 4.4km (60.82$km^2$) |
| 25kg + donor charge + bubble curtain | 0.54km (0.92$km^2$) | 5.3km (88.25$km^2$) | 0.76km (1.81$km^2$) |
| 55kg + donor charge | 1.9km (11.34$km^2$) | 41km (5,281.02$km^2$) | 6.4km (128.68$km^2$) |
| 55kg + donor charge + bubble curtain | 0.71km (1.58$km^2$) | 7.7km (186.27$km^2$) | 1.1km (3.80$km^2$) |

| Potential maximum charge weight (NEQ) | Maximum predicted impact range (km) (and area ($km^2$)) | | |
|---|---|---|---|
| | **TTS $SPL_{peak}$ Unweighted (Impulsive criteria)** | **TTS SEL Weighted (Impulsive criteria)** | **TTS SEL Weighted (Non-impulsive criteria)** |
| 120kg + donor charge | 2.5km (19.63$km^2$) | 57km (10,207.03$km^2$) | 9.4km (277.59$km^2$) |
| 120kg + donor charge + bubble curtain | 0.92km (2.66$km^2$) | 11km (380.13$km^2$) | 1.6km (8.04$km^2$) |
| 240kg + donor charge | 3.2km (32.17$km^2$) | 76km (18,145.84$km^2$) | 13km (530.93$km^2$) |
| 240kg + donor charge + bubble curtain | 1.1km (3.80$km^2$) | 15km (706.86$km^2$) | 2.2km (15.21$km^2$) |
| **525kg + donor charge** | 4.1km (52.81$km^2$) | **103km (33,329.16$km^2$)** | 19km (1,134.11$km^2$) |
| **525kg + donor charge + bubble curtain** | 1.5km (7.07$km^2$) | **22km (1,520.53$km^2$)** | 3.3km (34.21$km^2$) |
| **Grey seal and harbour seal (PCW)** | | | |
| | **212 dB re 1 µPa** | **170 dB re 1 $µPa^2s$** | **181 dB re 1 $µPa^2s$** |
| **0.5kg (low-order clearance)** | 0.45km (0.64$km^2$) | **0.8km (2.01$km^2$)** | 0.11km (0.38$km^2$) |
| 0.5kg + bubble curtain | 0.16km (0.08$km^2$) | 0.13km (0.05$km^2$) | <0.05km (<0.008$km^2$) |

| Potential maximum charge weight (NEQ) | Maximum predicted impact range (km) (and area ($km^2$)) | | |
|---|---|---|---|
| | **TTS $SPL_{peak}$ Unweighted (Impulsive criteria)** | **TTS SEL Weighted (Impulsive criteria)** | **TTS SEL Weighted (Non-impulsive criteria)** |
| 25kg + donor charge | 1.6km (8.04$km^2$) | 5.2km (84.95$km^2$) | 0.79km (1.96$km^2$) |
| 25kg + donor charge + bubble curtain | 0.6km (1.13$km^2$) | 0.94km (2.78$km^2$) | 0.13km (0.05$km^2$) |
| 55kg + donor charge | 2.1km (13.85$km^2$) | 7.5km (176.71$km^2$) | 1.1km (3.80$km^2$) |
| 55kg + donor charge + bubble curtain | 0.78km (1.91$km^2$) | 1.3km (5.31$km^2$) | 0.19km (0.11$km^2$) |
| 120kg + donor charge | 2.8km (24.63$km^2$) | 11km (380.13$km^2$) | 1.6km (8.04$km^2$) |
| 120kg + donor charge + bubble curtain | 1km (3.14$km^2$) | 1.9km (11.34$km^2$) | 0.29km (0.26$km^2$) |
| 240kg + donor charge | 3.5km (38.48$km^2$) | 14km (615.75$km^2$) | 2.3km (16.62$km^2$) |
| 240kg + donor charge + bubble curtain | 1.2km (4.52$km^2$) | 2.7km (22.90$km^2$) | 0.4km (0.50$km^2$) |
| **525kg + donor charge** | 4.6km (66.48$km^2$) | **20km (1,256.64$km^2$)** | 3.3km (34.21$km^2$) |
| **525kg + donor charge + bubble curtain** | 1.6km (8.04$km^2$) | **4km (50.27$km^2$)** | 0.59km (1.09$km^2$) |

### 10.4.5.3 Magnitude for SEP or DEP in Isolation

#### *10.4.5.3.1 Permanent Auditory Injury (PTS)*

56. The number of harbour porpoise, bottlenose dolphin, white-beaked dolphin, minke whale, grey seal and harbour seal that could potentially be impacted by a high-order UXO detonation (up to 525kg NEQ) without bubble curtain, a high-order UXO detonation (up to 525kg NEQ) with bubble curtain and low-order clearance (0.5kg) has been estimated for the SEP wind farm site, or the DEP wind farm site, plus the export cable corridor areas, based on the maximum potential PTS impact ranges (**Table 10.4.12**).

57. For the **high-order detonation** of the maximum potential UXO with an NEQ of 525kg plus donor charge **without a bubble curtain**, the magnitude for PTS is assessed as a worst-case for the SEP wind farm site, or the DEP wind farm site, with the export cable corridor (**Table 10.4.12**) to be:

- **Medium** for harbour porpoise and minke whale for the SEP wind farm site, DEP wind farm site, SEP and DEP wind farm sites with export cable corridor
- **Medium (medium)** for grey seal at the SEP wind farm site, DEP wind farm site, SEP and DEP wind farm sites with export cable corridor, and for harbour seal at the DEP wind farm site
- **Medium (low)** for harbour seal at the SEP wind farm site, and at the SEP and DEP wind farm sites with export cable corridor
- **Low (medium)** for bottlenose dolphin for the SEP wind farm site, DEP wind farm site, SEP and DEP wind farm sites with export cable corridor
- **Negligible** for white-beaked dolphin for the SEP wind farm site, DEP wind farm site, SEP and DEP wind farm sites with export cable corridor

58. For the **high-order detonation** of the maximum potential UXO with an NEQ of 525kg plus donor charge **with a bubble curtain**, the magnitude for PTS is assessed to be:

- **Medium** for harbour porpoise for the SEP wind farm site, DEP wind farm site, SEP and DEP wind farm sites with export cable corridor
- **Medium (low)** for grey seal and harbour seal at the SEP wind farm site and at the SEP and DEP wind farm sites with export cable corridor, and for harbour seal at the DEP wind farm site
- **Low (negligible)** for grey seal at the DEP wind farm site
- **Negligible (low)** for bottlenose dolphin for the SEP wind farm site, DEP wind farm site, SEP and DEP wind farm sites with export cable corridor
- **Negligible** for white-beaked dolphin and minke whale for the SEP wind farm site, DEP wind farm site, SEP and DEP wind farm sites with export cable corridor

59. For **low-order clearance** (0.5kg donor charge for all sizes of UXO) **without a bubble curtain**, the magnitude for PTS is assessed to be:

- **Low (negligible)** for grey seal and harbour seal at the SEP wind farm site
- **Negligible (negligible)** for bottlenose dolphin at the SEP wind farm site, and for bottlenose dolphin, grey seal and harbour seal at the DEP wind farm site and for the SEP and DEP wind farm sites with export cable corridor
- **Negligible** for harbour porpoise, white-beaked dolphin and minke whale for the SEP wind farm site, DEP wind farm site, SEP and DEP wind farm sites with export cable corridor

*Table 10.4.12: Maximum number of marine mammals potentially at risk of PTS during UXO clearance at the SEP wind farm site, or the DEP wind farm site, plus the export cable corridor*

| Species | Maximum impact range (and area) | Maximum number of individuals | % of reference population | Magnitude (permanent impact)* |
|---|---|---|---|---|
| **SEP wind farm site** | | | | |
| Harbour porpoise | High-order detonation (525kg (NEQ) + donor charge) without bubble curtain 13.0km (530.93km$^2$) | 334.5 (SEP summer density of 0.63/km$^2$) | 0.10% NS MU | **Medium** |
| | High-order detonation (525kg (NEQ) + donor charge) with bubble curtain 4.6km (66.48km$^2$) | 41.9 (SEP summer density of 0.63/km$^2$) | 0.01% NS MU | **Medium** |
| | Low-order clearance (0.5kg (NEQ)) 1.2km (4.52km$^2$) | 2.9 (SEP summer density of 0.63/km$^2$) | 0.0008% NS MU | **Negligible** |
| Bottlenose dolphin | High-order detonation (525kg (NEQ) + donor charge) without bubble curtain 0.73km (1.67km$^2$) | 0.05 (SCANS-III density of 0.0298/km$^2$) | 0.0025% GNS MU (0.02% of CES MU) | **Low (medium)** |
| | High-order detonation (525kg (NEQ) + donor charge) with bubble curtain 0.26km (0.21km$^2$) | 0.006 (SCANS-III density of 0.0298/km$^2$) | 0.0003% GNS MU (0.003% of CES MU) | **Negligible (low)** |
| | Low-order clearance (0.5kg (NEQ)) 0.07km (0.015km$^2$) | 0.0005 (SCANS-III density of 0.0298/km$^2$) | 0.00002% GNS MU (0.0002% of CES MU) | **Negligible (negligible)** |

