



Bellrock Offshore Wind Farm

Wind Farm Development Area

Environmental Impact Assessment Report - Volume IV

Appendix 9.3: Unexploded Ordnance Assessment

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Glossary of Terminology

Term	Definition
Applicant	Bellrock Offshore Wind Farm Limited, the legal entity submitting Section 36 Consent and Marine Licence applications for the Bellrock Wind Farm Development Area.
Bellrock Offshore Wind Farm (or the Bellrock Project)	<p>An offshore wind farm capable of exporting around 1.8 GW of renewable energy to the National Electricity Transmission System.</p> <p>The Wind Farm Development Area is located 120 km east of Stonehaven and will connect to the National Electricity Transmission System at the SSEN Transmission Hurlie substation, west of Stonehaven in Aberdeenshire. The Bellrock Offshore Wind Farm comprises of the following Development Areas:</p> <ul style="list-style-type: none"> ▪ Wind Farm Development Area; ▪ Offshore Transmission Development Area; and ▪ Onshore Transmission Development Area.
Cable protection	Protective measure to minimise the effects of scour and hazards along the inter-array cables, and protecting these cables at infrastructure crossing points.
Commencement of construction	<p>Commencement of construction to install the Wind Farm Infrastructure as authorised by the Wind Farm Development Area Section 36 Consent and Marine Licence (excluding site preparation works), being the earlier of:</p> <ul style="list-style-type: none"> ▪ Intrusive pre-installation surveys; ▪ Placement on or installation in the seabed of anchors and associated scour protection, and mooring lines; ▪ Trench excavation for inter-array cables; or ▪ Trenching for, or laying of inter-array cables on or in the seabed.
Development Area	<p>For consenting purposes, the area for which separate consents and/or Marine Licences will be sought by the Applicant, comprising:</p> <ul style="list-style-type: none"> ▪ Wind Farm Development Area; ▪ Offshore Transmission Development Area; and ▪ Onshore Transmission Development Area.
Dynamic inter-array cable	The section of inter-array cable between the floating substructure and the seabed, which is designed to accommodate the dynamic movement of the floating substructure.
Floating substructure	A floating structure which provides buoyancy and, in conjunction with the station keeping system, supports a superstructure (e.g. wind turbine generator or offshore substation), and maintaining its position within the structure's excursion limit.
Inter-array cable	Armoured cable containing electrical and fibre optic cores, which link the wind turbine generators to each other and to the subsea cable hubs and/or the offshore substations and include dynamic inter-array cable and static inter-array cable sections.

Term	Definition
National Electricity Transmission System	The high-voltage electricity power transmission network serving Great Britain which receives electricity from generators (such as offshore wind farms) and transmits that electricity to anywhere on the National Electricity Transmission System to satisfy demand.
Offshore export cable	Armoured cable containing electrical and fibre optic cores between the offshore substation(s) and the transition joint bay(s).
Offshore substation	An offshore platform which houses electrical equipment such as transformers, switchgear, and protection and control systems, enabling the wind farm's renewable electricity to be received via inter-array cables and exported via the offshore export cables.
Offshore Transmission Development Area	The boundary within which the Offshore Transmission Infrastructure will be constructed, operated and maintained, and decommissioned (and includes the whole of the Wind Farm Development Area).
Offshore Transmission Infrastructure	Infrastructure located within the Offshore Transmission Development Area including fixed bottom and/or floating offshore substations, offshore reactive compensation station(s) and associated scour protection; interconnector cables and associated cable protection; and offshore export cables and associated cable protection (including activities associated with the Offshore Transmission Infrastructure construction, operation and maintenance, and decommissioning).
Onshore Transmission Development Area	The boundary within which the Onshore Transmission Infrastructure will be constructed, operated and maintained, and decommissioned.
Scour protection	Protective material positioned around anchors to avoid sediment being eroded as a result of the flow of water.
Site preparation works	<p>Preparatory activities undertaken within the Wind Farm Development Area prior to the commencement of construction of the Wind Farm Infrastructure, which may comprise (and which may require separate consents):</p> <ul style="list-style-type: none"> ▪ Geophysical surveys, geotechnical surveys, and non-archaeological/archaeological diver/remotely operated vehicle surveys; ▪ Seabed preparation including sand wave levelling, slope levelling for gravity based anchors (if selected), boulder clearance, and pre-lay grapnel runs; ▪ Unexploded ordnance survey and/or clearance; ▪ Debris clearance; and ▪ Out of service cable/pipeline removal.
SSEN Transmission Hurlie substation	The onshore substation to be developed by SSEN Transmission, which will receive renewable electricity from the Bellrock Project onshore substation and allow supply of renewable electricity from the wind farm to the National Electricity Transmission System.
Static inter-array cable	The section of inter-array cable that is not designed to move.
Station keeping system	The system (including mooring lines and anchors) used to hold a floating offshore unit within its excursion limit and maintain the intended orientation of the floating offshore unit.

Term	Definition
Subsea cable hub	A subsea device, with a gravel pad foundation, which allows the connection of multiple inter-array cables.
Switchgear	Electrical equipment used to control, protect, and isolate electrical circuits and equipment.
Wind Farm Development Area	The boundary within which the Wind Farm Infrastructure will be constructed, operated and maintained, and decommissioned.
Wind turbine generator	A wind turbine generator converts wind energy into electrical energy. The main components include rotor assembly (composed of three blades and a hub); nacelle (containing the generator, shaft and gearbox, power electronic converter and transformer); and a tower (containing lifting equipment and switchgear).
Wind Farm Infrastructure	Infrastructure located within the Wind Farm Development Area including wind turbine generators; floating substructures, station keeping systems and associated scour protection; inter-array cables and associated cable protection; subsea cable hubs; and ancillary infrastructure including buoys (including activities associated with the Wind Farm Infrastructure construction, operation and maintenance, and decommissioning).

Glossary of Abbreviations

Term	Definition
ADD	Acoustic Deterrent Device
CGNS	Celtic and Greater North Seas
Defra	Department for Environment, Food & Rural Affairs
EIA	Environmental impact assessment
EPS	European Protected Species
GNS	Greater North Sea
HF	High Frequency
JNCC	Joint Nature and Conservation Committee
LF	Low Frequency
MD-LOT	Marine Directorate – Licencing and Operations Team
MMMP	Marine Mammal Mitigation Protocol
MMO	Marine Mammal Observer
MTD	Marine Technical Directorate Limited
MU	Management Unit
ncMPA	Nature Conservation Marine Protected Area
NEQ	Potential charge weights
NPL	National Physical Laboratory
NS	North Sea
PCW	Phocid Carnivores in Water
PTS	Permanent Threshold Shift
SAC	Special Area of Conservation
SCANS	Small Cetaceans in European Atlantic waters and the North Sea
SEL	Sound Exposure Level
SPL	Sound Pressure Level
TTS	Temporary Threshold Shift
UK	United Kingdom
VHF	Very High Frequency

Term	Definition
WFDA	Wind Farm Development Area

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1 Introduction

1. This Appendix supports **Chapter 9: Marine Mammals (Volume II)** of the Bellrock Wind Farm Development Area (WFDA) Environmental Impact Assessment (EIA) Report. It provides an indicative assessment of potential auditory injury and disturbance effects on marine mammals during unexploded ordnance clearance within the Bellrock WFDA, utilising the underwater noise modelling presented further in **Sections 6 and 8** and in **Appendix 9.2: Underwater Noise Modelling Report (Volume IV)**.
2. This assessment is indicative and provided with the EIA for information purposes only (as agreed with NatureScot during the Bellrock WFDA Scoping Workshop (October 2023), see consultation responses in Table 9.6 in **Chapter 9: Marine Mammals (Volume II)**). Unexploded ordnance clearance is not included in the Section 36 Consent and Marine Licence application for the Bellrock WFDA, as there is currently not sufficiently detailed information on unexploded ordnance presence available. A separate Marine Licence application for unexploded ordnance clearance will be submitted post-consent, once detailed information on the locations and extent of unexploded ordnance required to be cleared is known. A Marine Mammal Mitigation Protocol (MMMP) will be submitted alongside the Marine Licence application for unexploded ordnance clearance, this will be consulted on with the Marine Directorate – Licencing and Operations Team (MD-LOT) and NatureScot prior to the clearance works being undertaken. and NatureScot prior to the clearance works being undertaken.
3. A cumulative effect assessment for a range of impact pathways, including unexploded ordnance clearance at other projects, is provided in **Section 9.9.3.1.1 of Chapter 9: Marine Mammals (Volume II)**.
4. The assessment within this Appendix is in line and has been supported with information from the following relevant policies and guidance, as noted in Table 9.1 within **Chapter 9: Marine Mammals (Volume II)**:
 - Marine Environment: ‘Unexploded Ordnance Clearance Joint Position Statement’ (Department for Environment, Food & Rural Affairs (Defra) et al., 2025), which outlines the preferred approach to unexploded ordnance clearance;
 - Marine licensing – unexploded ordnance clearance: application guidance (Marine Directorate, 2025); and
 - Joint Nature and Conservation Committee (JNCC) ‘Guidelines for Minimising the Risk of Injury to Marine Mammals from unexploded ordnance Clearance in the Marine Environment’ (JNCC, 2025), which outlines measures to minimise potential injury from the unexploded ordnance clearance activities.

