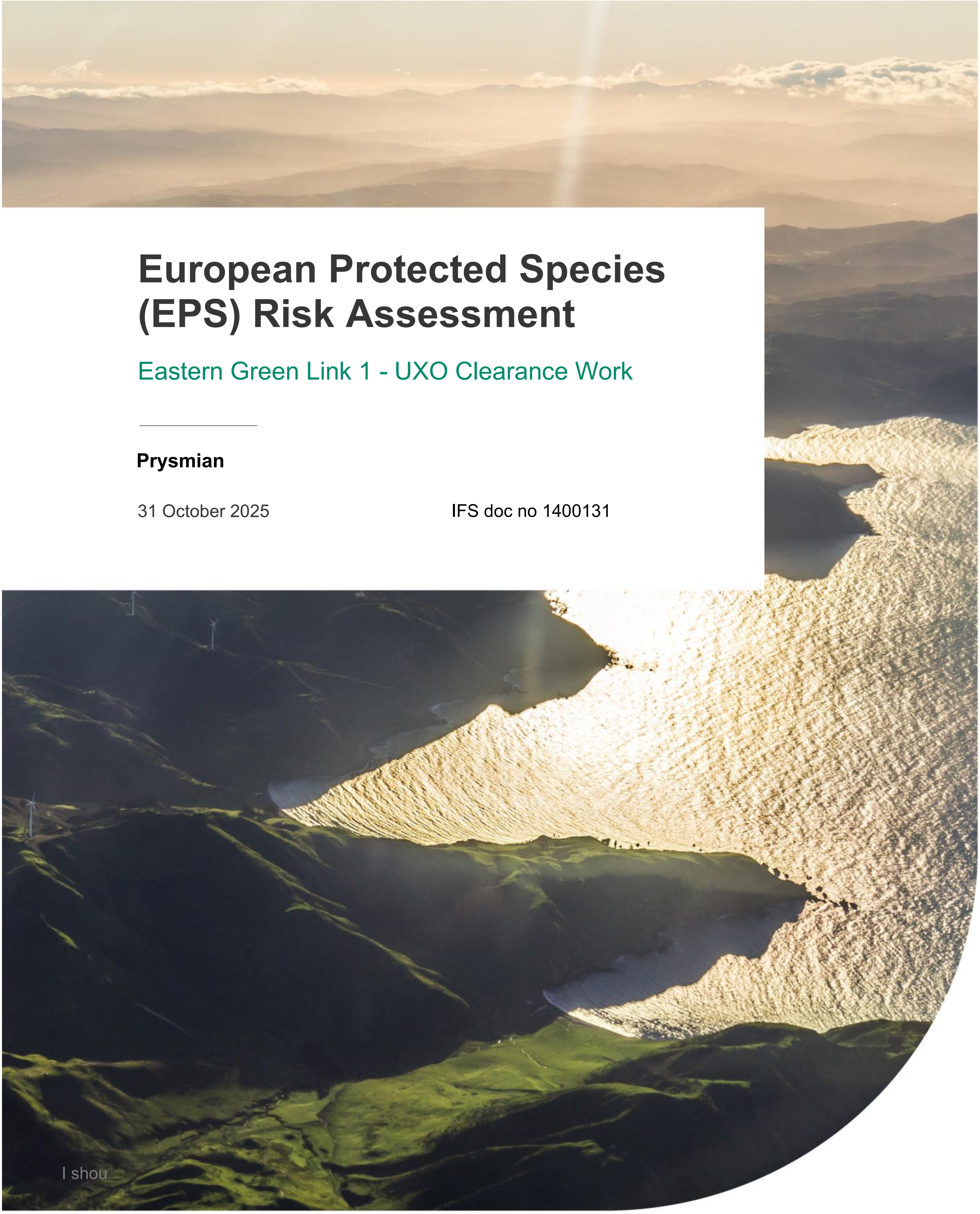
European Protected Species (EPS) Risk Assessment

Eastern Green Link 1 - UXO Clearance Work

Prysmian

31 October 2025 IFS doc no 1400131



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Contents

1. Introduction

Eastern Green Link 1 (EGL1; hereafter referred to as the ‘Marine Scheme’) is the one of several developments required to increase the capability of the existing Great Britain (GB) transmission network from Scotland to the North of England (Figure 1-1). This increase is required to facilitate growth in flow of renewable generation in the North to centres of demand in the South, helping ensure that the United Kingdom (UK) can meet its target of enabling 40 GW of renewable energy by 2030 and achieving a ‘Net Zero economy’ by 2050.

The Marine Scheme is being developed by a partnership between SP Energy Networks (SPEN) and National Grid Electricity Transmission (NGET).

The Marine Scheme involves construction of a 2 GW high voltage direct current (HVDC) electrical ‘superhighway’ operating at 525 kV between the Torness area in East Lothian, Scotland and Hawthorn Pit (to the north of Seaham) in County Durham, England. The cable will be approximately 196 km long in total; approximately 176 km will be subsea with each land section being about 10 km in length (Figure 1-1). Once complete it will be capable of bi-directionally transmitting up to 2 GW – sufficient power for up to 2 million homes.

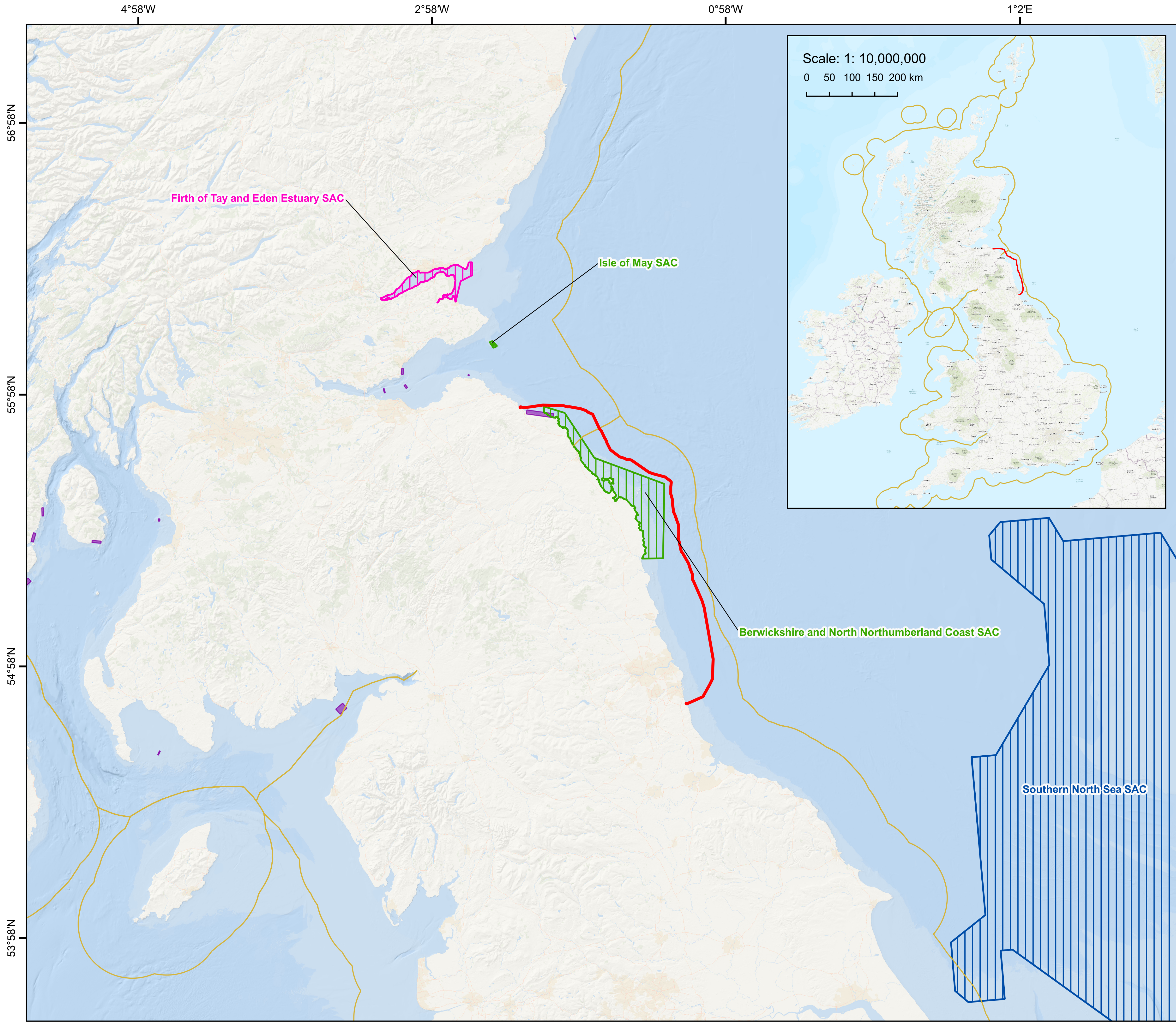
The Marine Scheme has been awarded the following Marine Licences:

- L/2023/00212/2 in English waters by the Marine Management Organisation (MMO); and
- MS-00009880 in Scottish waters by the Marine Directorate – Licensing Operations Team (MD-LOT).

The purpose of this European Protected Species (EPS) Risk Assessment is to:

- Describe the proposed UXO clearance work which is required to make safe the working area;
- Outline the legislation and guidance applicable to this assessment;
- Describe the marine EPS and other megafauna which are likely to occur in the region of the Marine Scheme;
- Assess whether there is any risk to marine EPS (and basking sharks) as a result of the proposed work;
- Outline any proposed mitigation measures; and
- Ascertain whether EPS and basking shark licences are required and can be awarded in Scottish territorial and offshore waters and whether a Marine Wildlife Licence is required and can be awarded in English territorial and offshore waters.

This European Protected Species Risk Assessment (EPS RA) (1400131) document has been prepared by Natural Power Consultants on behalf of PPL, to support the Marine Licence application for the clearance of Unexploded Ordnance (UXO) along the Marine Installation Corridor within United Kingdom (UK) waters and will be submitted alongside a suite of supporting documents including the Supporting Environmental Information (SEI) (1396955), a Report to Inform Appropriate Assessment (RIAA) (1369784), a Marine Conservation Zone (MCZ) Assessment (1397056) and the Marine Mammal Mitigation Plan (MMMP) (1369788).



Project:

Eastern Green Link 1, Scotland – England

Title:

Figure 1-1: Eastern Green Link 1 Location and Relevant Protected Sites

Key

- EGL1 Subsea Cable Route (EGL1)
- 12 nautical mile (NM) UK limit

Relevant Protected Sites

- Berwickshire and North Northumberland Coast SAC
- Isle of May SAC (Grey seal)
- Firth of Tay and Eden Estuary SAC (Harbour seal)
- Southern North Sea SAC (Harbour porpoise)
- Designated seal haul-out site

Scale @ A3:1:1,550,000

Coordinate System: WGS 84 UTM Zone 30N
Graticules: WGS84

0 10 20 30 40 km

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2. Planned Work

In order to undertake construction activities, a number of route preparation activities will be required to ensure that cable installation activities are performed safely without risk to personnel or equipment, including pre-installation surveys, route clearance, boulder clearance and UXO clearance. This EPS risk assessment covers the proposed UXO clearance work which is required to make safe the working area.

A hierarchical approach to addressing confirmed UXO (cUXO) will be applied. This will be (in order of preference), avoidance, relocation, or clearance (deflagration or detonation). Any removal or detonation measures will be undertaken by specialists in accordance with appropriate regulations and guidance.

2.1. Outline Method Statement

In June 2025, offshore geophysical surveys were undertaken in order to identify potential UXOs based on bathymetry, seabed data and magnetometry. After the survey was performed, a list of potential UXOs (pUXO) was defined. Based on this initial list, engineering works were performed to avoid these potential UXOs whenever possible. Where avoidance of potential UXOs is not possible, a target inspection (activity outside of the scope of the present document) will be performed by experts to determine if the target is a confirmed UXO.

UXO target inspection ('UXO TIs') was assessed and considered as part of the original 'main' EGL1 MLA (MLA/2022/00231), and UXO TIs are included within the consented EGL1 Marine Licence (L/2023/00212/2). As has been discussed and agreed with the MMO via regular post-consent / pre-construction engagement in 2024/2025, it is the intention of the Applicant and PPL alike to draw upon the existing Marine Licence for UXO TIs. Pursuant to this and as agreed with the MMO, a brief UXO TI method statement will be supplied to the MMO, alongside other minor / admin condition responses, in order to discharge this activity on the Marine Licence and 'unlock' use. A similar approach will be followed with MD-LOT to draw upon the existing Marine Licence (MS-00009880) for UXO TIs in Scotland.

Considering the timeline required for the submission of the licence, the final number (including location, size, type and exact methodology for clearance) of confirmed UXO to be cleared is not known at this stage but it is based on the initial list of potential UXO and first re-routing.

2.1.1. pUXO Targets

The below table presents numbers regarding the UXO process (Table 2.1). Numbers identified by a (*) will be confirmed after the target inspection operations.

The targets are located between 7 and 88.6m LAT.

Table 2.1: Number and locations of pUXO targets and estimated numbers of UXO required to be cleared

Location	Total pUXO targets	pUXO targets to be inspected	Estimated UXO targets	UXO to be cleared
	Identified from UXO survey – full corridor		Identified after Target Inspection	Which remain after micro-siting exercise
Full route	554	70*	55*	40*
Scotland	144	20*	15*	10*
England	410	50*	40*	30*

2.1.2. UXO Clearance

A variety of options for managing UXOs on site are available and will be considered on a case-by-case basis:

- Micro-siting i.e., avoidance of UXO;
- Relocation ('lift and shift') of UXO (where deemed safe to do so); and
- The primary method for clearance is low order and high order will only be used following attempts to undertake low order clearance;
  - Low-order (Deflagration) – Low-order technique causes UXO to burn out without detonating. A small charge is fired at the explosive fill of the UXO, causing the explosive content to ignite and burn out. The casing of the munition cracks open, but if successful, it should not detonate. Low-order clearance methods will be utilised in the first instance.
  - High-order (Detonation) – An ordnance detonation that results in an explosive ordnance producing the designed/intended explosive yield. This is typically achieved by sympathetic detonation caused by a place donor charge.