| Species | Maximum impact range (and area) | Maximum number of individuals | % of reference population | Magnitude (permanent impact)* |
|---|---|---|---|---|
| White-beaked dolphin | High-order detonation (525kg (NEQ) + donor charge) without bubble curtain<br>0.73km (1.67km$^2$) | 0.01<br>(density of 0.006/km$^2$) | 0.00002% CGNS MU | **Negligible** |
| | High-order detonation (525kg (NEQ) + donor charge) with bubble curtain<br>0.26km (0.21km$^2$) | 0.001<br>(density of 0.006/km$^2$) | 0.000003% CGNS MU | **Negligible** |
| | Low-order clearance (0.5kg (NEQ))<br>0.07km (0.015km$^2$) | 0.00009<br>(density of 0.006/km$^2$) | 0.0000002% CGNS MU | **Negligible** |
| Minke whale | High-order detonation (525kg (NEQ) + donor charge) without bubble curtain<br>9.5km (283.53km$^2$) | 2.8<br>(SCANS-III density of 0.0100/km$^2$) | 0.01% CGNS MU | **Medium** |
| | High-order detonation (525kg (NEQ) + donor charge) with bubble curtain<br>1.6km (8.04km$^2$) | 0.08<br>(SCANS-III density of 0.0100/km$^2$) | 0.0004% CGNS MU | **Negligible** |
| | Low-order clearance (0.5kg (NEQ))<br>0.22km (0.15km$^2$) | 0.0015<br>(SCANS-III density of 0.0100/km$^2$) | 0.000008% CGNS MU | **Negligible** |
| Grey seal | High-order detonation (525kg (NEQ) + donor charge) without bubble curtain<br>2.5km (19.63km$^2$) | 16.7<br>(SEP density of 0.853/km$^2$) | 0.19% SE England MU<br>(0.069% wider reference population) | **Medium (medium)** |

| Species | Maximum impact range (and area) | Maximum number of individuals | % of reference population | Magnitude (permanent impact)* |
|---|---|---|---|---|
| | High-order detonation (525kg (NEQ) + donor charge) with bubble curtain<br>0.9km (2.54km$^2$) | 2.2<br>(SEP density of 0.853/km$^2$) | 0.025% SE England MU<br>(0.009% wider reference population) | **Medium (low)** |
| | Low-order clearance (0.5kg (NEQ))<br>0.24km (0.18km$^2$) | 0.15<br>(SEP density of 0.853/km$^2$) | 0.002% SE England MU<br>(0.0006% wider reference population) | **Low (negligible)** |
| Harbour seal | High-order detonation (525kg (NEQ) + donor charge) without bubble curtain<br>2.5km (19.63km$^2$) | 5.4<br>(SEP density of 0.274/km$^2$) | 0.14% SE England MU<br>(0.018% wider reference population) | **Medium (low)** |
| | High-order detonation (525kg (NEQ) + donor charge) with bubble curtain<br>0.9km (2.54km$^2$) | 0.70<br>(SEP density of 0.274/km$^2$) | 0.019% SE England MU<br>(0.002% wider reference population) | **Medium (low)** |
| | Low-order clearance (0.5kg (NEQ))<br>0.24km (0.18km$^2$) | 0.050<br>(SEP density of 0.274/km$^2$) | 0.001% SE England MU<br>(0.002% wider reference population) | **Low (negligible)** |
| **DEP wind farm site** | | | | |
| Harbour porpoise | High-order detonation (525kg (NEQ) + donor charge) without bubble curtain<br>13.0km (530.93km$^2$) | 1,290.2<br>(DEP summer density of 2.43/km$^2$) | 0.37% NS MU | **Medium** |
| | High-order detonation (525kg (NEQ) + donor charge) with bubble curtain<br>4.6km (66.48km$^2$) | 161.5<br>(DEP summer density of 2.43/km$^2$) | 0.05% NS MU | **Medium** |

| Species | Maximum impact range (and area) | Maximum number of individuals | % of reference population | Magnitude (permanent impact)* |
|---|---|---|---|---|
| | Low-order clearance (0.5kg (NEQ))<br>1.2km (4.52km$^2$) | 11.0<br>(DEP summer density of 2.43/km$^2$) | 0.003% NS MU | **Low** |
| Bottlenose dolphin | The same as for SEP | | | |
| White-beaked dolphin | The same as for SEP | | | |
| Minke whale | The same as for SEP | | | |
| Grey seal | High-order detonation (525kg (NEQ) + donor charge) without bubble curtain<br>2.5km (19.63km$^2$) | 14.5<br>(DEP density of 0.739/km$^2$) | 0.17% SE England MU (0.06% wider reference population) | **Medium (medium)** |
| | High-order detonation (525kg (NEQ) + donor charge) with bubble curtain<br>0.9km (2.54km$^2$) | 1.9<br>(DEP density of 0.739/km$^2$) | 0.02% SE England MU (0.008% wider reference population) | **Low (negligible)** |
| | Low-order clearance (0.5kg (NEQ))<br>0.24km (0.18km$^2$) | 0.13<br>(DEP density of 0.739/km$^2$) | 0.0015% SE England MU (0.0006% wider reference population) | **Negligible (negligible)** |
| Harbour seal | High-order detonation (525kg (NEQ) + donor charge) without bubble curtain<br>2.5km (19.63km$^2$) | 1.6<br>(DEP density of 0.08/km$^2$) | 0.04% SE England MU (0.005% wider reference population) | **Medium (medium)** |
| | High-order detonation (525kg (NEQ) + donor charge) with | 0.20<br>(DEP density of 0.08/km$^2$) | 0.005% SE England MU (0.0007% wider reference population) | **Medium (low)** |

| Species | Maximum impact range (and area) | Maximum number of individuals | % of reference population | Magnitude (permanent impact)* |
|---|---|---|---|---|
| | bubble curtain<br>0.9km (2.54km$^2$) | | | |
| | Low-order clearance (0.5kg (NEQ))<br>0.24km (0.18km$^2$) | 0.01<br>(DEP density of 0.08/km$^2$) | 0.0004% SE England MU<br>(0.00005% wider reference population) | **Negligible (negligible)** |
| **SEP or DEP wind farm site with export cable corridor** | | | | |
| Harbour porpoise | High-order detonation (525kg (NEQ) + donor charge) without bubble curtain<br>13.0km (530.93km$^2$) | 775.2<br>(SEP, DEP and cable areas summer density of 1.46/km$^2$) | 0.22% NS MU | **Medium** |
| | High-order detonation (525kg (NEQ) + donor charge) with bubble curtain<br>4.6km (66.48km$^2$) | 97.1<br>(SEP, DEP and cable areas summer density of 1.46/km$^2$) | 0.03% NS MU | **Medium** |
| | Low-order clearance (0.5kg (NEQ))<br>1.2km (4.52km$^2$) | 6.6<br>(SEP, DEP and cable areas summer density of 1.46/km$^2$) | 0.002% NS MU | **Low** |
| Bottlenose dolphin | The same as for SEP or DEP | | | |
| White-beaked dolphin | The same as for SEP or DEP | | | |
| Minke whale | The same as for SEP or DEP | | | |
| Grey seal | High-order detonation (525kg (NEQ) + donor charge) without bubble curtain<br>2.5km (19.63km$^2$) | 14.4<br>(SEP, DEP cable areas density of 0.735/km$^2$) | 0.17% SE England MU<br>(0.06% wider reference population) | **Medium (medium)** |
| | High-order detonation (525kg (NEQ) + donor charge) with | 1.9<br>(SEP, DEP cable areas density of 0.735/km$^2$) | 0.02% SE England MU<br>(0.008% wider reference population) | **Medium (low)** |

| Species | Maximum impact range (and area) | Maximum number of individuals | % of reference population | Magnitude (permanent impact)* |
|---|---|---|---|---|
| | bubble curtain<br>0.9km (2.54km$^2$) | | | |
| | Low-order clearance (0.5kg (NEQ))<br>0.24km (0.18km$^2$) | 0.1<br>(SEP, DEP cable areas density of 0.735/km$^2$) | 0.002% SE England MU<br>(0.0006% wider reference population) | **Negligible (negligible)** |
| Harbour seal | High-order detonation (525kg (NEQ) + donor charge) without bubble curtain<br>2.5km (19.63km$^2$) | 3.7<br>(SEP, DEP cable areas density of 0.189/km$^2$) | 0.099% SE England MU<br>(0.008% wider reference population) | **Medium (low)** |
| | High-order detonation (525kg (NEQ) + donor charge) with bubble curtain<br>0.9km (2.54km$^2$) | 0.5<br>(SEP, DEP cable areas density of 0.189/km$^2$) | 0.013% SE England MU<br>(0.001% wider reference population) | **Medium (low)** |
| | Low-order clearance (0.5kg (NEQ))<br>0.24km (0.18km$^2$) | 0.03<br>(SEP, DEP cable areas density of 0.189/km$^2$) | 0.0009% SE England MU<br>(0.00008% wider reference population) | **Negligible (negligible)** |