5. As outlined in Section 9.5.1 of **Chapter 9: Marine Mammals (Volume II)**, the key marine mammal species relevant to the marine mammals study areas, which will be assessed in the unexploded ordnance assessment are:
- Harbour porpoise *Phocoena phocoena*;
 - Bottlenose dolphin *Tursiops truncatus*;
 - Common dolphin *Delphinus delphis*;
 - White-beaked dolphin *Lagenorhynchus albirostris*;
 - Killer whale *Orcinus orca*;
 - Minke whale *Balaenoptera acutorostrata*;
 - Fin whale *Balaenoptera physalus*;
 - Humpback whale *Megaptera novaeangliae*;
 - Grey seal *Halichoerus grypus*; and
 - Harbour seal *Phoca vitulina*.
6. **Appendix 9.1: Marine Mammals Technical Report (Volume IV)** provides further information that is relevant for the assessments for each of the species, including details from the site-specific surveys, density estimates, abundance estimates, distribution, diet, and seal haul-out sites.

2 Worst-case Scenario

7. **Table 2.1** presents the realistic worst-case parameters for assessing the impacts from unexploded ordnance clearance to marine mammals.
8. While it is expected that mitigation measures, as detailed in **Section 3** will be applied, the initial assessment in this Appendix considers all impacts without noise mitigation. A summary of the assessment with consideration of mitigation measures is subsequently provided.

Table 2.1: Realistic Worst-case Parameters for Marine Mammals Unexploded Ordnance Assessment (Indicative)

Parameters	Notes and Rationale
Types and sizes of unexploded ordnance: various possible types and sizes of unexploded ordnance, ranging from 0.25 kg to 750 kg.	Indicative only. A detailed unexploded ordnance survey would be completed prior to the commencement of construction. The exact type, size and number of possible detonations and duration of unexploded ordnance clearance operations is therefore not known at this stage. Therefore, Table 6.1 provides an example of unexploded ordnance types and sizes in line with guidance and unexploded ordnances identified for other projects that have been considered in this Appendix.
Number of unexploded ordnance requiring clearance: currently unknown.	
Clearance techniques: low-order clearance is considered to be the default method for unexploded ordnance that require clearance. As a worst-case, assessments are based on high-order clearance without noise mitigation.	Both low-order clearance and higher-order clearance are assessed, in line with guidance received from NatureScot ¹ in May 2025. High-order clearance would only be undertaken in the event that low-order clearance is not possible or failed to clear the device completely. A high-order clearance (without noise mitigation) is unlikely to be required, however, it is assessed as the worst-case.

¹ Email from NatureScot to the Applicant on the 2 May 2025. Please refer to **Chapter 9: Marine Mammals (Volume II)** for full details on consultation undertaken.

3 Mitigation Measures

9. The Applicant has committed to the mitigation measures for any unexploded ordnance clearance, as outlined below in **Table 3.1**. Current guidance from the JNCC ‘Guidelines for Minimising the Risk of Injury to Marine Mammals from unexploded ordnance Clearance’ (JNCC, 2025) or any subsequent guidance will inform the use of mitigation measures at the time of the Marine Licence application for unexploded ordnance clearance.

Table 3.1: Unexploded Ordnance Clearance Mitigation Measures

Parameters	Mitigation Measures
MMMP for unexploded ordnance clearance	<p>A detailed MMMP will be prepared for unexploded ordnance clearance to accompany the Marine Licence application for unexploded ordnance clearance. The MMMP for unexploded ordnance clearance will ensure that there are adequate mitigation measures to minimise the risk of any physical or permanent auditory injury to marine mammals as a result of unexploded ordnance clearance. It will be based upon best available information and methodologies at that time. The MMMP for unexploded ordnance clearance will be prepared in consultation with the MD-LOT and NatureScot.</p> <p>Mitigation measures in line with policy and guidance noted in Table 9.16 within Chapter 9: Marine Mammals (Volume II) could include:</p> <ul style="list-style-type: none"> ▪ Low-order clearance techniques, such as deflagration as the default method for clearance; ▪ All unexploded ordnance clearance to take place in daylight and, when possible, in favourable conditions with good visibility; ▪ Establishment of a monitoring area with minimum of 1 km radius; ▪ The observation of the monitoring area would be by dedicated and trained marine mammal observers (MMOs) during daylight hours and suitable visibility; ▪ The observation of the monitoring area using Passive Acoustic Monitoring as an additional monitoring tool; ▪ The activation of Acoustic Deterrent Devices (ADDs); ▪ The controlled clearances of the unexploded ordnance would be undertaken by specialist contractors, using the minimum amount of explosive required in order to achieve safe disposal of the unexploded ordnance; and ▪ Other unexploded ordnance clearance techniques, such as avoidance of unexploded ordnance, or relocation of unexploded ordnance. <p>The MMMP will assess the suitability and effectiveness of mitigation measures proposed.</p>

4 Unexploded Ordnance Clearance Techniques

10. All assessments have been based on the indicative worst-case scenario (**Section 2**) and maximum predicted impact ranges for impulsive thresholds.
11. High-order clearance is where the clearance involves detonating large explosive donor charges next to the unexploded ordnance, causing any live explosive material in the unexploded ordnance to detonate along with it. Low-order clearance techniques, where the ordnance is disposed of or rendered safe without a high-order clearance is the preferred option for unexploded ordnance clearance (Defra et al. 2025). Examples of low-order clearance techniques include (National Physical Laboratory (NPL), 2020a):
 - Freezing the munition to render it inactive;
 - Water abrasive suspension cutting in order to physically disrupt the munition;
 - Disposal in a Static Detonation Chamber;
 - Photolytic destruction of the munition; and
 - Low-order deflagration.
12. Deflagration is a technique whereby the explosive within the unexploded ordnance is rapidly burned at subsonic speeds using plasma from a small-shaped charge that generates insufficient shock to detonate the unexploded ordnance (Merchant and Robinson 2019); (NPL, 2020a). The explosive material inside the unexploded ordnance reacts with a rapid burning rather than a chain reaction that would lead to a full explosion (NPL, 2020a).
13. Substantial noise reduction for deflagration over high-order (Sound Pressure Level (SPL_{peak}) and Sound Exposure Level (SEL) are more than 20dB lower) and acoustic output for deflagration depends only on the size of the shaped charge (rather than the size of the unexploded ordnance) (NPL, 2020b; Robinson et al., 2020).
14. Low-order clearance techniques, such as deflagration, are relatively new to civilian applications but have been used by the United Kingdom (UK) military since 2005 (Merchant and Robinson, 2019). Recent evidence of a successful campaign applying low-order techniques was seen with the Moray West offshore wind farm, where 82 unexploded ordnances were able to be cleared using the technique (Ocean Winds et al., 2024).
15. When applying for Marine Licences, the Joint Position Statement (Defra et al. 2025) sets out that low noise methods should be the default method of clearance. There may be extraordinary circumstances which mean low noise clearance cannot be undertaken, and high order clearance is the only viable option. Such circumstances might include those where the factors of the unexploded ordnance or of its location (such as depth, level of degradation or shell thickness) far

exceed the expected or demonstrated capabilities of any known low noise clearance techniques such that any attempt to use low noise techniques would not be feasible.

16. Therefore, as a worst-case, high-order clearances without noise mitigation have been considered, alongside low-order clearance.