It is anticipated that 90% of UXO targets will be cleared using low-order clearance methods whilst up to 10% of UXO (maximum four UXOs) may require high-order clearance methods (i.e., a maximum of 36 low order clearances and 4 high order clearances). It is likely that different types of UXO will be present (Table 2.2), many of which are likely to have been subject to degradation or burying over time. It is anticipated that the largest UXO may have a net explosive quantity (NEQ) of 722kg (including donor charge).

Low order clearance is preferable to high order clearance as it avoids the high pressures associated with an explosion by using a small initiation explosive to 'burn away' the target explosive material within the UXO. Different sized initiation explosives may be required for different sized UXOs. To inform the EPS RA low order initiation explosives of 0.25 kg were used in the noise modelling (see Section 5.2). However, the mitigation outlined in Section 6 has been designed to apply to low order clearance using any size initiation explosive.

No more than one UXO detonation event is expected to occur in a 24-hour period. A detonation event is defined as a planned clearance through high order methods of a single UXO, or of multiple UXO where they are situated together such that a single detonation can be used for clearance.

All relocation and clearance work will be undertaken by specialists in accordance with the appropriate regulations and guidance.

Table 2.2: Range of charge weights and donor charges of UXO devices potentially present in the Marine Scheme

Device Type	Net Explosive Quantity (kg)		
	UXO	Donor Charge	Total
SC50	25	5	30
SC500	270	25	295
GY (EMCII)	300	25	325
Mark A mine	431	25	456
SC1000	530	25	555
LMB mine	697	25	722

Source: Appendix A (Morgan, 2025)

2.2. Proposed Vessels

It has not yet been confirmed which vessels will be used for the UXO clearance work. It is anticipated that a maximum of four vessels will be required:

- An 'ROV support vessel' from which any charges will be set and on which the mitigation personnel will be based. It is likely that ultra short baseline (USBL) equipment will be used if ROVs are being used, for example to place donor charges;
- A 'dive support' vessel from which divers can be deployed;
- A 'guard vessel' which will undertake preparation and implementation of the detonations and from which the Acoustic Deterrent Device (ADD) will be deployed; and
- A mitigation vessel for the deployment of a noise abatement system (NAS) if required.

These vessels will be on site for a limited duration (anticipated a maximum of 60 days including weather downtime), with no more than one high order UXO detonation expected to occur in a 24-hour period. Vessels will undertake 24/7 working and the UXO clearance strategy will be planned to minimise vessel transit lengths between targets.

Notably, it is important to recognise that the presence of a multitude of vessels during the installation process has already been fully assessed and considered within the previous EA, supplied to the MMO in support of the original 'main' MLA (MLA/2022/00231) (AECOM, 2022). The MMO provided a favourable determination and deemed the limited vessel noise associated with the Marine Scheme to be acceptable.

2.3. Timing and Duration

The EGL1 UXO clearance work is anticipated to take up to one month between Q2 and Q3 2026, following target inspection operations. The duration will depend on the exact number of UXO to be cleared but it is estimated a maximum of 60 days, including weather downtime. No more than one UXO detonation is expected to occur in a 24-hour period.

3. Legal Requirement

3.1. EPS

All species of cetacean in waters around the UK are considered EPS under Annex IV of the Habitats Directive (Council Directive 92/43/EEC) which covers animal and plant species of community interest in need of strict protection.

The need to consider EPS within English and Scottish territorial waters comes from two articles of legislation, these are:

- The Conservation of Habitats and Species Regulations 2017 which transpose the Habitats Directive into UK law. This legislation covers English and Welsh Territorial Waters; and
- The Conservation (Natural Habitats &c.) Regulations 1994 (as amended in Scotland) which transposes the Habitats Directive into Scottish law. This legislation covers Scottish Territorial Waters.

The need to consider EPS within offshore waters (>12 NM for the coast) comes from:

- The Conservation of Offshore Marine Habitats and Species Regulations 2017 (known as the Offshore Regulations) which transpose the Habitats Directive into UK law for all offshore activities. This legislation covers UK waters beyond the 12 NM limit.

All of these regulations (collectively known as the 'Habitats Regulations') provide for the designation of protected European sites (Special Areas of Conservation (SACs)) and the protection of EPS as designated under the Habitats Directive.

The Offshore Regulations state in Section 45, that it is an offence to:

- Deliberately capture, kill or injure any wild animal of a EPS, as listed under Annex IV of the Habitats Directive;
- Damage or destroy, or cause deterioration of the breeding sites or resting places of a EPS; and
- Deliberately disturb EPS (in particular disturbance which is likely to impair the ability of a significant group of animals of that species to survive, breed, rear or nurture their young, or which might affect significantly their local distribution or abundance).

The interpretation of the Habitats Directive (Council Directive 92/43/EEC) has been more conservative within Scottish EPS regulations than it has been in English and Welsh regulations. The Conservation of Habitats and Species Regulations 1994 (as amended in Scotland) state, under section 39, that it is an offence to:

- Deliberately **or recklessly** capture, kill or injure a wild animal of a EPS, as listed under Annex IV of the Habitats Directive;
- Damage **or recklessly** destroy, or cause deterioration of the breeding sites or resting places of an EPS;
- Deliberately **or recklessly** disturb EPS (in particular disturbance which is likely to impair their ability to survive, breed, reproduce, nurture their young, migrate or hibernate, or which might affect significantly their local distribution or abundance);
- Disturb **any** EPS in a matter that is, or in circumstances which are, likely to significantly affect the local distribution or abundance of the species to which it belongs; and
- **Deliberately or recklessly disturb any dolphin, porpoise or whale (cetacean) through Regulation 39 (2).**

The additional protection afforded by the Conservation of Habitats and Species Regulations 1994 (as amended in Scotland) has been shown in bold in the list above. It is therefore an offence to deliberately or recklessly disturb a single cetacean in Scottish Territorial Waters.

In addition, any means of capturing or killing which is indiscriminate and capable of causing the local disappearance of - or serious disturbance to - any population of EPS is an offence under both Scottish and English regulations.

Licences may be granted by the Secretary of State or the Marine Directorate (on behalf of the Scottish Ministers) which would allow otherwise illegal activities to go ahead.

Three tests must be passed before a license can be granted:

1. The license must relate to one of the purposes referred to in Regulation 44;
2. There must be no satisfactory alternative (Regulation 44, 3a); and
3. The action authorised must not be detrimental to the maintenance of the population of the species concerned at a Favourable Conservation Status (FCS) in their natural range (Regulation 44, 3b).

FCS is defined in the Habitats Regulations as the following:

- Population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable element of its natural habitats;
- The natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future; and
- There is, and will probably continue to be, a sufficiently large habitat to maintain its population on a long-term basis.

The proposed works are within the 12 NM limit of both English and Scottish Territorial Waters. However, sound from the proposed UXO clearance work has the potential to affect animals within offshore waters too. Therefore, the Habitats Regulations (as employed in England and Scotland respectively) and the Offshore Regulations both apply.

3.2. Seals

Under the Wildlife and Countryside Act 1981, the Conservation of Seals Act 1970, and the Conservation of Habitats and Species Regulations 2017, it is an offence to take, injure or kill a seal out to 12 nautical miles (NM).

Under the Conservation of Offshore Marine Habitats and Species Regulations 2017 it is an offence to capture or kill a seal beyond 12 NM.

The Marine (Scotland) Act 2010 provides the main legal framework for protecting seals in Scottish waters. The Act introduced a licensing system for killing or taking seals, making it an offence to do so without a licence. 194 seal haul-out sites in Scotland have been designated under the Protection of Seals (Designation of Haul-Out Sites) (Scotland) Order 2014 which protects seals from harassment by humans at locations where they come ashore to rest, moult, or breed.

3.3. Guidance

Guidance entitled 'The protection of marine European Protected Species from injury and disturbance: Guidance for the marine area in England and Wales and the UK offshore marine area' was published in 2010 by the Joint Nature Conservation Committee (JNCC), Natural England and the Countryside Council for Wales (now Natural Resources Wales) (JNCC *et al.,* 2010). This document has been used as a resource when a view is needed as to whether there is potential for an offence of deliberately disturbing or injuring/killing a marine EPS to occur within English territorial and UK offshore waters, as a result of any activity associated with the proposed works.

The guidance considers certain activities that produce loud noises in areas where an EPS could be present to have the potential to result in an injury or disturbance offence, unless appropriate mitigation measures are implemented. The risk of an offence being committed is dependent on a number of factors, including the following:

- Presence/absence of EPS;

- Noise associated with the activity and resulting impacts on EPS species;
- Frequency of occurrence of EPS;
- Density of EPS; and
- Length of exposure of EPS to noise associated with proposed activities.

The JNCC *et al.* (2010) guidance also considers that the potential for disturbance from some activities can be considered “trivial”. Activities which might be considered trivial include those that lead to “sporadic disturbances without any likely negative impact on the species”.

For an activity to be considered “non-trivial”, the JNCC guidance (JNCC *et al.,* 2010) states that “the disturbance to marine EPS would need to be likely to at least increase the risk of a certain negative impact on the species’ FCS”.

In Scotland the Marine Directorate and Scottish Natural Heritage (SNH) (now Nature Scot) produced guidance for Scottish inshore waters ‘The protection of Marine European Protected Species from injury and disturbance’ in March 2014 (Marine Scotland and SNH, 2014). This guidance was updated in July 2020 (Marine Scotland and SNH, 2020). The Marine Directorate recognise that the guidance ‘…*reflects a precautionary approach*…’ to the interpretation of the Habitats Directive with regards to EPS and requires the careful examination of the potential impact of proposed offshore activities, and the resultant noise produced, on individual animals likely to be present at the location.

The guidance states that the two main potential causes of death or injury are physical contact (with a vessel) and anthropogenic noise. Likelihood of disturbance for individuals includes factors such as:

- Spatial and temporal distribution of the animal in relation to the activity;
- Any behaviour learned from prior experience with the activity;
- Similarity of the activity to biologically important signals (particularly important in relation to activities creating sound); and
- The motivation of the animal to remain within the areas (e.g. food availability).

Likelihood of potential impacts should include the following considerations:

- Type of activity;
- Duration and frequency of the activity;
- Extent of the activity;
- Timing and location of the activity; and
- Other known activities in the area at the same time.

4. Marine EPS and other Megafauna in the Region of the Marine Scheme

Four cetacean species are considered to occur on a relatively common basis in the vicinity the Marine Scheme: Harbour porpoise (*Phocoena phocoena*), bottlenose dolphin (*Tursiops truncatus*), white-beaked dolphin (*Lagenorhynchus albirostris*) and minke whale (*Balaenoptera acutorostrata*) (Arso Civil *et al*., 2021; Cheney *et al*., 2024; Gilles *et al.,* 2023; IAMMWG, 2023).

Occasional visitors to the region include common dolphin (*Delphinus delphis*), Risso's dolphin (*Grampus griseus*), white-sided dolphin (*Lagenorhynchus acutus*), killer whale (*Orcinus orca*) and long-finned pilot whale (*Globicephala melas*). Sightings of humpback whale (*Megaptera novaeangliae*) and fin whale (*Balaenoptera physalus*) have also been recorded[1].

4.1.1. Harbour Porpoise

The harbour porpoise is widespread around the UK, including the North Sea, Irish Sea, the seas west of Ireland and Scotland, and northwards to Orkney and Shetland. Since the 1990s it has become much less common around the Northern Isles, but it appears to be returning to the English Channel and southern North Sea, where it was infrequent in the late 1980s. The recent SCANS-IV survey, the latest in a series of large-scale surveys for cetaceans in European Atlantic waters, showed that the harbour porpoise population in the North Sea is stable and there is very little difference in the estimated abundance between 2016 and 2022 (Gilles *et al*., 2023).

Harbour porpoise density in the vicinity of the Marine Scheme, from SCANS-IV, is provided in Table 4.1. The Scottish section of the subsea cable route is located entirely in SCANS-IV survey block NS-D while the English portion intersects both SCANS-IV survey block NS-D and block NS-C.

The relevant Inter-Agency Marine Mammal Working Group (IAMMWG) Management Unit (MU) abundance estimate is also provided in Table 4.1; the abundance of the UK portion of the MU has been used as the reference population.

The closest designated site (Special Area of Conservation (SAC)) for harbour porpoises (Southern North Sea SAC) is approximately 111 km south-east from the subsea cable route at its closest point (Figure 1-1).

Table 4.1: Harbour porpoise density and reference population abundance

SCANS-IV Survey Block	Density (animals per km^2)	Management Unit	Abundance	95% confidence interval (CI)
NS-C NS-D	0.6027 0.5985	North Sea	346,601	289,498 - 419,967
		UK portion of North Sea	159,632	127,442 – 199,954

Source: Gilles et al. (2023); IAMMWG (2023).

4.1.2. Bottlenose Dolphin

Both inshore and offshore bottlenose dolphin ecotypes are recognised in UK waters and are likely to occur in the vicinity of the Marine Scheme.

The Scottish section of the subsea cable route is located entirely within SCANS-IV survey block NS-D (for which there is no density estimate) whilst the English portion intersects block NS-C in addition to block NS-D. The density of bottlenose dolphins in the vicinity of the Marine Scheme, from SCANS-IV block NS-C (Gilles *et al*., 2023), is

1 https://www.seawatchfoundation.org.uk/recentsightings/

provided in Table 4.2. It should be noted that, due to their social structure and behaviour, density estimates are not always representative for the dolphin species; because individuals tend to occur in clusters or groups, rather than singly, use of a flat density surface can lead to conservative estimates of the number of individuals which have the potential to be impacted.

The relevant IAMMWG MU abundance estimate is also provided in Table 4.2; the abundance of the UK portion of the MU has been used as the reference population. The Coastal East Scotland MU abundance has not been used because this MU lies to the north of the subsea cable route.