* Magnitudes given in brackets are for the secondary MU assessed for bottlenose dolphin (CES), and the wider population for seal species

#### *10.4.5.3.2 Temporary Auditory Injury (TTS)*

60. The number of harbour porpoise, bottlenose dolphin, white-beaked dolphin, minke whale, grey seal and harbour seal that could potentially be impacted by a high-order UXO detonation (up to 525kg NEQ) without bubble curtain, a high-order UXO detonation (up to 525kg NEQ) with bubble curtain and low-order clearance (0.5kg) has been estimated for the SEP wind farm site, or for the DEP wind farm site, with the export cable corridor, based on the maximum potential TTS impact ranges (**Table 10.4.13**).

61. For the **high-order detonation** of the maximum potential UXO with an NEQ of 525kg plus donor charge **without a bubble curtain**, the magnitude for TTS is assessed, as a worst-case (**Table 10.4.13**), to be:

- **High (medium)** for grey seal at the SEP or DEP wind farm site with export cable corridor
- **High (low)** for grey seal at the SEP wind farm site and DEP wind farm site
- **Medium (low)** for harbour seal at the SEP wind farm site
- **Medium (negligible)** for grey seal at the SEP or DEP wind farm site with export cable corridor
- **Low** for minke whale at the SEP wind farm site and SEP or DEP wind farm site with export cable corridor ,and for harbour porpoise and minke whale at the DEP wind farm site
- **Low (negligible)** for harbour seal at the SEP or DEP wind farm site with export cable corridor
- **Negligible** for harbour porpoise and white-beaked dolphin at the SEP wind farm site and SEP or DEP wind farm site with export cable corridor, and for white-beaked dolphin at the DEP wind farm site
- **Negligible (negligible)** for bottlenose dolphin at the SEP wind farm site, DEP wind farm site, and SEP or DEP wind farm site with export cable corridor

62. For the **high-order detonation** of the maximum potential UXO with an NEQ of 525kg plus donor charge **with a bubble curtain**, the magnitude for TTS is assessed to be:

- **Negligible** for harbour porpoise, white-beaked dolphin, minke whale at the SEP wind farm site, at the DEP wind farm site, or at the SEP or DEP wind farm site with the export cable corridor
- **Negligible (negligible)** for bottlenose dolphin, grey seal, and harbour seal at the SEP wind farm site, DEP wind farm site, or at the SEP or DEP wind farm site with export cable corridor

63. For **low-order clearance** (0.5kg donor charge for all sizes of UXO) **without a bubble curtain**, the magnitude is assessed to be:

- **Negligible** for harbour porpoise, white-beaked dolphin, minke whale at the SEP wind farm site, at the DEP wind farm site, or at the SEP or DEP wind farm site with the export cable corridor
- **Negligible (negligible)** for bottlenose dolphin, grey seal, and harbour seal at the SEP wind farm site, DEP wind farm site, or at the SEP or DEP wind farm site with export cable corridor

*Table 10.4.13: Maximum number of marine mammals potentially at risk of TTS during UXO clearance at SEP wind farm site, or at the DEP wind farm site, with the export cable corridors*

| Species | Maximum impact range (and area) | Maximum number of individuals | % of reference population | Magnitude (temporary impact)* |
|---|---|---|---|---|
| **SEP wind farm site** | | | | |
| Harbour porpoise | High-order detonation (525kg (NEQ) + donor charge) without bubble curtain<br>23km (1,661.90km$^2$) | 1,047<br>(SEP summer density of 0.63/km$^2$) | 0.3% NS MU | **Negligible** |
| | High-order detonation (525kg (NEQ) + donor charge) with bubble curtain<br>8.4km (221.67km$^2$) | 139.65<br>(SEP summer density of 0.63/km$^2$) | 0.04% NS MU | **Negligible** |
| | Low-order clearance (0.5kg (NEQ))<br>2.3km (16.62km$^2$) | 10.47<br>(SEP summer density of 0.63/km$^2$) | 0.003% NS MU | **Negligible** |
| Bottlenose dolphin | High-order detonation (525kg (NEQ) + donor charge) without bubble curtain<br>1.3km (5.31km$^2$) | 0.16<br>(SCANS-III density of 0.0298/km$^2$) | 0.008% GNS MU<br>(0.07% of CES MU) | **Negligible (negligible)** |
| | High-order detonation (525kg (NEQ) + donor charge) with bubble curtain<br>0.49km (0.75km$^2$) | 0.022<br>(SCANS-III density of 0.0298/km$^2$) | 0.001% GNS MU<br>(0.01% of CES MU) | **Negligible (negligible)** |
| | Low-order clearance (0.5kg (NEQ))<br>0.54km (0.92km$^2$) | 0.027<br>(SCANS-III density of 0.0298/km$^2$) | 0.0014% GNS MU<br>(0.01% of CES MU) | **Negligible (negligible)** |
| White-beaked dolphin | High-order detonation (525kg (NEQ) + donor charge) without bubble curtain<br>1.3km (5.31km$^2$) | 0.03<br>(density of 0.006/km$^2$) | 0.00007% CGNS MU | **Negligible** |

| Species | Maximum impact range (and area) | Maximum number of individuals | % of reference population | Magnitude (temporary impact)* |
|---|---|---|---|---|
| | High-order detonation (525kg (NEQ) + donor charge) with bubble curtain 0.49km (0.75km$^2$) | 0.005 (density of 0.006/km$^2$) | 0.00001% CGNS MU | **Negligible** |
| | Low-order clearance (0.5kg (NEQ)) 0.54km (0.92km$^2$) | 0.006 (density of 0.006/km$^2$) | 0.00001% CGNS MU | **Negligible** |
| Minke whale | High-order detonation (525kg (NEQ) + donor charge) without bubble curtain 103km (33,329.16km$^2$) | 333.3 (SCANS-III density of 0.0100/km$^2$) | 1.66% CGNS MU | **Low** |
| | High-order detonation (525kg (NEQ) + donor charge) with bubble curtain 22km (1,520.53km$^2$) | 15.2 (SCANS-III density of 0.0100/km$^2$) | 0.08% CGNS MU | **Negligible** |
| | Low-order clearance (0.5kg (NEQ)) 4.5km (63.62km$^2$) | 0.64 (SCANS-III density of 0.0100/km$^2$) | 0.003% CGNS MU | **Negligible** |
| Grey seal | High-order detonation (525kg (NEQ) + donor charge) without bubble curtain 20km (1,256.64km$^2$) | 1,071.9 (SEP density of 0.853/km$^2$) | 12.37% SE England MU (4.44% wider reference population) | **High (low)** |
| | High-order detonation (525kg (NEQ) + donor charge) with bubble curtain 4km (50.27km$^2$) | 42.9 (SEP density of 0.853/km$^2$) | 0.49% SE England MU (0.18% wider reference population) | **Negligible (negligible)** |
| | Low-order clearance (0.5kg (NEQ)) 0.8km (2.01km$^2$) | 1.72 (SEP density of 0.853/km$^2$) | 0.02% SE England MU (0.007% wider reference population) | **Negligible (negligible)** |

| Species | Maximum impact range (and area) | Maximum number of individuals | % of reference population | Magnitude (temporary impact)* |
|---|---|---|---|---|
| Harbour seal | High-order detonation (525kg (NEQ) + donor charge) without bubble curtain<br>20km (1,256.64km$^2$) | 344.3<br>(SEP density of 0.274/km$^2$) | 9.18% SE England MU<br>(1.13% wider reference population) | **Medium (low)** |
| | High-order detonation (525kg (NEQ) + donor charge) with bubble curtain<br>4km (50.27km$^2$) | 13.8<br>(SEP density of 0.274/km$^2$) | 0.37% SE England MU<br>(0.045% wider reference population) | **Negligible (negligible)** |
| | Low-order clearance (0.5kg (NEQ))<br>0.8km (2.01km$^2$) | 0.55<br>(SEP density of 0.274/km$^2$) | 0.01% SE England MU<br>(0.0018% wider reference population) | **Negligible (negligible)** |
| **DEP wind farm site** | | | | |
| Harbour porpoise | High-order detonation (525kg (NEQ) + donor charge) without bubble curtain<br>23km (1,661.90km$^2$) | 4,038.4<br>(DEP summer density of 2.43/km$^2$) | 1.17% NS MU | **Low** |
| | High-order detonation (525kg (NEQ) + donor charge) with bubble curtain<br>8.4km (221.67km$^2$) | 538.7<br>(DEP summer density of 2.43/km$^2$) | 0.16% NS MU | **Negligible** |
| | Low-order clearance (0.5kg (NEQ))<br>2.3km (16.62km$^2$) | 40.4<br>(DEP summer density of 2.43/km$^2$) | 0.012% NS MU | **Negligible** |
| Bottlenose dolphin | The same as for SEP | | | |
| White-beaked dolphin | The same as for SEP | | | |
| Minke whale | The same as for SEP | | | |