5 Potential Effects

17. Unexploded ordnance surveys, undertaken prior to the commencement of construction, will identify whether there is unexploded ordnance present within the Bellrock WFDA which require clearance. While any identified unexploded ordnance would either be avoided or removed and disposed of onshore in a designated place, if safe to do so, there is the potential that underwater clearance could be required where it is necessary and unsafe to relocate/remove the unexploded ordnance.
18. The potential effects of underwater unexploded ordnance detonations on marine mammals include:
 - Physical injury from the direct or indirect blast wave effect of the high amplitude shock waves and sound wave produced by underwater detonation, which could result in immediate or eventual mortality;
 - Auditory impairment (from exposure to the sound wave), resulting in a temporary or permanent loss in hearing sensitivity such as Temporary Threshold Shift (TTS) or Permanent Threshold Shift (PTS);
 - Behavioural change, such as disturbance to feeding, mating, breeding, and resting (Richardson et al., 1995; Ketten 2004; von Benda-Beckmann et al., 2015); and
 - Indirect impacts to prey availability, such as disturbance to prey species such as fish.
19. The severity of the consequences of unexploded ordnance clearance on marine mammals would depend on many variables, but principally, on the charge weight and its proximity to the receptor. After clearance, the shock wave would expand spherically outwards and would travel in a straight line (i.e. line of sight), unless the wave is refracted through stratified layers, reflected, channelled or meets an intervening obstruction.
20. There are limited acoustic measurements for underwater clearances, and there can be large differences in the noise levels, depending on the charge size, as well as water depth, bathymetry, and seabed sediments at the site of the clearances, which can also influence noise propagation. The water depth in which the clearance occurs has a significant influence on the impact range for a given charge mass, for instance at deeper depths, noise propagates further on average (von Benda-Beckmann et al., 2015).
21. It is important to note that underwater noise modelling for assessments are based on the worst-case for high-order unexploded ordnance clearance without noise mitigation, which is highly unlikely, as low-order clearance would be the default clearance method and first option for any unexploded ordnance requiring clearance (i.e. those which cannot be avoided, relocated or removed in line with guidance set out in JNCC (2025)).

6 Underwater Noise Modelling

22. A number of unexploded ordnances with a range of charge weights (or quantity of contained explosive) could be located within the Bellrock WFDA. There is the potential for there to be a variety of explosive types, which would have been subject to degradation and burying over time. Two otherwise identical explosive devices are therefore likely to produce different blasts if one has been subject to different environmental factors.
23. A preliminary unexploded ordnance Threat and Risk Assessment Report (6 Alpha Associates, 2023) identified the types of unexploded ordnance devices (and sizes) that could potentially be present within the Bellrock WFDA (**Table 6.1**). The analysis showed that it is unlikely that a significant unexploded ordnance contamination threat is present within the boundaries of the Bellrock WFDA.

Table 6.1: Unexploded Ordnance Identified as Potentially Present in the Bellrock Wind Farm Development Area

Unexploded ordnance Devices Potentially Present	Estimated Ferrous Mass (kg)	Potential Charge Weights (NEQ) (kg)
53.3 cm G7e Torpedo	1,323	364
	1,248	364
50 cm G7 Torpedo	254	254
8.8 cm Naval Projectile	1.42	1.42
Notes: Source: 6 Alpha Associates (2023).		

24. A selection of explosive sizes has been considered in the estimation of the underwater noise levels produced by detonation of unexploded ordnance (see **Appendix 9.2: Underwater Noise Modelling Report (Volume IV)** for full details on noise modelling for unexploded ordnance clearance). These were chosen to provide an indicative spread of unexploded ordnance devices that have been identified at similar sites near to the Bellrock WFDA (**Table 6.2**). The unexploded ordnance identified in **Table 6.1** fall within the range of explosive sizes provided in **Table 6.2**.
25. The maximum equivalent charge weight for the potential unexploded ordnance devices that could be present within the Bellrock WFDA has been estimated as 750 kg. This has been modelled alongside a range of smaller devices, at charge weights of 25, 55, 120, 240, 525 and 698 kg (all based on previous projects and expert experience). The assessment provided in **Section 9** assumes the maximum explosive charge.
26. In addition, low-order clearance (such as deflagration) has been assessed. An additional donor weight of 0.25 kg has been included to initiate detonation. Estimation of the source noise level for each charge weight has been carried out in accordance with the methodology of Soloway and Dahl

(2014), which follows Arons (1954) and the Marine Technical Directorate Limited (MTD) (1996) (see **Appendix 9.2: Underwater Noise Modelling Report (Volume IV)**).

27. **Table 6.2** provides the source level used for the underwater noise modelling (further details on how these were calculated is provided in **Appendix 9.2: Underwater Noise Modelling Report (Volume IV)**).

Table 6.2: Summary of Source Levels Used for Unexploded Ordnance Clearance Modelling

Charge Weight	SPL _{peak} Source Level (dB re 1 µPa @ 1m)	SEL _{ss} Source Level (dB re 1 µPa ² s @ 1m)
Low-order (0.25 kg)	269.8	215.2
25 kg + donor charge	284.9	228.0
55 kg + donor charge	287.5	230.1
120 kg + donor charge	290.0	232.3
240 kg + donor charge	292.3	234.2
525 kg + donor charge	294.8	236.4
698 kg + donor charge	295.7	237.1
750 kg + donor charge	296.0	237.3

28. The noise produced by the detonation of explosives is influenced by a number of different factors (e.g. its design, composition, age, position, orientation, degree of degradation or damage, fragmentation, and whether it is covered by sediment) which are unknown and cannot be directly considered in an assessment. This produces a high degree of uncertainty in the estimation of the source noise level (i.e. the noise level at the position of the unexploded ordnance). A worst-case estimation has therefore been used for calculations, assuming that the unexploded ordnance to be detonated is not buried, degraded or subject to any other significant attenuation. Confirmed unexploded ordnance often have degraded shell casings, with potential loss to sea over time of some of the explosive material within. Consequently, the noise levels produced (**Table 6.2**), particularly by the larger explosives under consideration, are likely to be an over-estimation.
29. It should be noted that the assessment also does not take into account the variation in the noise level at different depths, or stratification layers. Sound propagation from any detonation is likely to be quieter in water close to the surface compared to deeper areas. Therefore, the risk to animals near the surface may be lower than indicated by the predicted impact ranges from the underwater noise modelling and hence could be considered conservative in respect of impact at different depths.
30. The potential effect has been assessed based on the latest Southall et al. (2019) thresholds and criteria for species of marine mammals that have been identified as potentially present in the Bellrock WFDA (refer to **Appendix 9.1: Marine Mammals Technical Report (Volume IV)**). 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 has been assumed as a worst-case scenario).

31. The SEL criteria are weighted, which considers the sound level based on the sensitivity of each receptor, for example, harbour porpoise are less sensitive to low frequency sound than minke whales. Southall et al. (2019) also includes criteria based on SPL_{peak} which are unweighted and do not take species hearing sensitivity into account.
32. Both SPL_{peak} and SEL values based on the impulsive and non-impulsive criteria have been included in the assessment. However, it is important to note that they are different criteria and as such they should not be compared directly. All decibel SPL values are referenced to $1 \mu Pa$ and all SEL values are referenced to $1 \mu Pa^2s$.
33. Peak noise levels have been found to be difficult to predict accurately in a shallow water environment (von Benda Beckmann et al., 2015) and tend to be significantly over-estimated over increased distances from the source. It is worth noting that an article by Southall (2021) discusses this aspect in detail, and notes that as the impulsive sound propagates through the water, the level of impulsiveness (kurtosis), is greatly reduced and at a distance this sound source will become a non-impulsive sound which is considered to be less of an impact to marine mammals. Therefore, it should be recognised that the use of impulsive exposure criteria for receivers at greater ranges (tens of kilometres) is almost certainly an overly precautionary interpretation of existing criteria.
34. Unfortunately, it is extremely difficult to determine the distance at which the kurtosis level reduces making the sound more like a non-impulsive noise. Therefore, the underwater noise modelling for the Bellrock WFDA has been 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 9.2: Underwater Noise Modelling Report (Volume IV)**).

7 Impact Assessment Methodology

35. This section details the unexploded ordnance assessment methodology for the indicative assessment of likely significant effects.

7.1 Magnitude

36. The assessment in **Section 9** is undertaken in line with the methodology as set out in **Chapter 9: Marine Mammals (Volume II)**, including the definition of impact magnitude levels which are given in **Table 7.1**.