The closest designated site for bottlenose dolphins (Moray Firth SAC) is approximately 280 km north-northwest from the subsea cable route at its closest point, however, with the southerly expansion of the east Scotland bottlenose dolphin population the potential for connectivity between the proposed work and individuals from the population which uses this SAC is high.

Table 4.2: Bottlenose dolphin density and reference population abundance

SCANS-IV Survey Block	Density (animals per km^2)	Management Unit	Abundance	95% confidence interval (CI)
NS-C NS-D	0.0419 n/a	Greater North Sea	2,022	548 - 7453
		UK portion of Greater North Sea	1,885	476 – 7,461

Source: Gilles et al. (2023); IAMMWG (2023).

4.1.3. White-Beaked Dolphin

White-beaked dolphins in UK waters predominantly occur offshore.

Their greatest densities have been recorded around Shetland, in the northern North Sea and off northwest Scotland (Gilles *et al.,* 2023). The density of white-beaked dolphins in the vicinity of the subsea cable route, from SCANS-IV, is provided in Table 4.3. The Scottish section of the subsea cable route is located entirely in SCANS-IV survey block NS-D whilst the English portion intersects block NS-C in addition to block NS-D. It should be noted that, due to their social structure and behaviour, density estimates are not always representative for the dolphin species; because individuals tend to occur in clusters or groups, rather than singly, use of a flat density surface can lead to conservative estimates of the number of individuals which have the potential to be impacted.

The relevant IAMMWG MU abundance estimate is also provided in Table 4.3; the abundance of the UK portion of the MU has been used as the reference population.

There are no designated sites (SACs) for white-beaked dolphins (this species is not listed on Annex II of the Habitats Directive).

Table 4.3: White-beaked dolphin density and reference population abundance

SCANS-IV Survey Block	Density (animals per km^2)	Management Unit	Abundance	95% confidence interval (CI)
NS-C NS-D	0.0149 0.0799	Celtic and Greater North Seas	43,951	28,439 - 67,924
		UK portion of Celtic and Greater North Seas	34,025	20,026 – 57,807

Source: Gilles et al. (2023); IAMMWG (2023).

4.1.4. Minke Whale

Minke whales are the smallest of the baleen whales and are widespread around the UK. There is evidence that their distribution in the North Sea shifted south between 1994 and 2005 (Hammond *et al*., 2013). The most recent SCANS survey showed many sightings further south in the North Sea than previously seen (Gilles *et al.,* 2023). Their abundance in the North Sea (between 1989 and 2022) appears to be relatively stable (Gilles *et al.,* 2023).

Minke whale density in the vicinity of the subsea cable route, from SCANS-IV, is provided in Table 4.4. The Scottish section of the subsea cable route is located entirely in SCANS-IV survey block NS-D whilst the English portion intersects block NS-C in addition to block NS-D.

The relevant IAMMWG MU abundance estimate is also provided in Table 4.4; the abundance of the UK portion of the MU has been used as the reference population.

There are no designated sites (SACs) for minke whales (the species is not listed on Annex II of the Habitats Directive). There is, however, a Marine Protected Area (MPA) for minke whale (the Southern Trench MPA) which is approximately 168 km north-northwest from the subsea cable route at its closest point.

Table 4.4: Minke whale density and reference population abundance

SCANS-IV Survey Block	Density (animals per km^2)	Management Unit	Abundance	95% confidence interval (CI)
NS-C NS-D	0.0068 0.0419	Celtic and Greater North Seas	20,118	14,061 - 28,786
		UK portion of Celtic and Greater North Seas	10,288	6,210 – 17,042

Source: Gilles et al. (2023); IAMMWG (2023).

4.2. Seals

Two seal species occur on a relatively common basis in the North Sea: Grey seal (*Halichoerus grypus*) and harbour seal (*Phoca vitulina*) (Carter *et al.,* 2022).

The subsea cable route does not directly overlap with any designated seal haul out sites. However, the Fast Castle seal haul of site is in the near vicinity of the cable route, being located approximately 1.5 km southeast of the landfall site in Torness (Figure 1-1).

This EPS Risk Assessment does not assess potential effects on seals because they are not EPS. However, any mitigation proposed (Section 6) will be applied to all marine megafauna species including seals.

4.2.1. Grey Seals

Grey seals are among the rarest seals in the world; the UK population represents about 40% of the world population and 95% of the European population. Grey seals spend most of the year at sea and may range widely in search of prey. They come ashore in the autumn forming breeding colonies on rocky shores, beaches, and in caves often on small largely uninhabited islands.

The greatest densities of grey seals in relation to the subsea cable route are found in the Berwickshire and North Northumberland Coast SAC (designated for this species) which is approximately 350 m from the subsea cable route at its closest point (Figure 1-1). The next closest SAC designated for grey seals is the Isle of May SAC which is 26.4 km northwest from the subsea cable route at its closest point (Figure 1-1).

4.2.2. Harbour Seals

Harbour seals have a near circumpolar distribution, with at least four subspecies recognised worldwide. Only the eastern Atlantic subspecies occurs in Europe. The UK population represents about 5% of the world population and approximately 50% of the European population. Harbour seals are the characteristic seal of sandflats and estuaries but are also found on rocky shores. As pups swim almost immediately after birth, harbour seals can breed in sheltered tidal areas where sand/mud banks allow access to deep water.

Harbour seals are not common in the vicinity of the subsea cable route. The closest SAC for harbour seal (Firth of Tay and Eden Estuary SAC) is approximately 50 km northwest from the subsea cable route at its closest point.

4.3. Other Marine Megafauna

4.3.1. Basking Shark

There have been few sightings of this species in the North Sea (Drewery, 2012; Wilson *et al.,* 2020) which indicates that they are uncommon in the vicinity of the subsea cable route. Due to their habit of feeding at slow speed very close to the surface, basking sharks are potentially at risk from collision with boat traffic (Wilson *et al.,* 2020). In contrast, although there is little information on sound detection in basking sharks, there is no direct evidence of sound causing basking shark mortality or stress (Wilson *et al.,* 2020). Although the potential effects of noise on basking sharks have not therefore been assessed, any mitigation proposed (Section 6) will be applied to all marine megafauna species including basking sharks.

4.3.2. Marine Turtles

Up to five species of marine turtle (which are also EPS) have been recorded in British waters. Leatherback turtles (*Dermochelys coriacea*) are the most commonly recorded turtle species however the species is thought to be at the most extreme northern limit of its natural range in UK waters (BEIS, 2016). Sightings in the North Sea are uncommon with most UK sightings occurring in the Irish Sea (BEIS, 2016). Due to their low likelihood of occurrence, this EPS Risk Assessment does not assess potential effects on turtles. However, any mitigation proposed (Section 6) will be applied to all marine megafauna species including turtles.

5. Description of Potential Impacts and Risk Assessment

During the UXO clearance work, there is potential for marine EPS to be impacted. The main activities associated with the work which may impact these species are:

- Increased anthropogenic noise from UXO clearance work;
- Increased anthropogenic noise from use of USBL equipment;
- Risk of collision with vessels; and
- Changes in turbidity.

5.1. Overview of the Potential Effects of Anthropogenic Noise on Marine Mammals

It is widely documented that marine mammals are sensitive to underwater noise with the level of sensitivity depending on the hearing ability of the species (Table 5.1).

Potential effects of underwater noise on marine mammals can be summarised as:

- Lethal effects and physical injury;
- Auditory injury; and
- Behavioural responses.

Table 5.1: Marine mammal hearing ranges

Functional hearing group	Example species	Estimated auditory bandwidth (kHz)
Low frequency cetacean	Minke whale	0.007 – 35
High frequency cetacean	Bottlenose dolphin	0.15 – 160
Very high frequency cetacean	Harbour porpoise	0.2 – 160
Phocid carnivores in water	Harbour seal Grey seal	0.05 – 86

Source: Southall et al. (2019).

5.1.1. Lethal Effects and Physical Injury

Because of the increased hazardousness of the shock wave associated with underwater detonations, potential physiological effects include mortality and direct (i.e., non-auditory) tissue damage known as primary blast injury (Finneran and Jenkins, 2012; Robinson *et al*., 2022). Primary blast injuries from explosive detonations are the result of differential compression and rapid re-expansion of adjacent tissues of different acoustic properties (e.g., between gas-filled and fluid-filled tissues or between bone and soft tissues). These injuries usually manifest themselves in the gas-containing organs (lung and gut) and auditory structures (e.g., rupture of the eardrum across the gas-filled spaces of the outer and inner ear).

5.1.2. Auditory Injury

Southall *et al.* (2019)[2] provide thresholds for received sound levels that have the potential to induce the onset of auditory injury in marine mammals (Table 5.2). It is worth noting that the criteria refer only to the 'onset' of injury risk rather than a confident assessment of an occurrence of the effect.

[2] The NMFS (2024) criteria have yet to receive formal sign-off from any of the UK regulators therefore the Southall *et al*. (2019) thresholds have been used to undertake this assessment.

JNCC *et al*. (2010) proposes that a permanent shift in the hearing thresholds (PTS) of an EPS would constitute an injury offence. The Southall *et al*. criteria for injury are based on quantitative sound level and exposure thresholds over which PTS onset could occur (Table 5.2). If it is likely that an EPS could become exposed to sound at or above the levels proposed, then there is a risk that an injury offence could occur.

Table 5.2: Permanent threshold shift (PTS) thresholds

Functional hearing group	Example species	Impulsive		Non-impulsive
		SPL_{peak} (dB re 1 µPa)	SEL (dB re 1 µPa²s)	SEL (dB re 1 µPa²s)
Low frequency cetacean	Minke whale	219	183	199
High frequency cetacean	Bottlenose dolphin White-beaked dolphin	230	185	198
Very high frequency cetacean	Harbour porpoise	202	155	173
Phocid carnivores in water	Harbour seal Grey seal	218	185	201

Source: Southall et al. (2019).

5.1.3. Behavioural Responses

Behavioural responses may arise where an activity is audible (see Table 5.1) and at a level above ambient noise. Due to the very short duration and likely small number of potential acoustic events during the proposed UXO clearance work, behavioural responses are likely to only occur in the very short term (in response to the detonation sequence on a given day should high order clearance be required). Studies looking at the effects of a commercial two-dimensional seismic survey and ADD playbacks on cetaceans in the Moray Firth found that fine-scale behavioural responses by harbour porpoise occurred during the work, but that animals were typically detected again at affected sites within a few hours (Thompson *et al.,* 2013; Thompson *et al.,* 2020). Therefore, following cessation of each detonation event, it is considered likely that any behavioural effects will be reversible and that animals will resume normal behaviour within the short term.

The number of individuals which may exhibit behavioural responses to the proposed UXO clearance (from both low order clearance, high order clearance and high order clearance with noise abatement) was estimated using the default effective deterrence ranges (EDR) for explosives (5 km and 26 km respectively) (JNCC, 2025a)[3].

5.2. Increased Anthropogenic Noise from UXO Clearance Work (Pre-Mitigation)

The predicted impact ranges from the proposed UXO clearance work were modelled by Subacoustech Environmental (Appendix A (Morgan, 2025)). Modelling was carried out for all four marine mammal hearing groups.

Because the pUXO target investigations have yet to take place, a range of UXO types and sizes have been assessed (Table 2.2).

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3 It is recognised that the EDRs for assessing the significance of noise disturbance in harbour porpoise SACs, including from UXO clearance, have recently been updated in England, Wales and Northern Ireland (JNCC, 2025b). However, these were not available at the time of undertaking this assessment and therefore have not been used. As the previous EDRs (as applied here) are larger than those in the updated guidance, this is considered a conservative approach for English waters.

As noted by Morgan (2025; Appendix A), the large number of unknown variables that will affect the output of UXO located for an extended period on the seabed lead to a great degree of uncertainty which makes accuracy challenging in a desktop assessment. The assessment uses calculations based on a methodology proposed by Soloway and Dahl (2014), following Arons (1954) and MTD (1996). It is expected that the presented ranges overestimate the actual ranges of impact that would occur in practice, both from physical sound propagation and biological perspective.

The quantitative assessment has focussed on harbour porpoise, the most common of the species likely to be present in the local area. Where potential impact ranges are greater for other species groups this has been noted.

5.2.1. Lethal Effects and Physical Injury

Although the potential for lethal effects and physical injury has not been modelled it is assumed that, in the absence of mitigation, they may occur as a result of the proposed UXO clearance work should individuals be present in close proximity to any high order detonations.

5.2.2. Auditory Injury (PTS)

The modelled PTS impact ranges relating to both Peak Sound Pressure Level (SPL_{peak}) and Single-Pulse Sound Exposure Level (SEL_{sp}) for each marine mammal hearing group for the various potential charge weights are shown in Table 5.3 below. For low order clearance the greatest of the PTS impact ranges was observed in very high frequency cetaceans at 0.99 km as determined against SPL_{peak} thresholds. For high order clearance the largest impact was from the 722 kg charge weight (including donor) for the SPL_{peak} thresholds, with a PTS impact range of 14 km for very high frequency cetaceans.

Table 5.3: Summary of the impulsive PTS impact ranges for low order and high order UXO clearance for relevant marine mammal hearing groups

Charge weight + donor (kg)	Impact Range (km)							
	Low frequency cetaceans		High frequency cetaceans		Very high frequency cetaceans		Phocid carnivores in water	
	SPL_{peak}	SEL_{sp}	SPL_{peak}	SEL_{sp}	SPL_{peak}	SEL_{sp}	SPL_{peak}	SEL_{sp}
0.25 (low order)	0.17	0.23	0.06	0.05	0.99	0.09	0.19	0.05
30	0.87	2.3	0.28	0.05	4.9	0.6	0.96	0.42
295	1.8	7.2	0.6	0.05	10	1.2	2	1.2
325	1.9	7.5	0.62	0.05	10	1.2	2.1	1.3
456	2.1	8.9	0.7	0.05	12	1.3	2.3	1.5
555	2.3	9.7	0.75	0.06	12	1.4	2.5	1.7
722	2.5	11	0.81	0.06	14	1.5	2.7	1.9

Source: Appendix A (Morgan, 2025)

5.2.2.1. Very High Frequency Cetaceans

The modelled PTS impact ranges for very high frequency cetaceans (harbour porpoise) for the various potential charge weights are shown in Table 5.3. For the low order clearance charge weight modelled the greatest of the PTS ranges (SPL_{peak}) is 0.99 km. For the greatest of the high order charges plus donor (722 kg), the greatest of the PTS ranges (SPL_{peak}) is 14 km.