| Species | Maximum impact range (and area) | Maximum number of individuals | % of reference population | Magnitude (temporary impact)* |
|---|---|---|---|---|
| Grey seal | High-order detonation (525kg (NEQ) + donor charge) without bubble curtain<br>20km (1,256.64km$^2$) | 928.7<br>(DEP density of 0.739/km$^2$) | 10.71% SE England MU (3.85% wider reference population) | **High (low)** |
| | High-order detonation (525kg (NEQ) + donor charge) with bubble curtain<br>4km (50.27km$^2$) | 37.1<br>(DEP density of 0.739/km$^2$) | 0.43% SE England MU (0.15% wider reference population) | **Negligible (negligible)** |
| | Low-order clearance (0.5kg (NEQ))<br>0.8km (2.01km$^2$) | 1.49<br>(DEP density of 0.739/km$^2$) | 0.017% SE England MU (0.006% wider reference population) | **Negligible (negligible)** |
| Harbour seal | High-order detonation (525kg (NEQ) + donor charge) without bubble curtain<br>20km (1,256.64km$^2$) | 100.5<br>(DEP density of 0.08/km$^2$) | 2.68% SE England MU (0.33% wider reference population) | **Low (negligible)** |
| | High-order detonation (525kg (NEQ) + donor charge) with bubble curtain<br>4km (50.27km$^2$) | 4.0<br>(DEP density of 0.08/km$^2$) | 0.11% SE England MU (0.013% wider reference population) | **Negligible (negligible)** |
| | Low-order clearance (0.5kg (NEQ))<br>0.8km (2.01km$^2$) | 0.16<br>(DEP density of 0.08/km$^2$) | 0.004% SE England MU (0.0005% wider reference population) | **Negligible (negligible)** |
| **SEP or DEP wind farm site with export cable corridor** | | | | |
| Harbour porpoise | High-order detonation (525kg (NEQ) + donor charge) without bubble curtain<br>23km (1,661.90km$^2$) | 2,426.4<br>(SEP, DEP and cable areas summer density of 1.46/km$^2$) | 0.70% NS MU | **Negligible** |

| Species | Maximum impact range (and area) | Maximum number of individuals | % of reference population | Magnitude (temporary impact)* |
|---|---|---|---|---|
| | High-order detonation (525kg (NEQ) + donor charge) with bubble curtain 8.4km (221.67km$^2$) | 323.6 (SEP, DEP and cable areas summer density of 1.46/km$^2$) | 0.09% NS MU | **Negligible** |
| | Low-order clearance (0.5kg (NEQ)) 2.3km (16.62km$^2$) | 24.3 (SEP, DEP and cable areas summer density of 1.46/km$^2$) | 0.007% NS MU | **Negligible** |
| Bottlenose dolphin | The same as for SEP or DEP | | | |
| White-beaked dolphin | The same as for SEP or DEP | | | |
| Minke whale | The same as for SEP or DEP | | | |
| Grey seal | High-order detonation (525kg (NEQ) + donor charge) without bubble curtain 20km (1,256.64km$^2$) | 923.6 (SEP, DEP cable areas density of 0.735/km$^2$) | 10.66% SE England MU (3.83% wider reference population) | **High (medium)** |
| | High-order detonation (525kg (NEQ) + donor charge) with bubble curtain 4km (50.27km$^2$) | 37.0 (SEP, DEP cable areas density of 0.735/km$^2$) | 0.43% SE England MU (0.15% wider reference population) | **Negligible (negligible)** |
| | Low-order clearance (0.5kg (NEQ)) 0.8km (2.01km$^2$) | 1.5 (SEP, DEP cable areas density of 0.735/km$^2$) | 0.017% SE England MU (0.006% wider reference population) | **Negligible (negligible)** |
| Harbour seal | High-order detonation (525kg (NEQ) + donor charge) without bubble curtain 20km (1,256.64km$^2$) | 237.5 (SEP, DEP cable areas density of 0.18/km$^2$) | 6.33% SE England MU (0.78% wider reference population) | **Medium (negligible)** |
| | High-order detonation (525kg (NEQ) + donor charge) with bubble curtain 4km (50.27km$^2$) | 9.5 (SEP, DEP cable areas density of 0.189/km$^2$) | 0.25% SE England MU (0.031% wider reference population) | **Negligible (negligible)** |

| Species | Maximum impact range (and area) | Maximum number of individuals | % of reference population | Magnitude (temporary impact)* |
|---|---|---|---|---|
| | Low-order clearance (0.5kg (NEQ)) 0.8km (2.01km$^2$) | 0.38 (SEP, DEP cable areas density of 0.189/km$^2$) | 0.01% SE England MU (0.0012% wider reference population) | **Negligible (negligible)** |

* Magnitudes given in brackets are for the secondary MU assessed for bottlenose dolphin (CES), and the wider population for seal species

#### 10.4.5.4 Impact Significance

64. Taking into account the high sensitivity for all species to PTS from UXO clearance, the impact significance, for a high-order detonation without mitigation, has been assessed as major adverse for harbour porpoise, minke whale, and grey seal, as moderate to major adverse for bottlenose dolphin and harbour seal, and minor adverse for white-beaked dolphin at either of the wind farm sites, with the export cable corridors (**Table 10.4.14**).

65. For low-order clearance, without further mitigation measures, such as monitoring zone and activation of ADDs, and based on a very precautionary high sensitivity for all marine mammals to PTS from low-order clearance, the impact significance has been assessed as minor to moderate adverse. However, with the additional mitigation measures, as laid out below, the residual impact significance would be minor (not significant).

66. For TTS, taking into account the medium sensitivity for all species to UXO clearance, the impact significance, for a high-order detonation without mitigation, has been assessed as minor adverse for harbour porpoise, bottlenose dolphin, white-beaked dolphin and minke whale at either of the SEP or DEP wind farm sites or the export cable corridor. The impact significance for grey seal and harbour seal is major to minor adverse at either of the wind farm sites with the export cable corridor (**Table 10.4.14**). For high-order detonation with bubble curtain and for low-order clearance, the impact significance is minor (not significant) for TTS in all species.

67. It should be noted that the conclusion of major or moderate adverse (significant) without mitigation for PTS is very precautionary, as the assessment is based on the worst case scenario.

#### 10.4.5.5 Mitigation

68. As outlined in **Section 10.4.3**, a MMMP for UXO clearance will be produced post-consent in consultation with the MMO and relevant SNCBs. The final MMMP for UXO clearance will be based on the latest scientific understanding and guidance, pre-construction UXO surveys at both SEP and DEP, as well as detailed project design. The implementation of the mitigation measures within the MMMP for UXO clearance will reduce the risk of any permanent auditory injury (PTS) during UXO clearance. The mitigation measure would also reduce the risk of TTS.

69. The proposed mitigation measures for consideration in the MMMP for UXO clearance include, the use of low-order clearance techniques, such as deflagration, establishing a monitoring zone and surveying prior to UXO clearance, the use of ADDs and the use of bubble curtains if any high-order detonations are required.

70. A marine wildlife licence application, if required, will be submitted post-consent. At this time, pre-construction UXO 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.

#### 10.4.5.6 Residual Impact Significance

71. The residual impact 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 at either of the wind farm sites with the export cable corridors, is reduced to a negligible magnitude, taking into account the proposed mitigation (low-order clearance, monitoring zone and ADD activation). Therefore, with high sensitivity for any physical injury or permanent auditory injury (PTS) and medium sensitivity for TTS / fleeing response, the potential impact significance is reduced to **minor adverse (not significant)** (**Table 10.4.14**).