Table 7.1: Definition of Magnitude of Impacts

Severity	Definition	Approximate Duration of Impact	% of Reference Population Exposed to the Impact
High	A change in the behaviour or size and extent of distribution of the relevant biogeographic population or the population that is the interest feature of a specific protected site that is predicted to irreversibly alter the population in the short-to-long term and to alter the long-term viability of the population and/or the integrity of the protected site. The effect, which may be either reversible or irreversible in individuals, would be of sufficient severity to affect the long-term viability of the relevant population over a generational scale.	Permanent	>1%
		Temporary	>10%
Medium	A change in the behaviour or size and extent of distribution of the relevant biogeographic population or the population that is the interest feature of a specific protected site that occurs in the short and long-term, but which is not predicted to alter the long-term viability of the population and/or the integrity of the protected site. The effect, which may be either reversible or irreversible in individuals, could result in some population-level effects, but not a level that would alter the relevant population trajectory over a generational scale.	Permanent	0.1% - 1%
		Temporary	5% - 10%
Low	A change in the behaviour or size and extent of distribution of the relevant biogeographic population or the population that is the interest feature of a specific protected site that is sufficiently small-scale or of short duration to cause no long-term harm to the feature/population. Whilst there may be effects at an individual level which may be either reversible or irreversible, these would not be at a scale that would lead to any population-level effects.	Permanent	0.001% - 0.1%
		Temporary	1% - 5%

Severity	Definition	Approximate Duration of Impact	% of Reference Population Exposed to the Impact
Negligible	Very slight change from the behaviour or size and extent of distribution of the relevant biogeographic population or the population that is the interest feature of a specific protected site. Effects are likely to be reversible and highly unlikely to result in any population-level effects.	Permanent	<0.001%
		Temporary	<1%
No change	No loss of, or gain in, size or extent of distribution of the relevant biogeographic population or the population that is the interest features of a specific protected site.	N/A	N/A

7.2 Sensitivity and Value

37. The assessment in **Section 9** is undertaken in line with the methodology as set out in **Chapter 9: Marine Mammals (Volume II)**, including the definition of sensitivity levels which are given in **Table 9.12**.

Table 7.2: Definition of Sensitivity Levels

Sensitivity	Definition
High	Individual receptor has very limited or no capacity to avoid, adapt to, accommodate or recover from the anticipated impact.
Medium	Individual receptor has limited capacity to avoid, adapt to, accommodate or recover from the anticipated impact.
Low	Individual receptor has some tolerance to accommodate, adapt to or recover from the anticipated impact.
Negligible	Individual receptor is generally tolerant to and can accommodate or recover from the anticipated impact.

38. In this assessment, sensitivity rating considers both the potential impact range and the species.
39. All species of marine mammal are considered to have **high** sensitivity to unexploded ordnance detonations if they were to be within the potential impact ranges for physical injury or PTS. Marine mammals within the potential impact area (PTS or injury) (see **Table 8.1**) are considered to have very limited capacity to avoid such effects, and unable to recover from physical injury or auditory injury.
40. Beyond the potential impact range for PTS but within the potential TTS and flee response/likely disturbance range (see **Table 8.1**), the sensitivity of marine mammals to underwater unexploded

ordnance detonations is considered to be **low** for dolphins and seals, but **medium** for harbour porpoise and baleen whales. Marine mammals within the potential impact area for TTS/disturbance are considered to have limited capacity to avoid such effects, although any impacts on marine mammals from TTS and disturbance would be temporary and they would be expected to return to the area once the activity had ceased.

41. 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.
42. The ‘value’ of the receptor forms an important element within the assessment, for instance, if the receptor is a protected species or habitat it is considered to be of higher value than a habitat or species that is not protected. It is important to understand that high value and high sensitivity are not necessarily linked within a particular effect. 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 qualitatively on a receptor-by-receptor basis.
43. Most species of marine mammals are protected by a number of international legislations, as well as European and 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 (Special Area of Conservation (SAC)). Minke whale are also afforded international protection through the designation of protected sites such as the Southern Trench Nature Conservation Marine Protected Area (ncMPA). As such, all species of marine mammal are considered to be of **high** value.

7.3 Effect Significance

44. The potential significance of effect for a given impact, is a function of the overall sensitivity and the magnitude of the impact (see **Chapter 5: EIA Methodology** for further details). A matrix is used (**Table 7.3**) as a framework to determine the significance of an effect. Definitions of each level of significance are provided in **Table 7.4**. Impacts and effects may be either positive (beneficial) or negative (adverse). Effects that are major or moderate adverse are considered to be significant in EIA terms.

Table 7.3: Matrix for Evaluating the Significance of an Effect

Sensitivity	Magnitude				
	High	Medium	Low	Negligible	No Change
High	Major	Major	Moderate	Minor	No effect
Medium	Major	Moderate	Minor	Negligible	No effect
Low	Moderate	Minor	Minor	Negligible	No effect
Negligible	Minor	Negligible	Negligible	Negligible	No effect

Table 7.4: Definitions of Effect Significance

Effect Significance	Definition
Major	Very large or large change in receptor condition, which are likely to be important considerations at a regional or district level because it 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 Effect	No change in receptor condition; therefore, no effect.

8 Results of Underwater Noise Modelling

45. The results of the underwater noise modelling (**Appendix 9.2: Underwater Noise Modelling Report (Volume IV)**) for a range of NEQ are presented in **Table 8.1** for PTS. The potential impact ranges have been modelled based on the latest Southall et al., (2019) thresholds and criteria. The impact ranges (and areas, based on the area of a circle) without noise mitigation are used to inform the indicative assessment.

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Table 8.1: Potential Maximum Impact Ranges (and Areas) of Permanent Threshold Shift for Marine Mammals During Unexploded Ordnance Clearance

Potential Maximum Charge Weight (NEQ)	Maximum Predicted Impact Range (and Area) Without Noise Mitigation		
	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 µPa ² s	173 dB re 1 µPa ² s
0.25 kg (low-order clearance)	990 m (3.08 km²)	80 m (0.002 km ²)	N/A
25 kg+ donor charge	4.6 km (66.5 km ²)	570 m (1.02 km ²)	N/A
55 kg + donor charge	6.0 km (113.1 km ²)	740 m (1.72 km ²)	N/A
120 kg + donor charge	7.8 km (191.1 km ²)	950 m (2.84 km ²)	70 m (0.02 km ²)
240 kg + donor charge	9.8 km (301.7 km ²)	1.1 km (3.8 km ²)	100 m (0.03 km ²)
525 kg + donor charge	12 km (452.4 km ²)	1.4 km (6.2 km ²)	130 m (0.05 km ²)
698 kg + donor charge	13 km (530.9 km ²)	1.5 km (7.1 km ²)	150 m (0.07 km ²)
750 kg + donor charge	14 km (615.8 km²)	1.5 km (7.1 km ²)	160 m (0.08 km ²)
Dolphins - Bottlenose dolphin, common dolphin, white-beaked dolphin, and killer whale (High Frequency (HF) cetaceans)			
-	230 dB re 1 µPa	185 dB re 1 µPa ² s	198 dB re 1 µPa ² s
0.25 kg (low-order clearance)	60 m (0.01 km²)	N/A	N/A
25 kg+ donor charge	260 m (0.2 km ²)	N/A	N/A
55 kg + donor charge	340 m (0.4 km ²)	N/A	N/A

Potential Maximum Charge Weight (NEQ)	Maximum Predicted Impact Range (and Area) Without Noise Mitigation		
	PTS SPL _{peak} Unweighted (Impulsive Criteria)	PTS SEL Weighted (Impulsive Criteria)	PTS SEL Weighted (Non-impulsive Criteria)
120 kg + donor charge	450 m (0.64 km ²)	N/A	N/A
240 kg + donor charge	560 m (1 km ²)	N/A	N/A
525 kg + donor charge	730 m (1.7 km ²)	50 m (0.01 km ²)	N/A
698 kg + donor charge	810 m (2.1 km ²)	60 m (0.01 km ²)	N/A
750 kg + donor charge	830 m (2.2 km²)	60 m (0.01 km ²)	N/A
Baleen whales - Minke whale, fin whale, humpback whale (Low Frequency (LF) cetacean)			
-	219 dB re 1 µPa	183 dB re 1 µPa2s	199 dB re 1 µPa2s
0.25 kg (low-order clearance)	170 m (0.09 km ²)	230 m (0.2 km²)	N/A
25 kg+ donor charge	820 m (2.1 km ²)	2.2 km (15.2 km ²)	130 m (0.05 km ²)
55 kg + donor charge	1.0 km (3.1 km ²)	3.2 km (32.17 km ²)	190 m (0.11 km ²)
120 kg + donor charge	1.3 km (5.3 km ²)	4.7 km (69.4 km ²)	280 m (0.3 km ²)
240 kg + donor charge	1.7 km (9.1 km ²)	6.5 km (132.7 km ²)	390 m (0.5 km ²)
525 kg + donor charge	2.2 km (15.2 km ²)	9.5 km (283.5 km ²)	570 m (1.02 km ²)
698 kg + donor charge	2.4 km (18.1 km ²)	10 km (314.2 km ²)	660 m (1.4 km ²)
750 kg + donor charge	2.5 km (19.6 km ²)	11 km (380.1 km²)	680 m (1.5 km ²)