Using the largest ranges for very high frequency cetaceans (SPL_{peak}), and assuming that spreading is approximately spherical (area = πr^2), the number of harbour porpoise which have the potential to be impacted has been estimated (Table 5.4) using the largest SCANS-IV density estimate from Block NS-D (Table 4.1) where the Marine Scheme is located.

Table 5.4: Number of harbour porpoise with potential to be impacted by PTS pre-mitigation

Charge weight + donor (kg)	SPL_{peak} range (km)	Area (km^2)	Number of individuals	% of reference population	
				MU	UK portion of MU
0.25 (low order)	0.99	3.08	2	0.001	0.001
30	4.9	75.43	45	0.013	0.028
295	10	314.16	189	0.055	0.119
325	10	314.16	189	0.055	0.119
456	12	452.39	273	0.079	0.171
555	12	452.39	273	0.079	0.171
722	14	615.75	371	0.107	0.232

5.2.2.2. High Frequency Cetaceans

The modelled PTS impact ranges for high frequency cetaceans (bottlenose dolphin and white-beaked dolphin) for the various potential charge weights are shown in Table 5.3. For the low order clearance charge weight modelled the greatest of the PTS ranges (SPL_{peak}) is 0.06 km. For the greatest of the high order charges plus donor (722 kg), the greatest of the PTS ranges (SPL_{peak}) is 0.81 km.

Using the largest ranges for high frequency cetaceans (SPL_{peak}), and assuming that spreading is approximately spherical (area = πr^2), the number of bottlenose dolphins which have the potential to be impacted has been estimated (Table 5.5) using the largest SCANS-IV density estimate from Block NS-C (Table 4.2) where the Marine Scheme is located.

Using the largest ranges for high frequency cetaceans (SPL_{peak}), and assuming that spreading is approximately spherical (area = πr^2), the number of white-beaked dolphins which have the potential to be impacted has been estimated (Table 5.6) using the largest SCANS-IV density estimate from Block NS-D (Table 4.3) where the Marine Scheme is located.

Table 5.5: Number of bottlenose dolphin with potential to be impacted by PTS pre-mitigation

Charge weight + donor (kg)	SPL_{peak} range (km)	Area (km^2)	Number of individuals	% of reference population	
				MU	UK portion of MU
0.25 (low order)	0.06	0.01	<1	<0.001	<0.001
30	0.28	0.25	<1	0.001	0.001
295	0.6	1.13	<1	0.002	0.003
325	0.62	1.21	<1	0.003	0.003
456	0.7	1.54	<1	0.003	0.003
555	0.75	1.77	<1	0.004	0.004
722	0.81	2.06	<1	0.004	0.005

Table 5.6: Number of white-beaked dolphin with potential to be impacted by PTS pre-mitigation

Charge weight + donor (kg)	SPL_{peak} range (km)	Area (km^2)	Number of individuals	% of reference population	
				MU	UK portion of MU
0.25 (low order)	0.06	0.01	<1	<0.001	<0.001
30	0.28	0.25	<1	<0.001	<0.001
295	0.6	1.13	<1	<0.001	<0.001
325	0.62	1.21	<1	<0.001	<0.001
456	0.7	1.54	<1	<0.001	<0.001
555	0.75	1.77	<1	<0.001	<0.001
722	0.81	2.06	<1	<0.001	<0.001

5.2.2.3. Low Frequency Cetaceans

The modelled PTS impact ranges for low frequency cetaceans (minke whale) for the various potential charge weights are shown in Table 5.3. For the low order clearance charge weight modelled the greatest of the PTS ranges (SEL_{sp}) is 0.23 km. For the greatest of the high order charges plus donor (722 kg), the greatest of the PTS ranges (SEL_{sp}) is 11 km.

Using the largest ranges for low frequency cetaceans (SEL_{sp}), and assuming that spreading is approximately spherical (area = πr^2), the number of minke whales which have the potential to be impacted has been estimated (Table 5.7) using the largest SCANS-IV density estimate from Block NS-D (Table 4.4) where the Marine Scheme is located.

Table 5.7: Number of minke whale with potential to be impacted by PTS pre-mitigation

Charge weight + donor (kg)	SPL_{peak} range (km)	Area (km^2)	Number of individuals	% of reference population	
				MU	UK portion of MU
0.25 (low order)	0.23	0.17	<1	<0.001	<0.001
30	2.3	16.62	1	0.003	0.007
295	7.2	162.86	7	0.034	0.066
325	7.5	176.71	7	0.037	0.072
456	8.9	248.85	10	0.052	0.101
555	9.7	295.59	12	0.062	0.120
722	11	380.13	16	0.079	0.155

5.2.3. Behavioural Responses

To estimate the number of individuals which have the potential to be exposed to sound levels which may induce a behavioural response, the following EDRs (for harbour porpoise) were used for all species as outlined in Section 5.1.3:

- Low order clearance: 5 km (JNCC, 2025a); and

- High order clearance: 26 km (JNCC, 2025a).

The area of the zone of potential effect (assuming that spreading is approximately spherical) was calculated using the equation area = πr^2 where r = 5 for low, and 26 for high, order clearance and equates to:

- Low order clearance: 78.5 km^2; and
- High order clearance: 2123.7 km^2.

The number of individuals with potential to be present within these zones was then estimated using the density information presented in Section 5 for both low order (Table 5.8) and high order clearance (Table 5.9).

Table 5.8: Number of individuals which may exhibit behavioural responses following low order clearance using the 5 km EDR (JNCC, 2025a)

Species	Number of individuals	% of reference population	% of UK portion of reference population
Harbour porpoise	47	0.014	0.030
Bottlenose dolphin	3	0.163	0.175
White-beaked dolphin	6	0.014	0.018
Minke whale	3	0.016	0.032

Table 5.9: Number of individuals which may exhibit behavioural responses following high order clearance using the 26 km EDR (JNCC, 2025a)

Species	Number of individuals	% of reference population	% of UK portion of reference population
Harbour porpoise	1280	0.369	0.802
Bottlenose dolphin	89	4.401	4.721
White-beaked dolphin	170	0.386	0.499
Minke whale	89	0.442	0.865

5.3. Increased Anthropogenic Noise from Use of USBL Equipment

It is likely that USBL equipment will be used if ROVs are being used, for example to place donor charges. The typical frequency range of USBLs is 18-55 kHz which is within the hearing range of marine mammals (see Table 5.1). As long as the source level of the USBLs used is less than 202 dB re 1 μPa (the lowest of the SPL_{peak} thresholds for auditory injury) there is no potential for auditory injury (USBLs typically have source levels of c.194 dB re 1 μPa). JNCC (2020) suggests an EDR of 5 km be applied to geophysical surveys (a suitable proxy for using USBL systems); however use of ROVs necessitating use of USBL is likely to only be required periodically, and for short durations. Furthermore, the EDR for USBL is the same as that for low order UXO clearance and falls well within that of high order UXO clearance, so is therefore suitably accounted for within the current assessment.

5.4. Risk of Collision with Vessels

The presence of a small number of UXO clearance/guard vessels will be very spatially and temporally limited and is not considered to notably increase vessel traffic in the area above baseline levels. The vessels will either be stationary or moving slowly during the proposed work. Where possible and appropriate, vessels will not exceed 14 knots when transiting to and between work sites.

The species present within the inshore and offshore waters around the subsea cable route are considered to be habituated to the presence of vessels. They are predominately small and agile making them less susceptible to collisions than, for example, large whale species.

Although the consequences of a collision (i.e., mortality, injury) may be severe, the likelihood of occurrence is very low for these species in this area and therefore the risk is considered to be negligible for both EPS, seals and basking sharks. Nonetheless, during transits, when vessel speed may be greater, transit watches (section 6.2) will be conducted.

5.5. Changes in Turbidity

Unlike low order, high order detonation of UXOs (should they be required) is likely to cause a temporary local increase in suspended sediment concentrations (SSCs) and therefore turbidity. Although SSCs may have settled by the time animals return to the UXO location, marine mammals are used to navigating and foraging in highly turbid environments (e.g., areas where the tide is running) and are therefore expected to be unaffected by such perturbations. Only a small area will be affected, with suitable alternative habitat being available locally in the meantime. The risk of changes in turbidity affecting navigation and foraging success are therefore considered to be negligible.

6. Mitigation Measures

6.1. UXO Clearance

In order to ensure the absence of marine EPS, basking sharks and seals in the vicinity of the clearance work mitigation will be put in place. This mitigation has been designed around the greatest (i.e., worst case) potential impact ranges which are those for very high frequency cetaceans (i.e., harbour porpoise). If the potential impacts on harbour porpoise are predicted to be negated through mitigation, this will also be the case for all other marine megafauna species.

The mitigation follows:

- The JNCC guidelines for minimising the risk of injury to marine mammals from UXO clearance (JNCC, 2025c);
- The Marine environment: unexploded ordnance clearance Joint Position Statement which states that low noise methods of clearance should be the default clearance method (DEFRA *et al*., 2025);
- The 2023 JNCC guidance for the use of Passive Acoustic Monitoring (PAM) in UK waters for minimising the risk of injury to marine mammals from offshore activities (JNCC, 2023); and
- The EGL1 Marine Mammal Mitigation Protocol (MMMP) for UXO Clearance (doc ref: 1369788).

The proposed mitigation is summarised in Table 6.1.

Table 6.1: Summary of mitigation.

Approach	Mitigation Measures
Micro-siting of the subsea cable route	The subsea cable route will be 'micro-sited' to avoid the UXO and prevent the need for a detonation where deemed safe to do so
Lift and shift	The 'lift and shift' approach (to move the UXO to another location) will be considered on a case-by-case basis where deemed safe to do so
Low order clearance	Pre-work search (min. 60 mins) Low order clearance Post-detonation search (min. 15 mins)
High order clearance	Pre-work search (min. 60 mins) Use of an ADD (see Table 6.2) Use of a NAS (UXO >30 kg) High order clearance Post-detonation search (min. 15 mins)

Further details on the mitigation are:

- Methods to avoid the need for UXO clearance will be considered for every cUXO in the first instance. If deemed safe do so alternative methods include:
  - Micro-siting i.e., avoidance of UXO; and
  - Relocation ('lift and shift') of UXO (where deemed safe to do so)[4].
- Work will only commence during the hours of daylight and in good weather conditions (i.e., when conditions are suitable for visual monitoring and visibility exceeds 1 km (so the entire mitigation zone can be seen) and sea state is below Beaufort sea state 4).

[4] It should be noted that if relocation ('lift and shift') of any UXO is undertaken, and it is deemed that there is a potential of detonation, then the full mitigation procedure for the corresponding UXO charge weight should be undertaken.

- Low order clearance methods will be used in the first instance. Three attempts will be made before moving to high order clearance methods. High order clearance will only be used by exception with evidence provided to demonstrate that low order clearance has not been successful;
- At least two dedicated Marine Mammal Observers[5] (MMOs) and one dedicated PAM operator[6] will conduct a minimum 60-minute visual and passive acoustic pre-work search of a 1 km radius mitigation zone to ensure the absence of marine mammals in the zone prior to the start of operations. The MMOs and PAM equipment and operator will be positioned such that they can effectively search the mitigation zone. Should a marine mammal be detected in the mitigation zone during the pre-work search by the MMOs or PAM operator, and it cannot be confirmed that the animal has moved out of the mitigation zone at the end of the search, a minimum of a 20-minute delay from the time of the last detection will be required prior to any clearance work taking place;
- For all high order UXO clearance an ADD will be used to encourage animals to flee from the zone of potential harm. Indicative periods of ADD use are shown in Table 6.2. The ADD used will be selected based on its effectiveness to adequately deter the marine megafauna species of concern in the area around the subsea cable route (McGarry *et al.,* 2020).
- Where required, the ADD procedure will start after at least 30 minutes of the pre-work search has been conducted. The pre-work search by both the MMOs and PAM operator will continue throughout the period of ADD use and during the detonation procedure;
- Where high order clearance of > 30 kg in weight is planned, a NAS (e.g., bubble curtain) will be used in order to reduce potential noise impacts (JNCC, 2025c). It is thought that using a NAS will result in a 6 dB reduction in peak sound pressure level and therefore reduce the radius, within which the level is above a given threshold, by around half (as a minimum), and the corresponding area by about 75% (Verfuss *et al.* 2019); and
- Following detonation of the UXO, a visual search of at least 15 minutes' duration will be conducted within the mitigation zone by the MMOs and PAM operator (JNCC, 2025c).

Table 6.2: Outline of mitigation (pre-work search and indicative periods of ADD use) time for each UXO charge weight (plus donor charge)

Clearance type	UXO charge weight (kg)	Noise Abatement Required	Visual and PAM pre-work search (mins)		Total mitigation time (mins)
			Pre-ADD use search	Period of ADD use	
Low order	0.25	NAS Not Required	60	0	60
High order	30		30	44	74
	295	NAS Required	30	45	75
	325		30	45	75
	456		30	56	86
	555		30	56	86
	722		30	67	97

5 MMOs will be trained (i.e., JNCC MMO certified) and experienced (i.e., experienced MMOs will have at least 20 weeks of experience within UK waters over the past 10 years (and be familiar with the identification of the marine mammal species likely to be encountered in the area) and practical experience of implementing the JNCC guidelines. Newly qualified MMOs will not work in isolation for their first few jobs).

6 PAM operators will be suitably trained and have an appropriate level of experience of conducting PAM for mitigation (i.e., experienced PAM operators will have at least 20 weeks of experience and newly qualified PAM operators should not work in isolation for their first five PAM jobs (JNCC, 2023b)).