*Table 10.4.14: Assessment of impact significance at the SEP wind farm site or the DEP wind farm site, with the export cable corridors for UXO clearance*

| Impact | Species | Sensitivity | Magnitude (for high-order detonation without bubble curtain) | Impact Significance | Mitigation | Residual Impact Significance |
|---|---|---|---|---|---|---|
| PTS during underwater UXO clearance | Harbour porpoise | High | Medium at SEP or DEP wind farm sites, or with the export cable corridor | Major adverse at SEP or DEP wind farm sites, with the export cable corridor | MMMP for UXO clearance (low-order clearance, monitoring zone and ADD activation) | **Minor adverse** |
| | Bottlenose dolphin | High | Low to medium at SEP or DEP wind farm sites, or with the export cable corridor | Moderate to major adverse at SEP or DEP wind farm sites, with the export cable corridor | | **Minor adverse** |
| | White-beaked dolphin | High | Negligible at SEP or DEP wind farm sites, or with the export cable corridor | Minor adverse at SEP or DEP wind farm sites, with the export cable corridor | | **Minor adverse** |
| | Minke whale | High | Medium at SEP or DEP wind farm sites, or with the export cable corridor | Major adverse at SEP or DEP wind farm sites, with the export cable corridor | | **Minor adverse** |
| | Grey seal | High | Medium at SEP or DEP wind farm sites, with the export cable corridor | Major adverse at SEP or DEP wind farm sites, with the export cable corridor | | **Minor adverse** |

| Impact | Species | Sensitivity | Magnitude (for high-order detonation without bubble curtain) | Impact Significance | Mitigation | Residual Impact Significance |
|---|---|---|---|---|---|---|
| | Harbour seal | High | Low to medium at SEP wind farm site, with the export cable corridor<br>Medium at DEP wind farm site | Moderate to major adverse at SEP wind farm site, with the export cable corridor<br>Major adverse at DEP wind farm sites | | **Minor adverse** |
| TTS during underwater UXO clearance | Harbour porpoise | Medium | Negligible at SEP wind farm site with the export cable corridor, or<br>Low at DEP wind farm site | Minor adverse at SEP and DEP wind farm sites, with the export cable corridor | MMMP for UXO clearance | **Minor adverse** |
| | Bottlenose dolphin | Medium | Negligible at SEP and DEP wind farm sites, with the export cable corridor | Minor adverse at SEP and DEP wind farm sites, with the export cable corridor | | **Minor adverse** |
| | White-beaked dolphin | Medium | Negligible at SEP and DEP wind farm sites, with the export cable corridor | Minor adverse at SEP and DEP wind farm sites, with the export cable corridor | | **Minor adverse** |
| | Minke whale | Medium | Low at SEP and DEP wind farm sites, with the export cable corridor | Minor adverse at SEP and DEP wind farm sites, with the export cable corridor | | **Minor adverse** |

| Impact | Species | Sensitivity | Magnitude (for high-order detonation without bubble curtain) | Impact Significance | Mitigation | Residual Impact Significance |
|---|---|---|---|---|---|---|
| | Grey seal | Medium | Low to high at SEP wind farm site<br>Medium to high at DEP wind farm site and with the export cable corridor | Minor to Major adverse at SEP wind farm site<br>Moderate to Major at DEP wind farm site with the export cable corridor | | **Moderate adverse** |
| | Harbour seal | Medium | Low to medium at SEP wind farm site<br>Negligible to low at DEP wind farm site<br>Negligible to medium for SEP and DEP with export cable corridors | Minor to Moderate adverse at SEP wind<br>Minor adverse at DEP wind farm site<br>Minor to Moderate adverse in the export cable corridor | | **Minor adverse** |

### 10.4.5.7 Impact Assessment for SEP and DEP (and Export Cable Corridors)

72. The impact for high-order UXO detonation (with or without bubble curtain) for SEP and DEP would be the same as that presented above for SEP or DEP in isolation, as only one high-order UXO detonation would be undertaken at one site at a time, i.e. there would be no simultaneous high-order UXO detonations between the two sites. Therefore, the impact assessment shown within **Table 10.4.15** is valid for the impact assessment for any high-order UXO detonation at SEP and DEP.

73. There is the potential that more than one low-order UXO clearance could take place at SEP and DEP at the same time. Therefore, as a precautionary approach, the number of marine mammals that could be impacted has been assessed based on one low-order UXO clearance at SEP and one low-order UXO clearance at DEP (**Table 10.4.15**).

*Table 10.4.15: Maximum number of marine mammals potentially at risk of PTS and TTS during low-order UXO clearance at SEP and DEP*

| Species | Impact | Maximum number of individuals | % of reference population | Magnitude |
|---|---|---|---|---|
| **SEP and DEP** | | | | |
| Harbour porpoise | PTS | 13.8 | 0.004% NS MU | **Low** |
| | TTS | 50.9 | 0.015% NS MU | **Negligible** |
| Bottlenose dolphin | PTS | 0.0009 | 0.00005% GNS MU (0.0004% of CES MU) | **Negligible** |
| | TTS | 0.06 | 0.003% GNS MU (0.02% of CES MU) | **Negligible** |
| White-beaked dolphin | PTS | 0.0002 | 0.0000004% CGNS MU | **Negligible** |
| | TTS | 0.011 | 0.00003% CGNS MU | **Negligible** |
| Minke whale | PTS | 0.003 | 0.000015% CGNS MU | **Negligible** |
| | TTS | 1.3 | 0.006% CGNS MU | **Negligible** |
| Grey seal | PTS | 0.3 | 0.003% SE England MU (0.0011% of wider reference population) | **Low (low)** |
| | TTS | 3.2 | 0.04% SE England MU (0.01% of wider reference population) | **Negligible (negligible)** |
| Harbour seal | PTS | 0.06 | 0.0017% SE England MU (0.0002% of | **Low (negligible)** |

| Species | Impact | Maximum number of individuals | % of reference population | Magnitude |
|---|---|---|---|---|
| | | | wider reference population) | |
| | TTS | 0.71 | 0.02% SE England MU (0.002% of wider reference population) | **Negligible (negligible)** |

74. Taking into account the precautionary high sensitivity for all species to PTS from low-order UXO clearance, the impact significance, for low-order clearance at SEP and DEP, has been assessed as moderate adverse for harbour porpoise, moderate to minor adverse for harbour seal, and minor adverse for bottlenose dolphin, white-beaked dolphin, minke whale and grey seal (**Table 10.4.16**).

75. The TTS impact significance for low-order clearance at SEP and DEP, has been assessed as minor adverse for harbour porpoise, bottlenose dolphin, white-beaked dolphin, minke whale, grey seal and harbour seal (**Table 10.4.16**).

76. The residual impact for PTS or TTS for low-order UXO clearance at SEP and DEP, after mitigation measures that will be implemented prior to all low-order UXO clearance including establishment of a monitoring zone and ADD activation, would be **minor (not significant)** for all marine mammal species (**Table 10.4.16**).

*Table 10.4.16: Assessment of impact significance for low-order UXO clearance at SEP and DEP*

| Impact | Species | Sensitivity | Magnitude | Impact Significance | Mitigation | Residual Impact Significance |
|---|---|---|---|---|---|---|
| PTS during underwater low-order UXO clearance at SEP and DEP | Harbour porpoise | High | Low for SEP and DEP | Moderate adverse for SEP and DEP | MMMP for UXO clearance (monitoring zone and ADD activation) | **Minor adverse** |
| | Bottlenose dolphin | High | Negligible for SEP and DEP | Minor adverse for SEP and DEP | | **Minor adverse** |
| | White-beaked dolphin | High | Negligible for SEP and DEP | Minor adverse for SEP and DEP | | **Minor adverse** |
| | Minke whale | High | Negligible for SEP and DEP | Minor adverse for SEP and DEP | | **Minor adverse** |
| | Grey seal | High | Low for SEP and DEP | Moderate adverse for SEP and DEP | | **Minor adverse** |
| | Harbour seal | High | Low to negligible for SEP and DEP | Moderate to minor adverse for SEP and DEP | | **Minor adverse** |
| TTS during underwater low-order UXO clearance at SEP and DEP | Harbour porpoise | Medium | Negligible for SEP and DEP | Minor adverse for SEP and DEP | MMMP for UXO clearance | **Minor adverse** |
| | Bottlenose dolphin | Medium | Negligible for SEP and DEP | Minor adverse for SEP and DEP | | **Minor adverse** |
| | White-beaked dolphin | Medium | Negligible for SEP and DEP | Minor adverse for SEP and DEP | | **Minor adverse** |

| Impact | Species | Sensitivity | Magnitude | Impact Significance | Mitigation | Residual Impact Significance |
|---|---|---|---|---|---|---|
| | Minke whale | Medium | Negligible for SEP and DEP | Minor adverse for SEP and DEP | | **Minor adverse** |
| | Grey seal | Medium | Negligible for SEP and DEP | Minor adverse for SEP and DEP | | **Minor adverse** |
| | Harbour seal | Medium | Negligible for SEP and DEP | Minor adverse for SEP and DEP | | **Minor adverse** |

### 10.4.6 Impact 2: Disturbance from Underwater Noise Associated with UXO Clearance

77. 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 impact ranges.