Potential Maximum Charge Weight (NEQ)	Maximum Predicted Impact Range (and Area) Without Noise Mitigation		
	PTS SPL _{peak} Unweighted (Impulsive Criteria)	PTS SEL Weighted (Impulsive Criteria)	PTS SEL Weighted (Non-impulsive Criteria)
Seals - Grey seal and harbour seal (Phocid Carnivores in Water (PCW))			
-	218 dB re 1 µPa	185 dB re 1 µPa²s	201 dB re 1 µPa²s
0.25 kg (low-order clearance)	190 m (0.11 km²)	N/A	N/A
25 kg+ donor charge	910 m (2.6 km ²)	390 m (0.5 km ²)	N/A
55 kg + donor charge	1.1 km (3.8 km ²)	570 m (1.02 km ²)	N/A
120 kg + donor charge	1.5 km (7.1 km ²)	830 m (2.2 km ²)	N/A
240 kg + donor charge	1.9 km (11.3 km ²)	1.1 km (3.8 km ²)	70 m (0.02 km ²)
525 kg + donor charge	2.5 km (19.6 km ²)	1.6 km (8.0 km ²)	100 m (0.03 km ²)
698 kg + donor charge	2.7 km (22.9 km ²)	1.9 km (11.4 km ²)	110 m (0.04 km ²)
750 kg + donor charge	2.8 km (24.6 km²)	2.0 km (12.6 km ²)	120 m (0.05 km ²)
<p>Notes:</p> <p>Maximum potential impact range and area for each species used in assessments are shown in red and bold text.</p> <p>N/A are ranges <50 metres.</p>			

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9 Assessment of Effects

46. The assessment is carried out using the worst-case density and reference populations for harbour porpoise, bottlenose dolphin, common dolphin, white-beaked dolphin, minke whale, fin whale, grey seal, and harbour seal as given in **Table 9.1** (see also **Appendix 9.1: Marine Mammals Technical Report (Volume IV)**).
47. Killer whale and humpback whale are assessed qualitatively based on other species from the same hearing group (as per Southall et al., 2019; see **Table 8.1**).

Table 9.1: Worst-case Density Estimates Used for Unexploded Ordnance Assessments

Species	Density (Animals/km ²)	Source	Reference Populations
Harbour porpoise (VHF)	1.273	Site-specific survey (HiDef aerial survey)	346,601 North Sea (NS) Management Unit (MU)
Bottlenose dolphin (HF)	0.0298	Small Cetaceans in European Atlantic waters and the North Sea (SCANS)-III; block R (Hammond et al., 2021)	2,022 Greater North Sea (GNS) MU
Common dolphin (HF)	0.026	Waggitt et al., 2019 over SCANS-IV; block NS-D	102,656 Celtic and Greater North Seas (CGNS) MU
White-beaked dolphin (HF)	0.243	SCANS-III; block R (Hammond et al., 2021)	43,951 CGNS MU
Killer whale (HF)	-	-	-
Minke whale (LF)	0.0419	SCANS-IV; block NS-D	20,118 CGNS MU
Fin whale (LF)	0.00009	SCANS-IV; block NS-D	24,932 Combined Regions
Humpback whale LF)	-	-	-
Grey seal (PCW)	0.02	Carter et al., 2025	33,336 (Combined MU)
Harbour seal (PCW)	0.00000002	Carter et al., 2022	383 (East Scotland)

49. Throughout the assessment, marine mammals are broken down into defining groups where there is a unique characteristic within that group and they are known to react the same way to a specific stressor. The defining groups are as follows:
- Baleen whales (also known as mysticetes or just whales):
 - Minke whale, fin whale and humpback whale.
 - Toothed whales (also known as odontocetes), which can be broken down into:
 - Harbour porpoise; and
 - Dolphins which consist of bottlenose dolphin, common dolphin, white-beaked dolphin and killer whale.
 - Phocids and pinnipeds:
 - Grey seals and harbour seals.
50. Given the lack of population data in the area for fin whale, humpback whale and killer whale, a proxy species or subset of species has been used to allow for a qualitative assessment of these species. For fin whale and humpback whale this is baleen whale species and for killer whale this is toothed whales, and more specifically, dolphins.

9.1 Impact 1: Permanent Auditory Injury from Underwater Noise Associated with Unexploded Ordnance Clearance

9.1.1 Magnitude

51. The number of marine mammal receptors that could potentially be impacted by a high-order unexploded ordnance clearance without noise mitigation and low-order clearance have been estimated for the Bellrock WFDA in **Table 9.2**.
52. The assessment is based on the maximum potential PTS impact ranges set out in **Table 8.1**.
53. For a high-order clearance (without noise mitigation) of the worst-case maximum potential unexploded ordnance (NEQ of 750 kg plus donor charge), the sensitivity for all marine mammals is assessed as high (see **Section 7.2**) and the magnitude for PTS is assessed (in **Table 9.2**) to be:
- **Medium** for harbour porpoise; and
 - **Negligible** for dolphins, baleen whales and seals.
54. For low-order clearance (NEQ of 0.25 kg) the magnitude for PTS is assessed (in **Table 9.2**) to be:
- **Negligible** for all marine mammal species.

Table 9.2: Maximum Number of Marine Mammals Potentially at Risk of Permanent Threshold Shift During High and Low-order Unexploded Ordnance Clearance Without Noise Mitigation

Species	Criteria	Maximum Impact Range (and Area)	Maximum Number of Individuals	% of Reference Population	Magnitude (Permanent Impact)
Harbour porpoise	PTS SPL _{peak} Unweighted (impulsive criteria)	High-order clearance (750 kg + donor) 14 km (615.8 km²)	784	0.23% of NS MU	Medium
		Low-order clearance (0.25 kg NEQ) 990 m (3.08 km²)	4	0.001% of NS MU	Negligible
Bottlenose dolphin	PTS SPL _{peak} Unweighted (impulsive criteria)	High-order clearance (750 kg + donor) 830 m (2.2 km²)	0.06	0.003% of GNS MU	Negligible
		Low-order clearance (0.25 kg NEQ) 60 m (0.01 km²)	0.0003	<0.0001% of GNS MU	Negligible
Common dolphin	PTS SPL _{peak} Unweighted (impulsive criteria)	High-order clearance (750 kg + donor) 830 m (2.2 km²)	0.06	<0.0001% of CGNS MU	Negligible
		Low-order clearance (0.25 kg NEQ) 60 m (0.01 km²)	0.0003	<0.0001% of CGNS MU	Negligible
White-beaked dolphin	PTS SPL _{peak} Unweighted (impulsive criteria)	High-order clearance (750 kg + donor) 830 m (2.2 km²)	0.6	<0.0001% of CGNS MU	Negligible
		Low-order clearance (0.25 kg NEQ) 60 m (0.01 km²)	0.003	<0.0001% of CGNS MU	Negligible

Species	Criteria	Maximum Impact Range (and Area)	Maximum Number of Individuals	% of Reference Population	Magnitude (Permanent Impact)
Minke whale	PTS SEL _{cum} Weighted (impulsive criteria)	High-order clearance (750 kg + donor) 11 km (380.1 km²)	16	0.08% of CGNS MU	Negligible
		Low-order clearance (0.25 kg NEQ) 230 m (0.2 km²)	0.007	<0.0001% of CGNS MU	Negligible
Grey seal	PTS SPL _{peak} Unweighted (impulsive criteria)	High-order clearance (750 kg + donor) 2.8 km (24.6 km²)	0.5	0.001% of Combined MUs	Negligible
		Low-order clearance (0.25 kg NEQ) 190 m (0.11 km²)	0.002	<0.0001% of Combined MUs	Negligible
Harbour seal	PTS SPL _{peak} Unweighted (impulsive criteria)	High-order clearance (750 kg + donor) 2.8 km (24.6 km²)	0.0000005	<0.0001% of East Scotland MU	Negligible
		Low-order clearance (0.25 kg NEQ) 190 m (0.11 km²)	0.000000002	<0.0001% of East Scotland MU	Negligible

9.1.2 Effect Significance

55. Taking into account the high sensitivity for all species to PTS from unexploded ordnance clearance and the magnitude of each species as noted in **Table 9.2**, the effect significance (**Table 7.3**), for a high-order clearance without noise mitigation, has been assessed as:
- **Major adverse** (significant in EIA terms) for harbour porpoise; and
 - **Minor adverse** (not significant in EIA terms) for all other marine mammal receptors.
56. For low-order clearance without noise mitigation, based on a high sensitivity for all marine mammals to PTS, the effect significance has been assessed as:
- **Minor adverse** (not significant in EIA terms) for all marine mammal receptors.
57. A summary of the effect significance PTS from unexploded ordnance clearance is provided in **Table 10.1**.