6.2. Transit Watches

An observer on the bridge of all vessels will keep watch for marine EPS, basking sharks and seals during all transits to and from the work sites. Any sightings will be communicated to the Officer on watch as soon as is practicable who will ensure that marine EPS, basking sharks and seals are avoided where safe to do so. At all times the Officer on watch will minimise high powered manoeuvres or rapid changes of course, where this does not impair safety, to avoid collisions.

The observer may be the Master of the vessel, a member of the bridge crew, another member of the ship's crew or a MMO as appropriate. Observers and the vessel operator will be briefed on the Scottish Marine Wildlife Watching Code[7] and Basking Shark Code of Conduct[8].

7 Scottish Marine Wildlife Watching Code | NatureScot

8 Download.ashx (sharktrust.org)

7. Assessment of Potential for Residual (Post-Mitigation) Effects from Increased Anthropogenic Noise from UXO Clearance Work

7.1. Lethal Effects and Physical Injury

It is likely that the visual and passive acoustic pre-work search of the (1 km radius) mitigation zone alone will be sufficient to negate the potential for lethal effects and physical injury in marine megafauna species. With this, in combination with the other mitigation procedures outlined in Table 6.1, individuals will not be present in close proximity to the proposed UXO clearance work and the potential for lethal effects and physical injury is nil.

7.2. Auditory Injury

It is likely that pre-work searches (1 km radius zone) alone will be sufficient to negate the potential for auditory injury as a result of low order clearance work using a 0.25 kg initiation explosive. The use of an ADD or NAS will not be required (Table 6.2).

For all high order UXO clearance ADD use will be required to ensure no individuals will be present in the zone of potential effect for auditory injury. The ADD use durations were calculated based on the time needed to clear the greatest (i.e., worst case) potential impact ranges (which are the SPL_{peak} ranges for very high frequency cetaceans (i.e., harbour porpoise) (Table 6.2)) for each UXO charge weight using a conservative flee speed of 1.5 m/s[9]. The ADD durations were adjusted to include the 1 km mitigation zone cleared during the pre-work search and the reduction in PTS impact range from the use of a NAS for high order clearance >30 kg.

With the implementation of the mitigation measures (pre-work search, use of an ADD and NAS) outlined in Table 6.1 and Table 6.2, no individuals of any marine megafauna species will be present within the zone of potential effect for auditory injury for either low order or high order UXO clearance.

7.3. Behavioural Responses

Behavioural responses will likely be short term; Thompson *et al*. (2020) showed that the minimum time to the first porpoise detection following a 15 minute ADD playback was 133 minutes for all C-PODs within 1 km of the playbacks. Suitable local alternative habitat is likely to be available in the meantime therefore the energetic costs of fleeing should be able to be met relatively quickly. Because each piece of clearance work will only take a few hours, it is unlikely that animals will be excluded from key areas for significant periods of time.

For low order clearance, the number of individuals which have the potential to be exposed to sound levels which may induce a behavioural response is the same as pre-mitigation (not withstanding that the 1 km mitigation zone will be clear of animals following the pre-work search) (Table 5.8).

Behavioural responses (for high order clearance) will not be reduced through use of an ADD because this approach relies on inducing a behavioural response in order that animals move out of the area of a more deleterious potential effect. As such, the number of individuals likely to exhibit a behavioural response from clearance of UXO ≤ 30 kg (i.e. without the use of a NAS) will be similar to the number estimated pre-mitigation (Table 5.9).

The potential for behavioural responses will be reduced by use of a NAS for high order clearances > 30 kg. The 15 km EDR for harbour porpoises provided in the JNCC Marine Noise Registry Help and Guidance (JNCC, 2025a) for high order UXO clearance with noise abatement has been used to estimate the number of individuals in the zone (the area of which is 706.9 km^2) which may exhibit behavioural responses for all species (Table 7.1). Behavioural

[9] A conservative flee speed of 1.5 m/s was chosen to be representative of all marine mammal species assessed.

responses will not be reduced through use of an ADD because this approach relies on inducing a behavioural response in order that animals move out of the zone of a more deleterious potential effect.

Table 7.1: Number of individuals which may exhibit behavioural responses following high order UXO clearance with noise abatement using the 15 km EDR (JNCC, 2025a)

Species	Number of individuals	% of reference population	% of UK portion of reference population
Harbour porpoise	426	0.123	0.267
Bottlenose dolphin	30	1.465	1.571
White-beaked dolphin	56	0.129	0.166
Minke whale	30	0.147	0.288

8. Assessment of Potential Offence

8.1. Increased Anthropogenic Noise from UXO Clearance Work

The conclusions of the assessment of residual (post-mitigation) effects as a result of the proposed UXO clearance work are as follows:

- The potential for lethal effects and physical injury is nil for all species;
- For low order clearance, the potential for auditory injury is nil for all species;
- For high order clearance, the potential for auditory injury is nil for all species;
- Behavioural responses will likely be short term therefore the energetic costs of fleeing should be able to be met relatively quickly. In line with the definition provided by JNCC *et al*. (2010a), this level of disturbance is sporadic without any likely negative impact on the species and therefore considered to be “trivial”.

In the context of the Regulations applicable to Scottish territorial waters (i.e. within 12NM), this potential for a temporary behavioural response by a small number of individuals constitutes an offence. However, this action is not considered to be detrimental to the maintenance of the populations of the species concerned at a FCS in their natural range. Therefore, an EPS licence (to disturb) will be required and can be granted for the UXO clearance work.

In the context of the Regulations applicable to English territorial waters, and both Scottish and English offshore waters (i.e. beyond 12NM), this potential for a temporary behavioural response by a small number of individuals does not constitute an offence. Therefore, EPS and Marine Wildlife Licences (to disturb) will not be required for this aspect of the UXO clearance work.

8.2. Increased Anthropogenic Noise from Use of USBL Equipment

The conclusions of the assessment of effects as a result of increased anthropogenic noise from use of USBL equipment are as follows:

- There is no potential for auditory injury; and
- Potential for disturbance is short-term, sporadic, and without any likely negative impact on the species – and therefore considered to be “trivial”.

This potential impact is not considered to be detrimental to the maintenance of the population of the species concerned at an FCS in their natural range. As such, an EPS licence (to disturb) can be awarded for this aspect of the UXO clearance work in Scottish territorial waters.

In English territorial waters, and both Scottish and English offshore waters, EPS and Marine Wildlife Licences (to disturb) will not be required for this aspect of the work.

8.3. Risk of Collision with Vessels

The risk of collision with vessels involved in the proposed UXO clearance work is negligible for the species likely to be present in this area. Nonetheless, watches will be undertaken during transits whilst vessels will be moving more quickly (see section 6.2).

This potential impact is not considered to be detrimental to the maintenance of the population of the species concerned at an FCS in their natural range and does not constitute an offence, therefore EPS, basking shark and Marine Wildlife Licences will not be required for this aspect of the proposed work.

8.4. Changes in Turbidity

The risk of changes in turbidity affecting navigation and foraging success of species likely to be present in this area is negligible.

This potential impact is not considered to be detrimental to the maintenance of the population of the species concerned at an FCS in their natural range and does not constitute an offence therefore EPS, basking shark and Marine Wildlife Licences will not be required for this aspect of the proposed work.

9. Summary

This assessment of the potential impacts on EPS, seals and basking sharks from activities associated with UXO Clearance work along the Eastern Green Link 1 subsea cable route (increased anthropogenic noise from UXO clearance work, increased anthropogenic noise from use of USBL equipment, risk of collision with vessels and changes in turbidity) concluded that with the application of mitigation measures:

- The potential for auditory injury is nil for all species from both low and high order UXO clearance;
- There is considered to be potential for a temporary behavioural response by a small number of animals in response to both low and high order UXO clearance and the use of USBL equipment;
- The potential for collision with vessels is considered to be negligible for all species; and
- The risk of changes in turbidity affecting navigation and foraging success of all species is negligible.

In the context of the Regulations applicable to Scottish territorial waters (i.e. within 12NM), this potential for a temporary behavioural response by a small number of individuals from UXO clearance work constitutes an offence. However, this action is not considered to be detrimental to the maintenance of the populations of the species concerned at a FCS in their natural range. Therefore, an EPS licence (to disturb) will be required and can be granted for the UXO clearance work in Scottish territorial waters.

In the context of the Regulations applicable to English territorial waters, and both Scottish and English offshore waters (i.e. beyond 12NM), this potential for a temporary behavioural response by a small number of individuals from UXO clearance work does not constitute an offence. Therefore, EPS and Marine Wildlife Licences (to disturb) will not be required for this aspect of the UXO clearance work.

The potential impacts from collision with vessels and changes in turbidity are not considered to be detrimental to the maintenance of the population of the species concerned at an FCS in their natural range and does not constitute an offence. Therefore, EPS, basking shark and Marine Wildlife Licences will not be required for these aspects of the proposed work.

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Reviews.

Appendices

A. UXO Clearance at EGL1: Underwater Noise Impact Assessment (Morgan, 2025)

UXO Clearance at EGL1: Underwater Noise Impact Assessment

[Redacted]

31st October 2025

Subacoustech Environmental Report No. P426R0104

Submitted to: [Redacted]

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This report is a controlled document. The report documentation page lists the version number, record of changes, referencing information, abstract and other documentation details.

Executive Summary

An assessment has been undertaken to model the potential effects of underwater noise on marine mammals and fish from planned unexploded ordinance (UXO) clearance, associated with the development of Eastern Green Link 1 in the North Sea. The assessment covers clearance of various UXO targets using both high-order detonation and low-order deflagration (which does not produce a detonation beyond the donor charge), though low-order deflagration is being prioritised wherever feasible.

Predictions of the sound levels generated by these activities were made using the methodology outlined in Soloway and Dahl (2014). These predictions were then interpreted using the guidelines provided in Southall *et al.* (2019) for marine mammals, and Popper *et al*. (2014) for fish, to estimate the impact of the sound levels on these receptors. The largest distance predicted for the risk of permanent auditory injury in marine mammals from a low order deflagration, as per Southall et al. (2019) impact criteria, is for harbour porpoise under the $L_{p,\mathrm{pk}}$ metric, if they are within 990 m. Using the $L_{E,p,\mathrm{wtd}}$ metric, LF cetaceans have the largest permanent auditory injury range of all marine mammals of 230 m from the source. All types of fish morphologies, as per Popper et al. (2014) are at risk of mortality or potential mortal injury if they are within 70 m of a low order deflagration, according to the $L_{p,\mathrm{pk}}$ metric. In the event of a high order detonation, all impact ranges are much greater, although this is not expected.

Finally, it should be highlighted that recent research has shown that Soloway and Dahl (2014) could overestimate $L_{p,\mathrm{pk}}$ noise levels but under-estimate $L_{E,p,\mathrm{wtd}}$ noise levels in some instances. Additionally, their predictions do not account for environmental factors, so the estimated impact ranges should be viewed as indicative of potential effects on receptors during UXO clearance

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Terminology

Decibel (dB)	A customary scale commonly used (in various ways) for reporting levels of sound. The dB represents a ratio/comparison of a sound measurement (e.g sound pressure) over a fixed reference level. The dB symbol is followed by a second symbol identifying the specific reference value (e.g., re 1 µPa).
Peak pressure	The highest pressure above or below ambient that is associated with a sound wave.
Peak-to-peak pressure	The sum of the highest positive and negative pressures that are associated with a sound wave.
Permanent Threshold Shift (PTS)	A permanent total or partial loss of hearing caused by acoustic trauma. PTS results in irreversible damage to the sensory hair cells of the ear, and thus a permanent reduction of hearing acuity.
Root Mean Square (RMS)	The square root of the arithmetic average of the squared pressures. Used as a measure of the average sound pressure level.
RMS Sound Pressure Level ($L_{p,\mathrm{RMS}}$)	The RMS sound pressure expressed in dB. One measure used to characterise impulsive sound. (dB re 1 µPa)
Sound Exposure Level (SEL or $L_{E,p}$)	The constant sound level acting for one second, which has the same amount of acoustic energy, as indicated by the square of the sound pressure, as the original sound. It is the time-integrated, sound-pressure-squared level that is typically used to compare transient sound events having different time durations, pressure levels, and temporal characteristics.
Sound Exposure Level, single pulse ($\mathrm{SEL}_{\mathrm{sp}}$ or $L_{E,p,sp}$)	Calculation of the sound exposure level representative of a single noise impulse, typically a pile strike.
Sound Pressure Level (SPL or L_p)	The sound pressure level is an expression of sound pressure using the decibel (dB) scale; the standard frequency pressures of which are 1 µPa for water and 20 µPa for air.
Sound Pressure Level Peak ($\mathrm{SPL}_{\mathrm{peak}}$ or $L_{p,\mathrm{pk}}$)	The highest (zero-peak) positive or negative sound pressure, in decibels.
Temporary Threshold Shift (TTS)	Temporary reduction of hearing acuity because of exposure to sound over time. The mechanisms underlying TTS are not well understood, but there may be some temporary damage to the sensory cells. The duration of TTS varies depending on the nature of the stimulus.
Unweighted sound level	Sound levels which are “raw” or have not been adjusted in any way, for example to account for the hearing ability of a species.
Weighted sound level	A sound level which has been adjusted with respect to a “weighting envelope” in the frequency domain, typically to make an unweighted level relevant to a particular species.