78. 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, 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.

79. 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).

80. 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.

81. The assessments for TTS / fleeing response have therefore been used for assessing the potential disturbance ranges for UXO high-order detonation. Therefore, the potential range and areas for TTS presented in **Table 10.4.11**, with the estimated number and percentage of reference populations that could be impacted as assessed in **Section 10.4.5.3.2** provides an indication of possible fleeing response.

82. 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 the SNS SAC (JNCC *et al*., 2020). SEP and DEP are not located within the SNS SAC, however, they are located within 26km, and therefore this is approach has been used for the EIA (as well as the Habitat Regulations Assessment (HRA)) for the assessment of harbour porpoise. 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 2,124km$^2$).

83. 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. As a worst-case, marine mammals could be temporarily disturbed from this area for UXO low-order clearances.

84. In addition, the MMMP for UXO clearance will include ADD activation prior to all UXO clearance, 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 with bubble curtain, high-order detonation without bubble curtain, size of UXO (NEQ) and location (e.g. marine mammal species that could be present in nearshore and offshore areas).

85. The duration of ADD activation required will 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 will be reviewed and updated for the marine licence and marine wildlife licence application prior to UXO clearance.

#### 10.4.6.1 Magnitude for SEP or DEP in Isolation

86. As assessed in **Section 10.4.5.3.2**, for a high-order detonation of the maximum potential UXO with an NEQ of 525kg plus donor charge without a bubble curtain, the magnitude for TTS / fleeing response is assessed, as a worst-case (**Table 10.4.13**), to be:

- **High (medium)** for grey seal at the SEP or DEP wind farm site with export cable corridor
- **High (low)** for grey seal at the SEP wind farm site and DEP wind farm site
- **Medium (low)** for harbour seal at the SEP wind farm site
- **Medium (negligible)** for grey seal at the SEP or DEP wind farm site with export cable corridor
- **Low** for minke whale at the SEP wind farm site and SEP or DEP wind farm site with export cable corridor ,and for harbour porpoise and minke whale at the DEP wind farm site
- **Low (negligible)** for harbour seal at the SEP or DEP wind farm site with export cable corridor
- **Negligible** for harbour porpoise and white-beaked dolphin at the SEP wind farm site and SEP or DEP wind farm site with export cable corridor, and for white-beaked dolphin at the DEP wind farm site
- **Negligible (negligible)** for bottlenose dolphin at the SEP wind farm site, DEP wind farm site, and SEP or DEP wind farm site with export cable corridor

87. For the high-order detonation of the maximum potential UXO with an NEQ of 525kg plus donor charge with a bubble curtain, the magnitude for TTS / fleeing response is assessed to be:

- **Negligible** for harbour porpoise, white-beaked dolphin, minke whale at the SEP wind farm site, at the DEP wind farm site, or at the SEP or DEP wind farm site with the export cable corridor
- **Negligible (negligible)** for bottlenose dolphin, grey seal, and harbour seal at the SEP wind farm site, DEP wind farm site, or at the SEP or DEP wind farm site with export cable corridor

88. For low-order clearance (0.5kg donor charge for all sizes of UXO) without a bubble curtain, the magnitude for TTS / fleeing response is assessed to be:

- **Negligible** for harbour porpoise, white-beaked dolphin, minke whale at the SEP wind farm site, at the DEP wind farm site, or at the SEP or DEP wind farm site with the export cable corridor
- **Negligible (negligible)** for bottlenose dolphin, grey seal, and harbour seal at the SEP wind farm site, DEP wind farm site, or at the SEP or DEP wind farm site with export cable corridor

89. 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 for the SEP and DEP wind farm sites individually and with the export cable corridors. The resulting magnitude is assessed to be low for DEP and negligible for SEP and export cable area (**Table 10.4.17**).

90. Further assessments in relation to the SNS SAC are provided in the **RIAA** (document reference 5.4).

91. 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 10.4.17: Estimated number of harbour porpoise that could potentially be disturbed during UXO clearance based on 26km EDR for high-order detonation with no mitigation at SEP or DEP or export cable area*

| Species | Location | Maximum impact area | Maximum number of individuals | % of reference population | Magnitude (temporary impact) |
|---|---|---|---|---|---|
| Harbour porpoise | SEP | 2,124km$^2$ | 1,338.1 (SEP summer density of 0.63/km$^2$) | 0.39% NS MU | **Negligible** |
| | DEP | 2,124km$^2$ | 5,161.3 (DEP summer density of 2.43/km$^2$) | 1.49% NS MU | **Low** |
| | SEP or DEP with | 2,124km$^2$ | 3.101.0 (SEP, DEP and | 0.89% NS MU | **Negligible** |

| Species | Location | Maximum impact area | Maximum number of individuals | % of reference population | Magnitude (temporary impact) |
|---|---|---|---|---|---|
| | export cable corridors | | cable areas summer density of 1.46/km$^2$) | | |

92. 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 impact has been assessed as negligible for all marine mammal species, with negligible to low for bottlenose dolphin depending on the MU (**Table 10.4.18**).

*Table 10.4.18: Estimated number of marine mammals that could potentially be disturbed during low-order UXO clearance based on 5km disturbance range at SEP or DEP, with export cable corridor*

| Species | Location | Maximum impact area | Maximum number of individuals | % of reference population | Magnitude (temporary impact) |
|---|---|---|---|---|---|
| Harbour porpoise | SEP | 78.54km$^2$ | 49.5 (SEP summer density of 0.63/km$^2$) | 0.01% NS MU | **Negligible** |
| | DEP | 78.54km$^2$ | 190.9 (DEP summer density of 2.43/km$^2$) | 0.06% NS MU | **Negligible** |
| | SEP, DEP and export cable areas | 78.54km$^2$ | 114.7 (SEP, DEP and cable areas summer density of 1.46/km$^2$) | 0.03% NS MU | **Negligible** |
| Bottlenose dolphin | SEP or DEP or export cable areas | 78.54km$^2$ | 2.3 (SCANS-III density of 0.0298/km$^2$) | 0.12% GNS MU (1.04% of CES MU) | **Negligible (low)** |
| White-beaked dolphin | SEP or DEP or export cable areas | 78.54km$^2$ | 0.47 (density of 0.006/km$^2$) | 0.001% CGNS MU | **Negligible** |
| Minke whale | SEP or DEP or export cable areas | 78.54km$^2$ | 0.79 (SCANS-III density of 0.0100/km$^2$) | 0.004% CGNS MU | **Negligible** |
| Grey seal | SEP | 78.54km$^2$ | 67.0 (SEP density of 0.853/km$^2$) | 0.77% SE England MU (0.28% of the wider | **Negligible (negligible)** |

| Species | Location | Maximum impact area | Maximum number of individuals | % of reference population | Magnitude (temporary impact) |
|---|---|---|---|---|---|
| | | | | reference population) | |
| | DEP | 78.54km$^2$ | 58.0 (DEP density of 0.739/km$^2$) | 0.67% SE England MU (0.24% of the wider reference population) | **Negligible (negligible)** |
| | SEP, DEP and export cable areas | 78.54km$^2$ | 57.7 (SEP, DEP cable areas density of 0.735/km$^2$) | 0.67% SE England MU (0.24% of the wider reference population) | **Negligible (negligible)** |
| Harbour seal | SEP | 78.54km$^2$ | 21.5 (SEP density of 0.274/km$^2$) | 0.57% SE England MU (0.07% of the wider reference population) | **Negligible (negligible)** |
| | DEP | 78.54km$^2$ | 6.3 (DEP density of 0.08/km$^2$) | 0.17% SE England MU (0.02% of the wider reference population) | **Negligible (negligible)** |
| | SEP or DEP with export cable corridor | 78.54km$^2$ | 14.8 (SEP, DEP cable areas density of 0.189/km$^2$) | 0.40% SE England MU (0.049% of the wider reference population) | **Negligible (negligible)** |

93. The estimated maximum ADD activation prior to UXO clearance has been determined based on the maximum predicted impact range for low-order clearance of 1.2km for harbour porpoise, for high-order detonation with bubble curtain of 4.6km for harbour porpoise and high-order detonation without bubble curtain of 13km for harbour porpoise (**Table 10.4.10**). 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 for SEP or DEP with the export cable corridor (**Table 10.4.19**).

94. 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 2.9km, based on swimming speed of 3.25m/s (Blix and Folkow, 1995).

95. For high-order detonation with bubble curtain the maximum ADD activation time for the largest UXO would be up to 50 minutes and without bubble curtain the maximum ADD activation time for the largest UXO would be up to a maximum of 155 minutes.

96. The magnitude of impact for ADD activation prior to UXO clearance has been assessed as negligible for all marine mammal species, with the exception of grey and harbour seal which has been assessed as low for the maximum ADD activation prior to high-order detonation without bubble curtain (**Table 10.4.19**).