9.1.3 Mitigation

58. The assessment above is undertaken without consideration of mitigation, in line with guidance received from NatureScot¹.
59. As outlined in **Section 3**, a MMMP for unexploded ordnance clearance will be produced post-consent in consultation with MD-LOT and NatureScot and will be based on the latest scientific understanding and guidance, results of pre-construction unexploded ordnance surveys in the Bellrock WFDA, as well as detailed project design.
60. For high-order clearance without noise mitigation (for a worst-case 750 kg + donor charge weight), an ADD would need to be activated for approximately 167 minutes, based on the variable estimated swimming speeds. However, a maximum of up to 80 minutes of ADD use would be applied. This is less than the highest PTS impact range of 14 km for harbour porpoise (see **Section 9.2.2** further detail on ADD use durations).
61. For the default method of low-order clearance, ADD use would only be required for up to 12 minutes. The ADD activation time is calculated based on the highest PTS impact range of 1 km and swim speed (see **Table 9.5**) for harbour porpoise and would cover the highest PTS impact range for all dolphins, baleen whales, and grey seal and harbour seal.
62. If not possible to wholly mitigate the potential for auditory injury, a marine wildlife EPS licence for injury would be applied for in relation to all EPS at risk, at the time of the Marine Licence application. An updated assessment will be undertaken for the Marine Licence application based on the actual type, weight, and number of unexploded ordnance identified for clearance.

9.1.4 Residual Effect Significance

63. If the mitigation measures (**Section 3**) are put in place, then the residual effect significance would be **minor adverse** (not significant in EIA terms) for the potential for PTS in all marine mammal species for both high-order and low-order clearance. Mitigation measures will be confirmed in the MMMP which will be submitted alongside the separate Marine Licence application for unexploded ordnance clearance post-consent, once detailed information on the locations and extent of unexploded ordnance required to be cleared is known.

9.2 Impact 2: Temporary Threshold Shift Disturbance from Underwater Noise Associated with Unexploded Ordnance Clearance

64. There are currently no agreed thresholds or criteria for the behavioural response and disturbance of marine mammals, therefore it is not possible to conduct underwater noise modelling to predict potential impact ranges.
65. For marine mammals, a fleeing response is assumed to occur at the same noise levels as TTS for a high-order unexploded ordnance clearance without noise mitigation. As outlined in Southall et al., (2007), the onset of behavioural disturbance is proposed to occur at the lowest level of noise exposure that has a measurable transient effect on hearing (i.e. TTS). Although, as Southall et al., (2007) recognised that this is not a behavioural effect per se, sound exposures to lower noise levels from a single pulse are not expected to cause disturbance. However, any compromise, even temporarily, to hearing functions could have the potential to affect behaviour.
66. The use of the TTS threshold is appropriate for unexploded ordnance disturbance because the noise from the unexploded ordnance clearance is only fleetingly in the environment. Therefore, the assumption is that, although noise levels lower than the TTS threshold may startle the individual, this will have 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).
67. 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.
68. The potential disturbance impact area during a unexploded ordnance clearance event was determined using the modelled worst-case impact ranges for TTS/fleeing response (see **Table 9.3**) (extracted from Tables 5.8, 5.9, and 5.10 in **Appendix 9.2: Underwater Noise Modelling Report (Volume IV)**).

Table 9.3: Worst-Case Temporary Threshold Shift Ranges for Each Marine Mammal Group for High-order Clearance and Low-order Clearance Without Noise Mitigation

Species	Group	Criteria	Maximum Impact Range (and Area) High-order 750 kg + Donor Charge	Maximum Impact Range (and Area) Low-order (0.25 kg)
Harbour porpoise	VHF	TTS SPL _{peak} Unweighted (impulsive criteria)	26 km (2,124 km ²)	1.8 km (10.2 km ²)
Bottlenose dolphin, common dolphin, white-beaked dolphin, and killer whale	HF	TTS SPL _{peak} Unweighted (impulsive criteria)	1.5 km (7.1 km ²)	100 m (0.03 km ²)
Minke whale, fin whale, humpback whale	LF	TTS SEL _{cum} Unweighted (impulsive criteria)	110 km (38,013 km ²)	3.2 km (32.2 km ²)
Grey seal and harbour seal	PCW	TTS SEL _{cum} Unweighted (impulsive criteria)	22 km (1,521 km ²)	570 m (1.0 km ²)

69. The assessments for TTS/fleeing response have therefore been used for assessing the potential disturbance ranges for unexploded ordnance high-order clearance without noise mitigation for those species where no further information is currently available. Therefore, the potential ranges and areas for TTS presented in **Table 9.3**, with the estimated number and percentage of reference populations (see **Table 9.1**) that could be affected provides an indication of possible fleeing response.

9.2.1 Magnitude – Unexploded Ordnance Clearance

70. The number of marine mammal receptors that could potentially be impacted by a high-order unexploded ordnance clearance and low-order clearance without noise mitigation have been estimated for the Bellrock WFDA in **Table 9.4**.

71. The assessment is based on the maximum potential TTS impact ranges set out in **Table 9.3**.

72. For a high-order clearance without noise mitigation of the worst-case maximum potential unexploded ordnance (NEQ of 750 kg plus donor charge), the sensitivity for all marine mammals is assessed as high (see **Section 7.2**), the magnitude for disturbance is assessed to be:

- **Medium** for baleen whales; and
- **Negligible** for harbour porpoise, dolphins and seals.

73. For low-order clearance (NEQ of 0.25 kg) the magnitude for TTS is assessed to be:

- **Negligible** for all marine mammal species.

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Table 9.4: Maximum Number of Marine Mammals Potentially at Risk of Disturbance During a High-order and Low-order Unexploded Ordnance Clearance Without Noise Mitigation

Species	Criteria	Maximum Impact Range (and Area)	Maximum Number of Individuals	% of Reference Population	Magnitude (Permanent Impact)
Harbour porpoise	TTS SPL _{peak} Unweighted (impulsive criteria)	High-order clearance (750 kg + donor) 26 km (2,124 km²)	2,703	0.8% of NS MU	Negligible
		Low-order clearance (0.25 kg NEQ) 1.8 km (10.2 km²)	13	0.004% of NS MU	Negligible
Bottlenose dolphin	TTS SPL _{peak} Unweighted (impulsive criteria)	High-order clearance (750 kg + donor) 1.5 km (7.1 km²)	0.21	0.01% of GNS MU	Negligible
		Low-order clearance (0.25 kg NEQ) 100 m (0.03 km²)	0.0009	<0.0001% of GNS MU	Negligible
Common dolphin	TTS SPL _{peak} Unweighted (impulsive criteria)	High-order clearance (750 kg + donor) 1.5k m (7.1 km²)	0.18	0.0002% of CGNS MU	Negligible
		Low-order clearance (0.25 kg NEQ) 100 m (0.03 km²)	0.0008	<0.0001% of CGNS MU	Negligible
White-beaked dolphin	TTS SPL _{peak} Unweighted (impulsive criteria)	High-order clearance (750 kg + donor) 1.5 km (7.1 km²)	2	0.005% of CGNS MU	Negligible
		Low-order clearance (0.25 kg NEQ) 100 m (0.03 km²)	0.008	<0.0001% of CGNS MU	Negligible

Species	Criteria	Maximum Impact Range (and Area)	Maximum Number of Individuals	% of Reference Population	Magnitude (Permanent Impact)
Minke whale	TTS SEL _{cum} Weighted (impulsive criteria)	High-order clearance (750 kg + donor) 110 km (38,013 km²)	1,593	7.9% of CGNS MU	Medium
		Low-order clearance (0.25 kg NEQ) 3.2 km (32.2 km²)	2	0.01% of CGNS MU	Negligible
Grey seal	TTS SEL _{cum} Unweighted (impulsive criteria)	High-order clearance (750 kg + donor) 22 km (1,521 km²)	31	0.11% of Combined MUs	Negligible
		Low-order clearance (0.25 kg NEQ) 570 m (1 km²)	0.02	<0.0001% of Combined MUs	Negligible
Harbour seal	TTS SEL _{cum} Unweighted (impulsive criteria)	High-order clearance (750 kg + donor) 22k m (1,521 km²)	0.00003	<0.0001% of East Scotland MU	Negligible
		Low-order clearance (0.25 kg NEQ) 570 m (1 km²)	0.00000002	<0.0001% of East Scotland MU	Negligible

9.2.2 Magnitude - Acoustic Deterrent Device Activation

74. For high-order clearance without noise mitigation (for a worst-case 750 kg + donor charge weight), an ADD would need to be activated for 167 minutes, based on the variable estimated swimming speeds. For the default method of low-order clearance, ADD would only be required for up to 12 minutes. The ADD activation time is calculated based on species swim speeds and the highest PTS impact ranges. This is 14 km for harbour porpoise and would cover the highest PTS impact range for all dolphins (of 830 m), baleen whales (of 11 km), and grey seal and harbour seal (for 2.8 km) (**Table 9.5**).