Units

dB	Decibel (sound pressure)
kg	Kilogram (mass)
km	Kilometre (distance)
m	Metre (distance)
ms^{-1}	Metres per second (speed)
Pa	Pascal (pressure)
Pa^2s	Pascal squared seconds (acoustic energy)
µPa	Micropascal (pressure)

Acronyms

EGL1	Eastern Green Link 1
HF	High-Frequency Cetaceans
LF	Low-Frequency Cetaceans
NEQ	Net Explosive Quantity
PCW	Phocid Carnivores in Water
PPV	Peak Particle Velocity
PTS	Permanent Threshold Shift
SE	Sound Exposure
SEL ($L_{E,p}$)	Sound Exposure Level
SEL_{sp} ($L_{E,p,sp}$)	Single Pulse Sound Exposure Level
SPL	Sound Pressure Level
SPL_{peak} ($L_{p,pk}$)	Peak Sound Pressure Level
$SPL_{peak\text{-}to\text{-}peak}$ ($L_{p,pk\text{-}pk}$)	Peak-to-peak Sound Pressure Level
SPL_{RMS} ($L_{p,RMS}$)	Root Mean Squared Sound Pressure Level
TTS	Temporary Threshold Shift
VHF	Very High-Frequency Cetaceans
UXO	Unexploded Ordinance

1 Introduction

1.1 Project Overview

Natural Power have requested an underwater noise assessment for anticipated unexploded ordinance (UXO) clearance activities related to the construction of the Eastern Green Link 1 (EGL1) underwater cable, located in the North Sea, UK. EGL1 is a planned 196 km cable under the seabed, running from Thorntonloch Beach in East Lothian, Scotland to the beach just north of Seaham in County Durham, England. Before construction can begin, there is a potential need to clear UXO currently located on or close to the seabed along the planned cable route. These activities are likely to generate high levels of underwater noise that may impact marine life. Therefore, as part of a Marine License application for UXO clearance, the potential noise levels associated with the UXO clearance and impacts this may have on relevant marine fauna in the region must be assessed.

This report provides the results and findings of the underwater noise assessment of the anticipated UXO clearance activities. The assessment predicts sound pressure levels and sound exposure levels generated during these activities, which are used to assess the impact of these levels on sensitive marine animals in the region, with particular focus on the impact on marine mammals and fish.

1.2 Sound Sources

Various UXO devices requiring clearance could be present on site, with sizes ranging from 25 kg to 697 kg. This is based on the range of devices that have been found in similar projects in the North Sea, although this has not yet been confirmed by survey on the EGL1 route. Both high-order (full detonation of the device) and low order (destruction of the device without detonation) clearance scenarios have been assessed, although a low order technique is being prioritised wherever feasible. Source noise level and propagation produced by the techniques are provided in Sections 3.1 and 3.2.

1.3 Document Overview

This report presents a detailed assessment of the potential underwater noise from the anticipated UXO clearance activities in the North Sea, and covers the following:

- Section 2: Review of background information on measuring and assessing underwater noise.
- Section 3: Discussion of the method for sound level prediction, including assumptions for these estimates.
- Section 4: Interpretation of the results using suitable noise metrics and criteria.
- Section 5: Discussion
- Section 6: Summary and Conclusion

2 Underwater Noise Concepts

Sound travels much faster in water (approximately 1,500 ms^{-1}) than in air (343 ms^{-1}) as water is relatively incompressible and has a higher density than air. This affects the way in which sound measurements are expressed between the two mediums, which means that underwater sound levels are not directly comparable to airborne sound levels. This is noted for context but this report does not contain or include any reference to airborne sound levels.

2.1 Units of Measurement

Sound measurements are usually expressed using the decibel (dB) scale, which is a logarithmic measure of sound. The dB scale represents a ratio, and therefore, it is used with a reference unit, which is the base from which the ratio is expressed. The fundamental definition of the dB scale is given in in Equation 1:

(1)

$$Sound\ pressure\ level\ (L_p) = 20\log_{10}\left(\frac{P}{P_{ref}}\right)$$

where P is pressure, measured in Pascals (Pa), and P_{ref} is the reference pressure, given as 1 µPa ($1x10^{-6}$ Pa) as defined in ISO 18405:2017 for underwater noise. Noise can be quantified using various metrics depending on the nature of the sound, as discussed below.

2.1.1 Sound Pressure Level

Sound Pressure Level (SPL or L_p) is a measure of the pressure variation caused by sound waves, expressed in decibels (dB), as seen in Equation 1. Variations of L_p are used depending on the noise source being measured. Unless otherwise defined, all L_p noise levels in this report are referenced to 1 µPa.

2.1.1.1 Level of the Mean Squared Sound Pressure

An unweighted sound pressure level, averaged over a measurement period, known as a root mean squared (RMS) sound pressure level (SPL_{RMS} or $L_{p,RMS}$), can be used to represent the noise levels. The $L_{p,RMS}$ can vary significantly depending on the measurement duration.

2.1.1.2 Level of the Peak Sound Pressure

Transient, impulsive pressure waves, such as generated from explosions are usually expressed using the level of peak sound pressure (SPL_{peak} or $L_{p,pk}$). This is calculated using the maximum pressure variation from positive to zero, representing the peak change in pressure as the transient wave propagates. A further variation of this is the peak-to-peak sound pressure level ($SPL_{peak\text{-}peak}$ or $L_{p,pk\text{-}pk}$) which considers the maximum pressure variation from positive to negative. For a symmetrically distributed wave, the peak-to-peak pressure is twice the peak level, or 6 dB higher.

2.1.2 Sound Exposure Level

Sound Exposure Level (SEL or $L_{E,p}$) is a measure of Sound Exposure (SE), which represents the total acoustic energy of a sound event in decibels (dB), accounting for both the sound's intensity and duration. $L_{E,p}$ provides a way to quantify the total energy in a sound, making it useful for assessing the impact of both continuous and transient sounds. Variations of $L_{E,p}$ are used depending on the noise source being measured. For context, $L_{E,p}$ can be compared $L_{p,\mathrm{RMS}}$ using Equation 2:

(2)

$$L_{E,p} = L_{p,RMS} + 10 \times \log_{10} T$$

where the $L_{p,RMS}$ is a measure of the average level of broadband noise and the $L_{E,p}$ sums the cumulative broadband noise energy. For continuous sounds shorter than one second, the $L_{E,p}$ is lower than the $L_{p,RMS}$. For durations longer than one second, the $L_{E,p}$ exceeds the $L_{p,RMS}$ (e.g., a 10-second sound results in a 10 dB higher $L_{E,p}$ and a 100-second sound results in a 20 dB higher $L_{E,p}$). Unless otherwise defined, all $L_{E,p}$ noise levels in this report are referenced to 1 µPa²s.

2.1.2.1 Single Pulse Sound Exposure Level

Single Pulse Sound Exposure Level (SEL_{sp} or $L_{E,p,sp}$) refers to the total acoustic energy from a single, loud, short duration noise event (such as a blast or impact) measured over a specified duration. This can be expressed using Equation 3:

$$L_{E,p,sp} = 10 \times \log_{10} \left(\frac{\int_0^T p^2(t)dt}{p^2{}_{ref} T_{ref}} \right) \quad (3)$$

where p is the acoustic pressure in Pascals, T is the total duration of sound in seconds, and t is time in seconds.

Since explosives are a single event which therefore generate only a single pulse that does not accumulate, reference to single pulse in the notation is not necessary and $L_{E,p}$ will be used to describe all SE metrics.

2.2 Properties of Sound

Sound can be categorised loosely into two types: impulsive and non-impulsive. These can be defined as:

- Impulsive: a sound with a high peak sound pressure, short duration, fast rise-time and broad frequency content at the source. (e.g seismic airguns, explosives (including UXO clearance), impact piling)
- Non-impulsive: a steady-state sound. It does not necessarily have to have a long duration (e.g vibropiling, drilling)

These differences are crucial for assessing auditory injury, as impulsive sound is typically more harmful than non-impulsive sound. Different metrics are needed to describe these distinct sound sources:

- Impulsive: Use $L_{p,pk}$, $L_{E,p,sp}$ etc.
- Non-impulsive: Use $L_{p,RMS}$ etc.

Noise from UXO clearance will be assumed to be impulsive in this assessment.

2.3 Analysis of Environmental Effects: Assessment Criteria

Over the past 20 years, it has become clear that human-generated underwater noise impacts marine animals. The severity of these effects depends on factors like sound level, frequency, exposure duration, and repetition rate (Hastings and Popper, 2005). As a result, research on aquatic animals' hearing abilities has grown, with studies focused on high-level sound sources such as seismic airguns, impact piling, and blasting, which have the most immediate environmental effects, though interest in chronic sound exposure is rising.

The impacts of underwater sound on marine animals can be broadly summarised as follows:

- Physical traumatic injury and fatality.
- Auditory injury (either permanent or temporary).

The following sections outline the underwater noise criteria used in this study for marine mammals and fish in the North Sea.

2.3.1 Marine Mammals

2.3.1.1 Southall *et al.* (2019): Auditory Injury (PTS and TTS) criteria

Southall *et al*. (2019) is one of the most recognised references for marine mammal hearing thresholds and aligns with the thresholds provided in the National Marine Fisheries Service (NMFS, 2018) guidance. At the time of undertaking the assessment in April, although NMFS (2024) had been published as an updated weighting criteria and impact threshold, no UK regulators had provided guidance that the updated thresholds were acceptable and should be used in modelling assessments. Therefore, at the time of assessment Southall *et al.* (2019) was the most trusted criteria.

The Southall *et al.* (2019) guidance categorises marine mammals into groups based on species with similar auditory capabilities and applies filters to the unweighted noise levels to approximate their hearing sensitivities. These groups are summarised in Table 2-1, with auditory weighting functions in Figure 2-1. Additional groups for sirenians and other marine carnivores are provided but not included in this study, as these species are not common in the North Sea. It should be noted that the inclusion of "wtd" in $L_{E,p,wtd}$ notation refers to a $L_{E,p}$ with an appropriate Southall *et al.* (2019) marine mammal weighting function applied.

Table 2-1: Marine mammal hearing groups (from Southall et al., 2019).

Hearing group	Auditory Weighting Function	Generalised hearing range	Species group	Example species
Low-frequency Cetaceans	LF	7 Hz to 35 kHz	Baleen whales	Sei Whale, Fin Whale, Minke Whale, Humpback Whale
High-frequency Cetaceans	HF	150 Hz to 160 kHz	Toothed whales, including dolphins and beaked whales	Bottlenose Dolphin, White-beaked Dolphin, Risso's Dolphin, Common Dolphin, Orca, Sperm Whale, Pilot Whale, Northern Bottlenose Whale
Very high-frequency Cetaceans	VHF	275 Hz to 160 kHz	True porpoise	Harbour porpoise
Phocid carnivores in water	PCW	50 Hz to 86 kHz	True seals	Harbour seal, Grey Seal

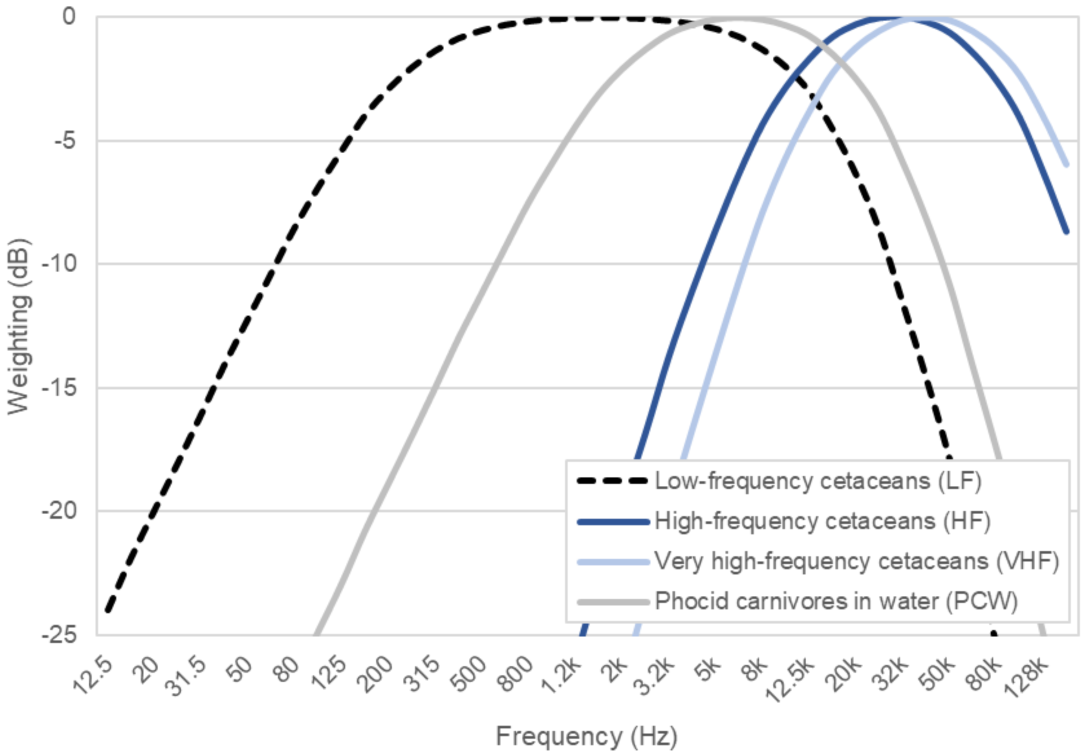

Figure 2-1: Auditory weighting functions for low-frequency cetaceans (LF), high-frequency cetaceans (HF), very high-frequency cetaceans (VHF), and phocid carnivores in water (PCW) (from Southall et al., 2019)

Southall *et al.* (2019) presents noise impact thresholds for marine mammal groups based on:

- The sound type (impulsive vs non-impulsive)
- The type of auditory injury of concern

Impact ranges based on impulsive criteria are recommended for most sources, except clearly non-impulsive ones. However, if the predicted range exceeds 3.5 km (see Section 1.2.1), the true impact range is likely to lie between the impulsive and non-impulsive ranges. Thus, both criteria are considered unless the sound source is explicitly non-impulsive.

Southall *et al.* (2019) presents specific impact thresholds for impulsive and non-impulsive sounds, based on different levels of auditory injury associated the characteristics of these sounds. Auditory injury is categorised into two types:

- PTS (permanent threshold shift): the greatest severity, which is unrecoverable (but incremental) reduction in hearing sensitivity.
- TTS (temporary threshold shift): the least severity, which is a short-term reduction in hearing sensitivity.