97. For bottlenose dolphin, based on the CES MU the magnitude could be low for 50 minute ADD activation and medium for maximum ADD activation. However, as previously outlined the assessments for bottlenose dolphin have been based on a very precautionary approach, as there is currently no density estimate for the area in and around SEP and DEP. In addition, bottlenose dolphin are more likely to be present close to shore, rather than the offshore areas. Therefore, the risk to bottlenose dolphin is likely to be a lot less than in the worst-case assessment.

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

*Table 10.4.19: Estimated number of marine mammals that could potentially be disturbed during ADD activation for UXO clearance and impact magnitude*

| Species | Low-order clearance | High-order detonation with bubble curtain | High-order detonation without bubble curtain |
|---|---|---|---|
| | Up to 15 minutes | Up to 50 minutes | Up to 155 minutes |
| Harbour porpoise | 13.9 (0.004% NS MU) **Negligible** | 154.6 (0.045% NS MU) **Negligible** | 1,485.6 (0.43% NS MU) **Negligible** |
| Bottlenose dolphin | 0.17 (0.008% GNS MU; 0.08% CES MU) **Negligible** | 1.90 (0.09% GNS MU; 0.85% CES MU) **Negligible (negligible)** | 18.2 (0.90% GNS MU; 8.1% CES MU) **Negligible (medium)** |
| White-beaked dolphin | 0.03 (0.00008% CGNS MU) **Negligible** | 0.38 (0.0009% CGNS MU) **Negligible** | 3.67 (0.008% CGNS MU) **Negligible** |
| Minke whale | 0.26 (0.001% CGNS MU) **Negligible** | 3.0 (0.015% CGNS MU) **Negligible** | 28.7 (0.14% CGNS MU) **Negligible** |
| Grey seal | 4.9 (0.06% SE MU; 0.02% of the wider reference population) **Negligible (negligible)** | 54.3 (0.63% SE MU; 0.23% of the wider reference population) **Negligible (negligible)** | 521.5 (6.0% SE MU; 2.2% of the wider reference population) **Medium (low)** |
| Harbour seal | 1.6 (0.04% SE MU; 0.01% of the wider reference population) **Negligible (negligible)** | 17.4 (0.46% SE MU) ; 0.06% of the wider reference population **Negligible (negligible)** | 167.5 (4.5% SE MU; 0.55% of the wider reference population) **Low (negligible)** |

#### 10.4.6.2 Impact Significance

99. Taking into account the medium sensitivity of marine mammals to disturbance from UXO clearance and the magnitude, the temporary disturbance of marine mammals during UXO clearance has been assessed as **minor adverse** for SEP and DEP (**Table 10.4.20**).

#### 10.4.6.3 Mitigation

100. Mitigation techniques such as low-order clearance, monitoring zone and bubble curtain for high-order detonation would reduce the potential disturbance of marine mammals during UXO clearance (**Section 10.4.3.1**).

#### 10.4.6.4 Residual Impact Significance

101. The residual impact of the potential disturbance of marine mammals as a result of underwater noise during UXO clearance at either SEP or DEP is reduced to **minor adverse (not significant)** (**Table 10.4.20**)

*Table 10.4.20: Assessment of impact significance for disturbance of marine mammals during UXO clearance at SEP or DEP, with the export cable corridor*

| Impact | Species | Sensitivity | Magnitude | Impact Significance | Mitigation | Residual Impact Significance |
|---|---|---|---|---|---|---|
| TTS / fleeing response | see **Table 10.4.14** | | | | | |
| 26km EDR | Harbour porpoise | Medium | Low to Negligible | Minor adverse | MMMP (low-order clearance, monitoring zone and bubble curtain for high-order detonation) | Minor adverse |
| 5km disturbance for low-order clearance | Harbour porpoise | Medium | Negligible | Minor adverse | | Minor adverse |
| | Bottlenose dolphin | Medium | Low to Negligible | Minor adverse | | Minor adverse |
| | White-beaked 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 |
| | Bottlenose dolphin | Medium | Negligible to medium | Minor to moderate adverse | | Minor adverse |
| | White-beaked dolphin | Medium | Negligible | Minor adverse | | Minor adverse |
| | Minke whale | Medium | Negligible | Minor adverse | | Minor adverse |
| | Grey seal | Medium | Low to medium | Minor to moderate adverse | | Minor adverse |

| Impact | Species | Sensitivity | Magnitude | Impact Significance | Mitigation | Residual Impact Significance |
|---|---|---|---|---|---|---|
| | Harbour seal | Medium | Negligible to low | Minor adverse | | Minor adverse |

### 10.4.6.5 Impact Assessment for SEP and DEP

102. The potential disturbance for high-order UXO detonation (with or without bubble curtain) for SEP and DEP would be the same as that presented above for SEP or DEP in isolation, as only one high-order UXO detonation would be undertaken at one site at a time, i.e. there would be no simultaneous high-order UXO detonations between the two sites.

103. There is the potential that more than one low-order UXO clearance could take place at SEP and DEP. Therefore, as a precautionary approach the number of marine mammals that could be disturbed has been assessed based on one low-order UXO clearance at SEP and one low-order UXO clearance at DEP (**Table 10.4.21**).

104. The precautionary up to 15 minutes ADD activation prior to low-ordnance clearance, has a potential disturbance range of 1.35km for harbour porpoise, bottlenose dolphin, white-beaked dolphin, grey seal and harbour seal and 2.9km for minke whale. Therefore, the disturbance as a result of ADD activation is within the estimated 5km disturbance range for low-order UXO clearance, including vessels associated with UXO clearance, and is therefore not an additive effect to the overall area of potential disturbance.

105. The timing, location, area and duration of UXO clearance at SEP and DEP, including ADD activation will be assessed to determine the potential disturbance of marine mammals for the marine licence and marine wildlife licence application prior to UXO clearance.

*Table 10.4.21: Maximum number of marine mammals potentially disturbed during low-order UXO clearance at SEP and DEP*

| Species | Impact | Maximum number of individuals | % of reference population | Magnitude |
|---|---|---|---|---|
| **SEP and DEP** | | | | |
| Harbour porpoise | 5km disturbance for low-order clearance | 240.3 | 0.07% NS MU | **Negligible** |
| | ADD activation prior to low-order clearance | 17.5 | 0.005% NS MU | **Negligible** |
| Bottlenose dolphin | 5km disturbance for low-order clearance | 4.7 | 0.23% GNS MU (2.09% CES MU) | **Negligible (low)** |
| | ADD activation prior to low-order clearance | 0.34 | 0.017% GNS MU (0.15% CES MU) | **Negligible (negligible)** |
| White-beaked dolphin | 5km disturbance for low-order clearance | 0.94 | 0.002% CGNS MU | **Negligible** |
| | ADD activation prior to low-order clearance | 0.07 | 0.0002% CGNS MU | **Negligible** |
| Minke whale | 5km disturbance for low-order clearance | 1.6 | 0.008% CGNS MU | **Negligible** |

| Species | Impact | Maximum number of individuals | % of reference population | Magnitude |
|---|---|---|---|---|
| | ADD activation prior to low-order clearance | 0.53 | 0.0026% CGNS MU | **Negligible** |
| Grey seal | 5km disturbance for low-order clearance | 125.0 | 1.44% SE England MU (0.52% of the wider reference population) | **Low (negligible)** |
| | ADD activation prior to low-order clearance | 9.1 | 0.11% SE England MU (0.04% of the wider reference population) | **Negligible (negligible)** |
| Harbour seal | 5km disturbance for low-order clearance | 27.8 | 0.74% SE England MU (0.09% of the wider reference population) | **Negligible (negligible)** |
| | ADD activation prior to low-order clearance | 2.0 | 0.05% SE England MU (0.007% of the wider reference population) | **Negligible (negligible)** |

106. Taking into account the precautionary medium sensitivity for all species to disturbance from low-order UXO clearance including ADD activation, the impact significance, for SEP and DEP, has been assessed as **minor adverse (not significant)** for harbour porpoise, bottlenose dolphin, white-beaked dolphin, minke whale, grey seal and harbour seal (**Table 10.4.22**).

107. The residual impact for disturbance from low-order UXO clearance including ADD activation at SEP and DEP, would be **minor adverse (not significant)** for all marine mammal species (**Table 10.4.22**).