Table 9.5: Estimated Acoustic Deterrent Device Duration for the Maximum

Species Groups	Swim Speed (m/s)	Maximum PTS Impact Ranges Without Noise Mitigation (km) (see Table 8.1)		ADD Duration (Mins) Required		Distance (km) Each Species Would Swim In the ADD Duration	
		High-order	Low-order	High-order	Low-order	High-order	Low-order
LF	2.1 ¹	11	0.23	87	1.8	21	1.5
HF	1.52 ²	0.83	0.06	9	0.7	15.2	1.1
VHF	1.4 ¹	14	0.99	167	11.8	14	1.0
PCW	1.8 ¹	2.8	0.19	26	1.8	18	1.3

Notes:

¹ Scottish Natural Heritage (SNH), 2016.
² Bailey and Thompson, 2006.

75. There is a knowledge gap regarding the ranges at which ADDs become less effective and would no longer cause a marine mammal to flee. As per ADD review in the JNCC report No. 615 (McGarry et al., 2022), the ranges of deterrence distances can vary significantly from only a few metres to several kilometres (approximately 6 km for VHF cetacean); these differed between devices and dependent on the acoustic properties of the environment (Rosemeyer et al., 2021). A report from Marine Scotland noted the increase of previously known impact ranges from 3.5 km to up to 7.5 km for porpoises (Coram et al., 2014). It is unknown whether ADD is effective beyond these ranges.
76. The lack of evidence that ADDs are effective for VHF cetaceans beyond the impact ranges discussed above, implies that prolonged activation time would introduce additional noise to the environment. The JNCC report (McGarry et al., 2022) presented concerns regarding the potential for hearing damage (PTS) from some ADD devices but stated that the risk of injury from ADD deployment was likely to be low, unless the animals remained in the vicinity of the device.
77. Because of this, the ADD would be activated for a maximum of approximately 80 minutes, which balances the need to reduce the risk of injury with the need to avoid introducing unnecessary noise into the marine environment, in line with the guidance set out in JNCC (2025). During the 80 minutes, harbour porpoise (VHF) would move 6.7 km away, dolphins (HF) would move 7.2 km

away, baleen whales (LF) would move 11 km away and seals (PCW) would move 8.6 km away, taking into account the swimming speeds as presented in **Table 9.5**. This would be less than the highest PTS impact range of 14 km for harbour porpoise, but higher than the highest PTS impact range for baleen whales (of 11 km), all dolphins of 830 m and 2.8 km for grey seal and harbour seal.

78. An ADD activation period of 80 minutes would deter harbour porpoise beyond the potential PTS impact range for a high-order unexploded ordnance clearance without noise mitigation of up to 55 kg NEQ (based on NEQs modelled), while a high-order clearance without noise mitigation for unexploded ordnance heavier than 55 kg NEQ would result in potential PTS ranges that exceed the predicted ADD deterrence range for 80 minutes of ADD activation.
79. There is therefore the potential for injury to occur for harbour porpoise during high-order unexploded ordnance clearance without noise mitigation heavier than 55 kg NEQ. Should this be required, alternative mitigation would be required to avoid injury to this EPS. If it is not possible to wholly mitigate the potential for auditory injury, an EPS licence for injury will be secured prior to the start of unexploded ordnance clearance works.
80. The effects of ADD activation have been assessed using the estimated maximum ADD activation prior to unexploded ordnance clearance. This estimation is based on the maximum predicted impact range: 990 m for low-order clearance for harbour porpoise, and 14 km for a high-order clearance without noise mitigation for harbour porpoise (**Table 9.5**).
81. The maximum number of marine mammals that could be disturbed as a result of ADD activation prior to unexploded ordnance clearance has been estimated based on the maximum density estimate for each species (**Table 9.6**).
82. The magnitude of impact for ADD activation prior to unexploded ordnance clearance has been assessed as **negligible** for all marine mammal species, (**Table 9.5**) due to the percentage of the population being impacted is less than one percent (**Chapter 9: Marine Mammals (Volume II)**). Since all hearing groups are represented in this assessment and killer whale and humpback whale are rarely occurring in Bellrock WFDA, it can be presumed that the effect of ADD disturbance to both are therefore considered to be **negligible**.
83. ADD would only be activated for the minimum time required to ensure effective mitigation. Disturbance as a result of ADD activation would be within the maximum impact range assessed for TTS/disturbance from unexploded ordnance clearance and would therefore not be an additive effect to the overall area of potential disturbance.

Table 9.6: Estimated Number of Marine Mammals that Could Potentially be Disturbed During Acoustic Deterrent Device Activation for Unexploded Ordnance Clearance

Species	Low-order Clearance up to 12 minutes		High-order (Without Noise Mitigation) Clearance up to 80 Minutes	
	Number of Individuals Potentially Disturbed (% of Reference Population)	Magnitude	Number of Individuals Potentially Disturbed (% of Reference Population)	Magnitude
Harbour porpoise	4 (0.001% of NS MU)	Negligible	172 (0.05% of NS MU)	Negligible
Bottlenose dolphin	0.1 (0.001% of GNS MU)	Negligible	5 (0.25% of GNS MU)	Negligible
Common dolphin	0.09 (0.00009% of CGNS MU)	Negligible	4 (0.004% of CGNS MU)	Negligible
White-beaked dolphin	0.9 (0.002% of CGNS MU)	Negligible	39 (0.09% of CGNS MU)	Negligible
Minke whale	0.3 (0.001% of CGNS MU)	Negligible	13 (0.07% of CGNS MU)	Negligible
Grey seal	0.1 (0.0003% of combined MUs)	Negligible	4.5 (0.013% of combined MUs)	Negligible
Harbour seal	0.0000001 (<0.0001% of East Scotland MU)	Negligible	0.000004 (<0.0001% of East Scotland MU)	Negligible

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9.2.3 Effect Significance

84. Taking into account the low sensitivity for dolphins and seals and medium sensitivity to harbour porpoise, minke, humpback and fin whale to disturbance from unexploded ordnance clearance, the effect significance, for a high-order clearance without noise mitigation, has been assessed as:
- **Moderate adverse** (significant in EIA terms) for baleen whales; and
 - **Negligible adverse** (not significant in EIA terms) for harbour porpoise, dolphins and seals.
85. For low-order clearance, without mitigation measures, the effect significance has been assessed **negligible adverse** (not significant in EIA terms) for all marine mammal species.
86. With the low sensitivity for dolphins and seals and medium sensitivity to harbour porpoise and baleen whales, the effect significance of disturbance from ADD use has been assessed **negligible adverse** (not significant in EIA terms) for all marine mammal species.
87. A summary of the effect significance of disturbance from unexploded ordnance clearance is provided in **Table 10.1**.

9.2.4 Mitigation

88. The assessment above is undertaken without consideration of mitigation, in line with guidance received from NatureScot¹.
89. As outlined in **Section 3**, a MMMP for unexploded ordnance clearance would be produced post-consent in consultation with MD-LOT and NatureScot and would be based on the latest scientific understanding and guidance, results of pre-construction unexploded ordnance surveys in the Bellrock WFDA, as well as detailed project design.

9.2.5 Residual Effect Significance

90. If the mitigation measures (**Section 3**) are put in place, then the residual effect significance would be **minor adverse** (not significant in EIA terms) for the potential for disturbance effects in all marine mammal species for both high-order and low-order clearance. Mitigation measures will be confirmed in the MMMP which will be submitted alongside the separate Marine Licence application for unexploded ordnance clearance post-consent, once detailed information on the locations and extent of unexploded ordnance required to be cleared is known.