TTS represents the potential auditory impact with the most extensive range, but PTS represents the most significant and permanent impairment, making it the key impact threshold.

Since UXO detonations are an impulsive sound source, this study considered the impulsive sound criteria for marine mammal PTS and TTS thresholds from Southall *et al.* (2019), which is summarised in Table 2-2. However, since the sound is expected to propagate beyond 3.5 km from the source, the non-impulsive sound criteria has also been considered, which is summarised in Table 2-3.

Table 2-2: The Southall et al. (2019) $L_{p,pk}$ and $L_{E,p,wtd}$ criteria for PTS and TTS in marine mammals, associated with impulsive noise sources.

Southall *et al.* (2019)	$L_{p,pk}$ (dB re 1 µPa)		$L_{E,p,wtd}$ (dB re 1 µPa²s)	
	PTS	TTS	PTS	TTS
LF Cetaceans	219	213	183	168
HF Cetaceans	230	224	185	170
VHF Cetaceans	202	196	155	140
PCW Pinnipeds	218	212	185	170

Table 2-3: The Southall et al. (2019) $L_{E,p,wtd}$ criteria for PTS and TTS in marine mammals, associated with non-impulsive noise sources.

Southall *et al.* (2019)	$L_{E,p,wtd}$ (dB re 1 µPa²s)	
	PTS	TTS
LF Cetaceans	199	179
HF Cetaceans	198	178
VHF Cetaceans	173	153
PCW Pinnipeds	201	181

2.3.2 Fish

2.3.2.1 Popper *et al.* (2014): Mortality, injury and behavioural effects

Popper *et al.* (2014) offers updated guidelines on underwater noise impacts to marine fauna (excluding marine mammals). Unlike earlier studies, It categorises fish based on physiological morphology, particularly swim bladder function, that affect hearing sensitivity and provides criteria for key anthropogenic sound sources. Marine faunae are grouped into sea turtles, eggs and larvae, and three fish hearing categories:

- Fish: no swim bladder
- Fish: swim bladder not involved in hearing
- Fish: Swim bladder involved in hearing.

Popper *et al.* (2014) then provides impact thresholds for each marine faunae category related to sound exposure, including:

- Mortality and potential mortal injury: immediate or delayed death.
- Impairment, such as:
    - Recoverable injury: injuries unlikely to result in mortality.
    - Temporary Threshold Shift (TTS): short or long-term changes in hearing sensitivity that may or may not reduce fitness.
    - Masking: Reduction in sound detectability due to the simultaneous presence of another sound.
- Behavioural effects: substantial change in behaviour for the animals exposed to a sound (long or short term).

Despite emerging evidence of fish sensitivity to particle motion (see Section 1.2.2), the Popper *et al.* (2014) criteria provide a quantitative criterion as thresholds for impact onsets in terms of sound pressure related functions (e.g., $L_{p,\mathrm{pk}}$, $L_{p,\mathrm{RMS}}$, $L_{E,p}$). When the available data is insufficient to provide a quantitative criterion, Popper *et al.* (2014) provides a relative assessment of risk, qualified as either high, moderate, or low, based on the receptor. These risks are assessed for three approximate distances relative to the sound source; the near-field (tens of meters), intermediate-field (hundreds of meters) or far-field (thousands of meters).

Since both UXO clearance techniques involve a detonation of either the UXO itself during the high order detonation or of the donor charge as part of the low order deflagration, this study uses the criteria from Popper *et al.* (2014) for explosions as a proxy for this noise source, which is summarised in Table 2-4.

Table 2-4: Recommended guidelines for explosions according to Popper et al. (2014) for fish, sea turtles and eggs and larvae (N = Near-field; I = Intermediate-field; F = Far-field).

Popper *et al*. (2014) criteria for Explosions					
Type of fish	**Mortality and potential mortal injury**	**Impairment**			**Behaviour**
		Recoverable injury	**TTS**	**Masking**	
Fish: no swim bladder	**229 – 234 $L_{p,pk}$**	(N) High (I) Low (F) Low	(N) High (I) Moderate (F) Low	NA	(N) High (I) Moderate (F) Low
Fish: swim bladder not involved in hearing	**229 – 234 $L_{p,pk}$**	(N) High (I) High (F) Low	(N) High (I) Moderate (F) Low	NA	(N) High (I) High (F) Low
Fish: swim bladder involved in hearing	**229 – 234 $L_{p,pk}$**	(N) High (I) High (F) Low	(N) High (I) High (F) Low	NA	(N) High (I) High (F) Low
Sea Turtles	**229 – 234 $L_{p,pk}$**	(N) High (I) High (F) Low	(N) High (I) High (F) Low	NA	(N) High (I) High (F) Low
Eggs and Larvae	> 13 mm/s peak velocity	(N) High (I) Low (F) Low	(N) High (I) Low (F) Low	NA	(N) High (I) Low (F) Low

3 Underwater Noise Level Prediction: Methodology

3.1 Clearance Methodology

Accurate prediction of sound generated during UXO clearance requires an understanding of the techniques used. UXO clearance typically involves one of two methods: high order detonation or low order deflagration (which does not result in detonation beyond that of the donor charge), each producing different acoustic signatures.

3.1.1 High Order Clearance

High-order UXO clearance is the traditional approach for UXO disposal. A smaller donor charge detonated adjacent to the UXO and produces a shock wave that triggers the UXO, causing a large explosion and potential environmental damage. The main sound considered in an impact assessment is the sound generated by the detonation of the main UXO target, combined with the detonation of the donor charge. In most cases, only one donor detonation is required to clear the target.

3.1.2 Low Order Clearance

Low-order clearance aims to neutralise the UXO with minimal explosive force, reducing sound levels, seabed disturbance, and potential risk of harm to marine life. This technique uses deflagration, which uses a small, shaped charge (typically 250 g or less) to breach the casing and burn the internal explosive material of the target UXO. This disrupts the target without generating a high order detonation. In most cases, low order clearance is the preferred method of UXO clearance over high order clearance.

The donor charge detonation and burning process both generate sound, with the low order donor charge producing more sound (Cheong *et al*. 2020), however, both produce much less than a high order detonation. There is no correlation between sound levels and the explosive potential of the target UXO during low-order deflagration, suggesting the sound primarily comes from the clearance charge, and not the UXO itself (Oliva *et al. 2024;* Cheong *et al*. 2020). Low-order clearance may leave residual explosive material, requiring additional deflagration or removal. In some rare cases, deflagration could unintentionally trigger a high-order event.

3.2 Sound Level Prediction

3.2.1 Sound Sources (Potential UXO Devices)

The sound generated by explosive detonations is influenced by many factors, but only the charge weight (based on the TNT equivalent) is easily quantifiable. Other variables such as design, composition, age, position, orientation, and sediment cover are typically unknown at this assessment stage, resulting in significant uncertainty in source level estimates. To account for this, a worst-case scenario is assumed, where the UXO is treated as undamaged, uncovered, and in 'as-new' condition. This is especially relevant for larger devices, which are expected to have some degradation. However, it should be noted that this approach often leads to an overestimation of sound levels.

The net explosive quantity (NEQ) for potential UXO devices is presented in Table 3-1. While not exhaustive, this range likely encompasses the largest expected devices. For high order detonations, the UXOs will be detonated using a smaller donor charge with a separate NEQ, which varies depending on the NEQ of the target UXO. Since the donor charge contributes to the sound generated via this clearance technique, it has been included in the total NEQ for each device for associated calculations. For low order deflagration, sound is primarily generated by the smaller charge, and therefore, predictions for low order deflagration use a representative charge weight of 0.25 kg (250 g). A worst-case high order detonation scenario has also been considered for comparison.

Table 3-1: NEQ values of potential devices associated with low order clearance and high order clearance.

Clearance	Device Type	Net Explosive Quantity (kg)		
		UXO	Donor	Total
Low Order	Shaped charge	0.25	n/a	0.25
High Order	SC50	25	5	30
	SC500	270	25	295
	GY (EMCII)	300	25	325
	Mark A mine	431	25	456
	SC1000	530	25	555
	LMB mine	697	25	722

3.2.2 Sound Level Prediction (Soloway and Dahl, 2014)

Estimation of the source sound level for each combined charge weight was carried out in accordance with the methodology of Soloway and Dahl (2014), which follows Arons (1954) and Marine Technology Directorate Ltd (MTD, 1996). Soloway and Dahl (2014) provide models that can be used to characterise sound levels at a given distance, meaning that the maximum distance at which a receptor-based noise threshold is exceeded (e.g Southall *et al.,* 2019; Popper *et al.,* 2014) can be calculated. This technique is widely accepted by regulators in the prediction of impact ranges associated with UXO clearance.

Soloway and Dahl (2014) provide a model to estimate the sound levels generated by underwater explosions, which includes an empirical model $L_{p,\mathrm{pk}}$ and a semi-empirical model for $L_{E,p}$ based on measured data. These formulas use geometric spreading to estimate sound levels and the propagation of the sound using only distance and TNT equivalent charge weight as inputs. These establish a trend based on measurements of underwater blast in open water given by, for $L_{p,\mathrm{pk}}$ in Equation 4:

$$L_{p,pk} = 52.4 \times 10^6 \left(\frac{R}{W^{1/3}}\right)^{-1.13} \tag{4}$$

and for $L_{E,p}$ in Equation 5:

$$L_{E,p} = 6.14 \times \log_{10}\left(W^{1/3}\left(\frac{R}{W^{1/3}}\right)^{-2.12}\right) + 219 \tag{5}$$

where R is the measurement range in meters (m), and W is the NEQ of the UXO (kg). These equations offer a relatively straightforward method for estimating the range of effect. However, it should be noted that the model is not spatially explicit, as it does not account for variations in bathymetry or seabed type. Consequently, the results are independent of the UXOs specific location. A summary of the unweighted UXO source levels (i.e. by convention at 1 m from the source) calculated using this method for modelling are given in Table 3-2.

Table 3-2: Summary of the unweighted $L_{p,pk}$ and $L_{E,p}$ source levels used for UXO modelling

Total UXO NEQ (kg)	Estimated Source Level @ 1 m	
	$L_{p,pk}$ (dB re 1 µPa)	$L_{E,p}$ (dB re 1 µPa^{2}s)
0.25	269.8	215.2
30	285.4	228.4
295	292.9	234.8
325	293.2	235.0
456	294.3	236.0
555	295.0	236.5
722	295.9	237.2

Equations 4 and 5 are derived from UXO noise measurements taken over short ranges from the source. The acoustic signature of a UXO detonation is generally broadband across the frequency range but is predominantly a low frequency noise source. Therefore, to facilitate accurate calculation over greater distances, a sound absorption coefficient has been introduced, which accounts for frequency dependent absorption that becomes apparent with long range propagation. In this instance, a 0.003 dB/km attenuation correction was added to Equations 4 and 5, which is representative of the primarily low frequency nature (63 Hz to 200 Hz, Ainslie and McColm, 1998) of explosive noise. This has been standard practice in all recent UXO assessments using the Soloway and Dahl (2014) methodology.

3.2.3 Impact Range Assessment

A frequency spectrum derived from UXO measurements (Cook and Banda, 2021) was adjusted to achieve the approximate source levels presented in Table 3-2. An example of the 1/3rd octave spectrum used is shown in Figure 3-1. Spectrums associated with each predicted sound level were weighted using the marine mammal weightings from Southall *et al.* (2019), detailed in Figure 2-1.

These weighted levels were then assessed against the Southall *et al.* (2019) guidelines to estimate the range at which thresholds for impulsive and non-impulsive sounds might be exceeded for marine mammals. Separately, sound levels calculated using the equations from Soloway and Dahl (2014) were assessed against the Popper *et al.* (2014) guidelines to predict the range at which explosive thresholds would be exceeded for fish.

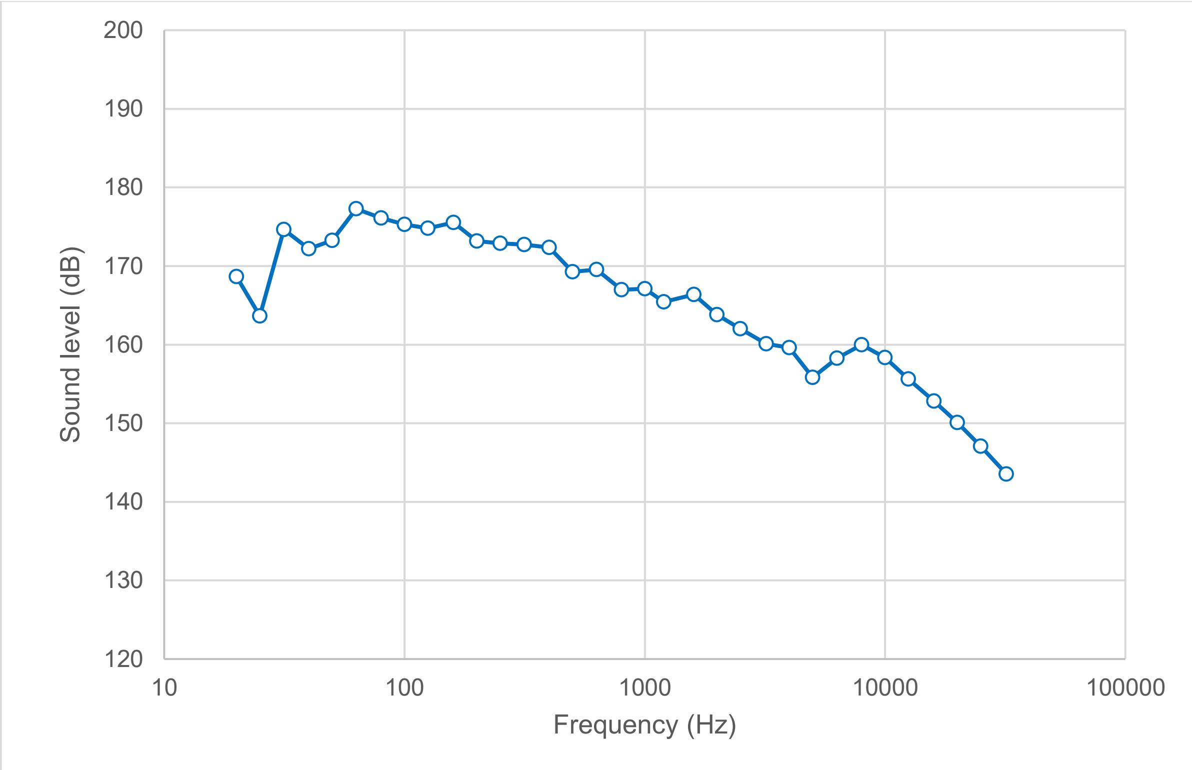

Figure 3-1 – UXO noise frequency spectrum containing 1/3rd octave band levels used in impact range prediction.