*Table 10.4.22: Assessment of impact significance for disturbance during low-order UXO clearance, including ADD activation at SEP and DEP*

| Impact | Species | Sensitivity | Magnitude | Impact Significance | Mitigation | Residual Impact Significance |
|---|---|---|---|---|---|---|
| Disturbance during underwater low-order UXO clearance, including ADD activation at SEP and DEP | Harbour porpoise | Medium | Negligible for SEP and DEP | Minor adverse for SEP and DEP | MMMP for UXO clearance | Minor adverse |
| | Bottlenose dolphin | Medium | Negligible (low) for SEP and DEP | Minor adverse for SEP and DEP | | Minor adverse |
| | White-beaked dolphin | Medium | Negligible for SEP and DEP | Minor adverse for | | Minor adverse |

| Impact | Species | Sensitivity | Magnitude | Impact Significance | Mitigation | Residual Impact Significance |
|---|---|---|---|---|---|---|
| | | | | SEP and DEP | | |
| | Minke whale | Medium | Negligible for SEP and DEP | Minor adverse for SEP and DEP | | Minor adverse |
| | Grey seal | Medium | Negligible (low) for SEP and DEP | Minor adverse for SEP and DEP | | Minor adverse |
| | Harbour seal | Medium | Negligible for SEP and DEP | Minor adverse for SEP and DEP | | Minor adverse |

### 10.4.7 Impact 3: Changes to Prey Availability as a result of Underwater Noise from UXO Clearance Activities

#### 10.4.7.1 Sensitivity of Marine Mammals

108. As outlined in **Appendix 10.1**, 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.

109. Bottlenose dolphin and white-beaked dolphin are opportunistic feeders, feeding on wide range of prey species and have large foraging ranges (see **Appendix 10.1**) and are therefore considered to have low sensitivity to changes in prey resources.

110. 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 10.1**). Therefore, minke whale are considered to have a low to medium sensitivity to changes in prey resource.

111. 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 10.1**). Grey seal and harbour seal are therefore considered to have low sensitivity to changes in prey resources.

### 10.4.7.2 Magnitude for SEP or DEP in Isolation

#### *10.4.7.2.1 Underwater noise*

112. Potential sources of underwater noise and vibration during construction include UXO clearance, piling, increased vessel traffic, sea bed preparation, rock placement and cable installation. Of these, UXO clearance and piling are considered to produce the highest levels of underwater noise and therefore has the greatest potential to result in adverse impacts on fish.

113. High levels of underwater noise can cause physiological (mortality, permanent injury or temporary injury), behavioural (startled movements, swimming away from noise source, change migratory patterns or cease reproductive activities) and environmental (changes to prey species or feeding behaviours) impacts on fish species.

114. Underwater noise modelling (**Appendix 10.2**), 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).

115. The underwater noise modelling results (**Appendix 10.2**) indicates that fish species in which the swim bladder is involved in hearing are the most sensitive to the impact of underwater noise.

116. **Table 10.4.23** summarises the maximum impact ranges for fish species during UXO clearance. With a maximum impact range of up to 810m, this is considerably less than the 13km PTS impact range for harbour porpoise, based on the unweighted $SPL_{peak}$ criteria (**Table 10.4.10**). Therefore, there would be no additional impacts as a result of any changes in prey availability during UXO clearance than the direct impacts to marine mammals as a result of underwater noise assessed in **Sections 10.4.5** and **10.4.6**.

117. Any potential changes to prey availability as a result of UXO clearance is assessed as **negligible (not significant)** for marine mammals, as any impacts on prey would be less than the direct impacts on marine mammals.

*Table 10.4.23: 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 | 25kg + donor charge | 55kg + donor charge | 120kg + donor charge | 240kg + donor charge | 525kg + donor charge |
|---|---|---|---|---|---|---|
| 234 dB (Mortality and potential mortal injury) | <50m | 170m | 230m | 300m | 370m | 490m |
| 229 dB (Mortality and potential mortal injury) | 80m | 290m | 380m | 490m | 620m | 810m |

### 10.4.8 Assessment Summary

118. The potential impacts on marine mammals from UXO clearance at SEP or DEP in isolation are summarised in **Table 10.4.24**.

119. The potential impacts on marine mammals from UXO clearance at SEP and DEP are summarised in **Table 10.4.25**.

*Table 10.4.24: Summary of potential impacts during construction, operation, maintenance and decommissioning of SEP or DEP in isolation, including cumulative impacts on marine mammals*

| Potential impact | Receptor | Sensitivity | Magnitude | Pre-mitigation impact | Mitigation measures proposed | Residual impact |
|---|---|---|---|---|---|---|
| **Construction** | | | | | | |
| **Impact 1: Auditory Injury from Underwater Noise Associated with UXO Clearance** | | | | | | |
| PTS for UXO high-order detonation with no mitigation | Harbour porpoise and minke whale | High | Medium | Major adverse | MMMP for UXO Clearance | Minor adverse |
| | Bottlenose dolphin and harbour seal | High | Low to Medium | Major to Moderate adverse | | Minor adverse |
| | White-beaked dolphin | High | Negligible | Minor adverse | | Minor adverse |
| | Grey seal | High | Medium | Major adverse | | Minor adverse |
| TTS for UXO high-order detonation with no mitigation | Harbour porpoise | Medium | Low to Negligible | Minor adverse | MMMP for UXO Clearance | Minor adverse |
| | Bottlenose dolphin and white-beaked dolphin | Medium | Negligible | Minor adverse | | Minor adverse |
| | Minke whale | Medium | Low | Minor adverse | | Minor adverse |
| | Grey seal | Medium | Low to high | Minor to Major adverse | | Minor adverse |
| | Harbour seal | Medium | Low to medium | Minor to Moderate adverse | | Minor adverse |
| **Impact 2: Disturbance from Underwater Noise Associated with UXO Clearance** | | | | | | |
| TTS/ fleeing response | Harbour porpoise | Medium | Low to Negligible | Minor adverse | | Minor adverse |

| Potential impact | Receptor | Sensitivity | Magnitude | Pre-mitigation impact | Mitigation measures proposed | Residual impact |
|---|---|---|---|---|---|---|
| | Bottlenose dolphin and white-beaked dolphin | Medium | Negligible | Minor adverse | MMMP for UXO Clearance | Minor adverse |
| | Minke whale | Medium | Low | Minor adverse | | Minor adverse |
| | Grey seal | Medium | Low to high | Minor to Major adverse | | Minor adverse |
| | Harbour seal | Medium | Low to medium | Minor to Moderate adverse | | Minor adverse |
| Disturbance (26km EDR) | Harbour porpoise | Medium | Negligible to Low | Minor adverse | | Minor adverse |
| Low-ordnance clearance (5km) | Harbour porpoise, white-beaked dolphin, minke whale, grey seal, and harbour seal | Medium | Negligible | Minor adverse | | Minor adverse |
| | Bottlenose dolphin | Medium | Negligible to low | Minor adverse | | Minor adverse |
| ADD activation for UXO clearance | Harbour porpoise, white-beaked dolphin and minke whale | Medium | Negligible | Minor adverse | | Minor adverse |
| | Bottlenose dolphin | Medium | Negligible to medium | Minor to moderate adverse | | Minor adverse |
| | Grey seal | Medium | Low to medium | Minor to moderate adverse | | Minor adverse |
| | Harbour seal | Medium | Negligible to low | Minor adverse | | Minor adverse |

*Table 10.4.25 Summary of potential impacts during construction, operation, maintenance and decommissioning of SEP and DEP, including cumulative impacts on marine mammals*

| Potential impact | Receptor | Sensitivity | Magnitude | Pre-mitigation impact | Mitigation measures proposed | Residual impact |
|---|---|---|---|---|---|---|
| **SEP and DEP** | | | | | | |
| **Construction** | | | | | | |
| **Impact 1: Auditory Injury from Underwater Noise Associated with UXO Clearance** | | | | | | |
| PTS during underwater low-order UXO clearance at SEP and DEP | Harbour porpoise and grey seal | High | Low | Moderate adverse | MMMP for UXO Clearance | Minor adverse |
| | Bottlenose dolphin, white-beaked dolphin, and minke whale | High | Negligible | Minor adverse | | Minor adverse |
| | Harbour seal | High | Negligible to low | Minor to Moderate adverse | | Minor adverse |
| TTS during underwater low-order UXO clearance at SEP and DEP | All species | Medium | Negligible | Minor adverse | MMMP for UXO Clearance | Minor adverse |
| **Impact 2: Disturbance from Underwater Noise Associated with UXO Clearance** | | | | | | |
| Disturbance during underwater low-order UXO clearance, including ADD | Harbour porpoise white-beaked dolphin, minke whale and harbour seal | Medium | Negligible | Minor adverse | MMMP for UXO Clearance | Minor adverse |
| | Bottlenose dolphin and grey seal | Medium | Negligible to Low | Minor adverse | | Minor adverse |

| Potential impact | Receptor | Sensitivity | Magnitude | Pre-mitigation impact | Mitigation measures proposed | Residual impact |
|---|---|---|---|---|---|---|
| **SEP and DEP** | | | | | | |
| activation at SEP and DEP | | | | | | |

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