9.3 Impact 3: Changes to Prey Availability as a Result of Underwater Noise from Unexploded Ordnance Clearance Activities

91. Any impacts on prey species have the potential to indirectly affect marine mammals, as outlined in **Chapter 8: Fish and Shellfish (Volume II)**.

9.3.1 Sensitivity

92. A brief overview of the diets and feeding behaviours of each marine mammal receptor is provided below:

- Harbour porpoise diet consists of a wide variety of prey species and varies geographically and seasonally, reflecting changes in available food resources. Harbour porpoise have relatively high energy demands and need to capture enough prey to meet daily energy requirements. However, 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;
- Bottlenose dolphin are opportunistic feeders and take a wide variety of fish and invertebrate species. Benthic and pelagic fish (both solitary and schooling species), however, they are selective opportunists and although they may have preference for a type of prey, their diet seems to be determined largely by prey availability. Bottlenose dolphin are therefore considered to have a **low** sensitivity to changes in prey resource;
- Common dolphin are cooperative feeders, working within a pod to capture prey and have a varied diet. Common dolphin are therefore considered to have a **low** sensitivity to changes in prey resource;
- White-beaked dolphin have a varied diet and are therefore considered to have a **low** sensitivity to changes in prey resource;
- Killer whale diet is specific to location and ecotype, making them susceptible to changes in prey availability. The killer whale ecotypes that could be present in the Bellrock WFDA tend to have a more varied diet in comparison to other ecotypes. The prey could either be fish or seals, killer whale are therefore considered to have a **medium** sensitivity to prey changes;
- 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. Minke whale are therefore considered to have a **low to medium** sensitivity to changes in prey resource;
- Fin whale are pelagic feeders, feeding on small krill and schooling fish by lunge feeding. Although the daily amount of food required by fin whales is very large, the diet mainly consists of small planktonic crustaceans and are therefore considered to have a **low** sensitivity to changes in prey resource;
- Humpback whale are very similar to fin whales and also have a diverse diet and are flexible with regard to choosing their prey which ranges from krill to small schooling fish and is therefore considered to have a **low** sensitivity to changes in prey resource; and

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

93. For more comprehensive information, please refer to **Appendix 9.1: Marine Mammal Baseline (Volume IV)**.

9.3.2 Magnitude

94. Unexploded ordnance clearance has potential to produce high levels of underwater noise and therefore has the potential to result in adverse impacts on fish/prey availability.

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

96. Underwater noise modelling (**Appendix 9.2: Underwater Noise Modelling Report (Volume IV)**) 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).

97. The underwater noise modelling results (**Appendix 9.2: Underwater Noise Modelling Report (Volume IV)**) indicate that fish species in which the swim bladder is involved in hearing were the most sensitive to the impact of underwater noise associated with unexploded ordnance clearance.

98. **Table 9.7** summarises the maximum impact ranges for all fish groups (**paragraph 96**) during unexploded ordnance clearance. Whilst mortality is most likely to occur at a SPL of 234 dB, the potential for mortal injury is slightly less at a SPL of 229 dB. With a maximum impact range of up to 970 m, this is considerably less than the 14 km PTS impact range for harbour porpoise, based on the unweighted SPL_{peak} criteria (**Appendix 9.2: Underwater Noise Modelling Report (Volume IV)**). Therefore, there would be no additional impacts as a result of any changes in prey availability during unexploded ordnance clearance besides the direct impacts to marine mammals as a result of underwater noise.

99. Since some of the killer whales from the Shetland-Orkney ecotype are considered marine mammal eaters (see **Appendix 9.1: Marine Mammals Technical Report (Volume IV)**) for further information), should seals be temporarily displaced from the Bellrock WFDA during unexploded ordnance clearance, then some killer whales would also be displaced and thus there would be no or little effect on their foraging behaviour to hunt seals and the magnitude of impact is therefore considered to be **negligible**.

100. The magnitude of any potential changes to prey availability as a result of unexploded ordnance clearance is assessed as **negligible** for all marine mammals, as any impacts on prey would be less than the direct impacts on marine mammals.

Table 9.7: Summary of the Impact Ranges for Unexploded Ordnance Detonation Using the Unweighted Sound Pressure Level (SPL_{peak}) Clearance Noise Criteria from Popper et al., (2014) for Fish Species

Potential Impact	0.25 kg	25 kg	55 kg	120 kg	240 kg	525 kg	698 kg	750 kg
	+ Donor Charge							
234 dB (Mortality and potential mortal injury)	N/A	170 m	230 m	300 m	370 m	490 m	530 m	550 m
229 dB (Mortality and potential mortal injury)	60 m	290 m	380 m	490 m	620 m	810 m	890 m	910 m
Notes: N/A indicates ranges <50 metres.								

9.3.3 Effect Significance

101. Taking into account the low to medium sensitivity as well as the negligible magnitude of impact, the significance of effect on marine mammals due to changes in prey availability has been assessed as **negligible adverse** (not significant in EIA terms).
102. Due to the negligible adverse significance, it is not considered that additional mitigation will be required.

10 Assessment Summary

103. This indicative assessment has established that there may be some minor adverse residual effects during the unexploded ordnance clearance within the Bellrock WFDA, which is considered not significant in EIA terms. While the effects are expected to be short-term and localised, disturbance effects to marine mammals can extend beyond the Bellrock WFDA. However, these effects are considered temporary and are recoverable over time. The potential effects on marine mammals from unexploded ordnance clearance within the Bellrock WFDA are summarised in **Table 10.1**.
104. While high-order clearance has been assessed as the worst-case, it is important to note that recent projects, such as the Moray West Offshore Wind Farm, have had successful unexploded ordnance clearance campaigns where no high-order clearances were required. Therefore, the assessment into high-order clearances is considered as extremely precautionary and unlikely.
105. A separate Marine Licence application for unexploded ordnance clearance will be submitted post-consent, once detailed information on the locations and extent of unexploded ordnance required to be cleared is known. A MMMP will be submitted alongside the Marine Licence application for unexploded ordnance clearance, this will be consulted on with MD-LOT and NatureScot prior to the clearance works being undertaken.

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Table 10.1: Summary of Potential Effects to Marine Mammals Due to Unexploded Ordnance Clearance

Potential Impact	Receptor	Sensitivity	Magnitude	Pre-mitigation Effect	Mitigation Measures	Residual Effect
Impact 1: Permanent auditory injury from underwater noise associated with unexploded ordnance clearance						
PTS for unexploded ordnance high-order clearance	Harbour porpoise	High	Medium	Significant (Major adverse)	MMMP for unexploded ordnance clearance	Not Significant (Minor adverse)
	All other marine mammals	High	Negligible	Not Significant (Minor adverse)	None required, but MMMP for unexploded ordnance clearance would reduce potential for effect	Not Significant (Minor adverse)
PTS for unexploded ordnance low-order clearance	All marine mammals	High	Negligible	Not Significant (Minor adverse)	None required, but MMMP for unexploded ordnance clearance would reduce potential for effect	Not Significant (Minor adverse)
Impact 2: TTS and disturbance from underwater noise associated with unexploded ordnance clearance						
TTS and disturbance from high-order clearance	Baleen whales	Medium	Medium	Significant (Moderate adverse)	MMMP for unexploded ordnance clearance would reduce potential for effect	Not Significant (Minor adverse)
	Harbour porpoise	Medium	Negligible	Not Significant (Minor adverse)	None required, but MMMP for unexploded ordnance clearance would reduce potential for effect	Not Significant (Minor adverse)
	Dolphin and seal species	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)

Potential Impact	Receptor	Sensitivity	Magnitude	Pre-mitigation Effect	Mitigation Measures	Residual Effect
TTS and disturbance from low-order clearance	Harbour porpoise and baleen whales	Medium	Negligible	Not Significant (Negligible adverse)	None required	Not Significant (Negligible adverse)
	Dolphin and seal species	Low	Negligible	Not Significant (Negligible adverse)		Not Significant (Negligible adverse)
Disturbance from ADD activation	All species	Medium to Low	Negligible	Not Significant (Negligible adverse)	None required	Not Significant (Negligible adverse)
Impact 3: Changes to prey availability as a result of underwater noise from unexploded ordnance clearance activities						
Changes to prey availability as a result of underwater noise from unexploded ordnance clearance activities	Harbour porpoise and baleen whales	Low to Medium	Negligible	Not Significant (Negligible adverse)	None required, but MMMP for unexploded ordnance clearance would reduce potential for effect	Not Significant (Negligible adverse)
	Bottlenose dolphin, common dolphin, white-beaked dolphin, grey seal and harbour seal	Low	Negligible			
	Killer whale	Medium	Negligible			

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