4 Underwater Noise Level Prediction: Results

Table 4-1 to Table 4-3 present the impact ranges for UXO detonation, considering various charge weights and impact criteria. Ranges smaller than 50 m have not been presented.

4.1 Marine Mammals

Using the $L_{p,pk}$ criteria from *Southall et al.* (2019) applied to the predicted marine mammal weighted sound levels, the VHF cetacean group are predicted to have the largest PTS impact ranges of all marine mammals considered. For low order clearance (0.25 kg), animals within 990 m of the detonation are likely to exceed the PTS threshold for VHF cetaceans. These results, along with PTS impact ranges predicted for other species groups, and TTS impact ranges predicted across all groups, are presented in Table 4-1. Predictions for PTS and TTS ranges across other various UXO charge weights for high order detonations are also presented in Table 4-1.

Table 4-1: Estimated impact ranges for UXO detonations across various NEQs (UXO plus donor charge) using the Southall et al. (2019) $L_{p,pk}$ marine mammal criteria for impulsive noise sources.

Southall *et al*. (2019) criteria $L_{p,pk}$ (Impulsive)		Estimated impact range (m)						
		0.25 kg	**30 kg**	**295 kg**	**325 kg**	**456 kg**	**555 kg**	**722 kg**
LF Cetaceans	**PTS**	**170**	870	1,800	1,900	2,100	2,300	2500
	TTS	**320**	1,600	3,400	3,500	3,900	4,200	4,600
HF Cetaceans	**PTS**	**60**	280	600	620	700	750	810
	TTS	**100**	520	1,100	1,100	1,200	1,300	1,500
VHF Cetaceans	**PTS**	**990**	4,900	10,000	10,000	12,000	12,000	14,000
	TTS	**1,800**	9,000	19,000	19,000	22,000	23,000	25,000
PCW Pinnipeds	**PTS**	**190**	960	2,000	2,100	2,300	2,500	2,700
	TTS	**360**	1,700	3,800	3,900	4,300	4,600	5,100

When the $L_{E,p,wtd}$ criteria for impulsive noise are applied to the predicted sound levels, the LF cetacean group are predicted to have the largest PTS impact ranges. For low order clearance (0.25 kg), animals within 230 m of the detonation are predicted exceed the PTS threshold for LF cetaceans, under the impulsive criteria. These results, along with PTS impact ranges predicted for other species groups, and TTS impact ranges predicted across all groups, are presented in Table 4-2. Predictions for PTS and TTS ranges across other various UXO charge weights for high order detonations are also presented in Table 4-2.

Table 4-2: Estimated impact ranges for UXO detonations across various NEQs (UXO plus donor charge) using the Southall et al. (2019) $L_{E,p,wtd}$ marine mammal criteria for impulsive noise sources.

Southall *et al.* (2019) criteria $L_{E,p,wtd}$ (Impulsive)		Estimated impact range (m)						
		0.25 kg	30 kg	295 kg	325 kg	456 kg	555 kg	722 kg
LF Cetaceans	PTS	**230**	2,300	7,200	7,500	8,900	9.700	11,000
	TTS	**3,200**	31,000	82,000	86,000	98,000	100,000	110,000
HF Cetaceans	PTS	**< 50**	< 50	< 50	< 50	50	60	60
	TTS	**< 50**	160	430	440	500	540	600
VHF Cetaceans	PTS	**90**	600	1,200	1,200	1,300	1,400	1,500
	TTS	**750**	2,500	3,600	3,700	3,900	4,000	4,100
PCW Pinnipeds	PTS	**< 50**	420	1,200	1,300	1,500	1,700	1,900
	TTS	**570**	5,600	15,000	16,000	18,000	20,000	22,000

4.2 Fish

According to the $L_{p,pk}$ metric from the Popper et al (2014) guidelines, for a low order deflagration, the maximum predicted range for the threshold of mortality and potential mortal injury is predicted for all fish groups at between < 50 - 70 m from the detonation. These results, along with other fish groups, and impact ranges for other effects, are provided in Table 4-3. Predictions for PTS and TTS ranges across other various UXO charge weights for high order detonations are also presented in Table 4-3.

Table 4-3: Estimated impact ranges for the UXO detonations across various NEQs (UXO plus donor charge) using the Popper et al (2014) $L_{p,pk}$ fish criteria for explosions.

Popper *et al.* (2014) criteria $L_{p,pk}$	Estimated impact range (m)						
	0.25 kg	30 kg	295 kg	325 kg	456 kg	555 kg	722 kg
Mortal and potential mortal injury	**< 50 – 70**	180 - 130	400 – 670	410 – 690	460 – 770	490 – 830	540 - 900

5 Discussion

5.1 Prediction Validation

The methods employed by Soloway and Dahl (2014) are recognised as the best available method for sound level prediction for UXO clearance. The sound levels predicted here remain appropriate for the purposes of this report. However, the results have been validated against other measured datasets.

5.1.1 Peak of the Sound Pressure Level

The approach, based on Soloway and Dahl (2014), was validated for the $L_{p,pk}$ metric using raw underwater noise data from two recent UXO clearance studies. One dataset, from Robinson *et al.* (2022), was collected in the Moray Firth at the Moray East offshore windfarm (avg. depth ~45 m). While 17 UXO targets were identified, most charge weights were unspecified; therefore, average values ranging from 0.5 kg to 295.5 kg were used, with donor charges between 6 kg and 25 kg. Comparison of this dataset with modelling predictions shows that the measured $L_{p,pk}$ levels are approximately 40 dB lower than predicted $L_{p,pk}$ across each charge size modelled. This difference was consistent with increased range between 1,500 m – 6,000 m.

SMRU Consulting (SMRUC, 2022) provided a UXO clearance dataset using the Hydra low-yield method, collected between May and October 2021 at the Seagreen Alpha and Bravo offshore windfarms in the outer Firth of Forth and Tay, Scotland (avg. depth ~55 m). Three UXOs were monitored: two 25 kg sea mines and one 227 kg buoyant mine. Each detonation used a 750 g Semtex donor charge, with recordings at 500 m and 1,500 m. The comparison is shown in Figure 5-1.

Both datasets demonstrate deviation between measured values and predicted values, where measured $L_{p,pk}$ values were less than predicted by both models, confirming its precautionary nature. Deviations of measured values from predicted values could be due to:

- Limitations in the prediction model (e.g. the model doesn't consider bathymetry, sediment type etc.)
- Differences in the sound produced by the explosive due to the detonation configuration.
- Degradation in the devices over the long period of time they remained underwater.

Modelled predictions differ more from the Robinson *et al.* (2022) dataset than from SMRUC (2022), with Robinson *et al.*'s data being significantly quieter than predicted by Soloway and Dahl (2014). This likely reflects the use of low-yield methods and newer, intact donor charges, which differ from actual UXO devices.

The primary conclusion that can be drawn from this comparison is that the model used represents a precautionary prediction for the $L_{p,pk}$ metric across the dataset for high order UXO clearance, and thus provides a conservative approach, with reassurance that a high order clearance on site is likely to be significantly quieter than predicted by the model.

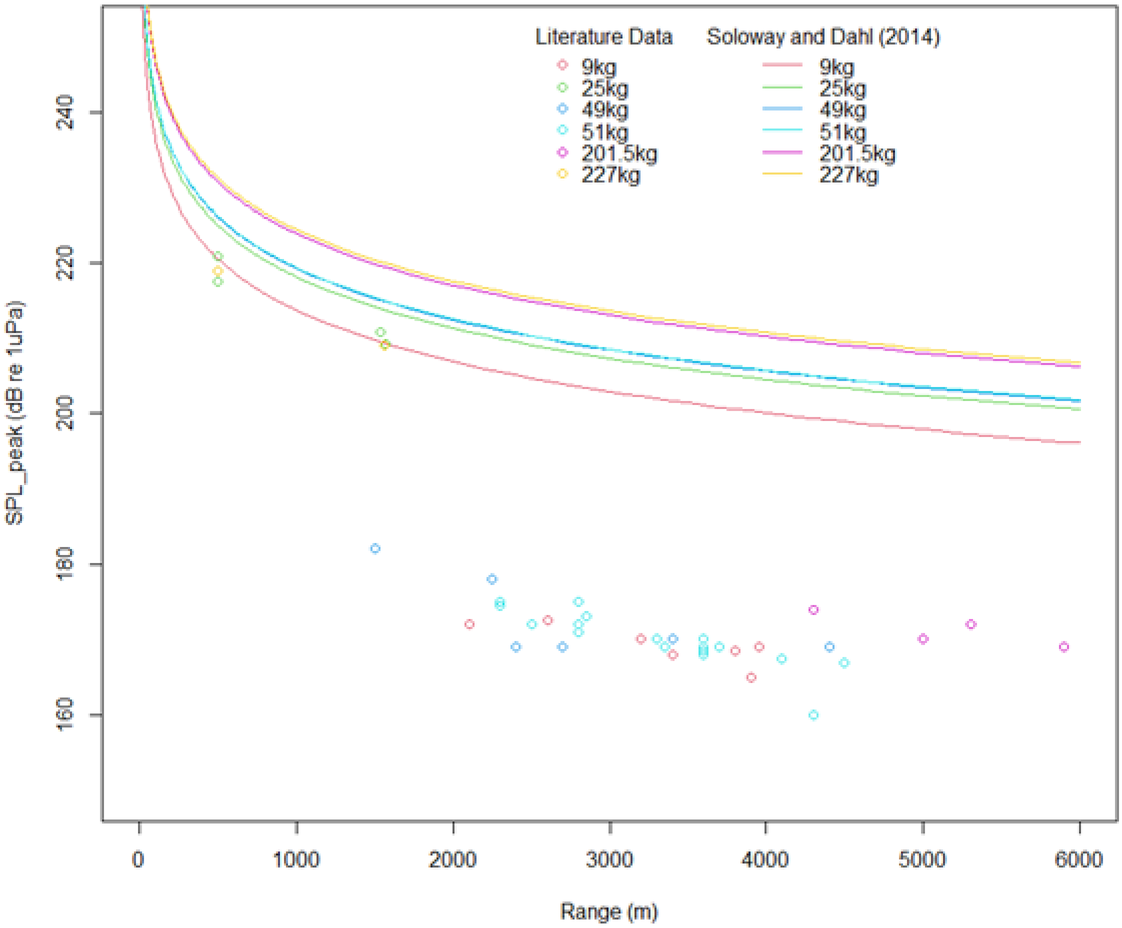

Figure 5-1 - $L_{p,pk}$ vs range of various charge weights. O = data obtained from literature (Robinson et al. (2022) and SMRUC (2022), solid lines = modelled predictions using Soloway and Dahl (2014), dotted lines = modelled predictions using MTD.

5.1.2 Sound Exposure Level predictions

The approach, based on Soloway and Dahl (2014), was also validated for the $L_{E,p}$ metric using raw underwater noise data from UXO clearance measured by Subacoustech in the North Sea. Raw data measured by Midforth (2024) for low order deflagration, using a charge weight of 0.25 kg was reported to have a source level of 231 dB $L_{E,p}$ at 1 m from the source. This level is 15.8 dB more than predicted for this charge weight using Soloway and Dahl (2014).

It is becoming increasingly apparent that the methodology from Soloway and Dahl (2014) is likely to be underestimating the $L_{E,p}$, meaning that is does not provide a precautionary estimate for the sound levels that may be generated by UXO detonations, and the sound levels, and the subsequent effects on marine life (in this instance, the predicted impact ranges) may be higher than predicted. The $L_{E,p}$ sound levels predicted here using Soloway and Dahl (2014), and the subsequent predicted impact ranges, should be taken with caution. In this instance, and until an improved calculation methodology is developed, it is suggested that reference to the results using sound levels predicted using the $L_{p,pk}$ would provide a more confident prediction.

5.2 Limitations

It should be noted that $L_{p,\mathrm{pk}}$ values are difficult to predict accurately over long distances (von Benda-Beckmann et al., 2015), and the Soloway and Dahl (2014) equations do not account for frequency when considering transmission loss. Hence, they are considered somewhat conservative for large distances as frequency would affect the level of sound absorption over these ranges. Soloway and Dahl (2014) validated their method only for small charges and ranges under 1 km. However, their results align with von Benda-Beckmann *et al.* (2014), who measured 263 kg charges at greater distances. While the addition of an attenuation correction over long distances applied here attempts to reduce this uncertainty, the predicted sound levels for the $L_{p,\mathrm{pk}}$ metric may still overestimate at long range.

Another limitation of the Soloway and Dahl (2014) equation is that it does not consider bathymetry, nor weather conditions, which can also contribute to propagation loss. Furthermore, Soloway and Dahl (2014) also does not account for variations in sound levels at different depths in the water column. Animals near the surface may experience lower noise exposure due to acoustic effects (MTD, 1996), meaning the actual risk to these animals could be less than predicted. As such, the impact ranges in this assessment are considered conservative with respect to depth-related exposure.

6 Conclusion

Subacoustech Environmental, on behalf of Natural Power, have undertaken an underwater noise assessment in anticipation of UXO clearance activities taking place in North Sea, as part of the installation of the EGL1 underwater cable.

The level of underwater sound generated was predicted using the methodology outlined in Soloway and Dahl (2014). This calculation procedure considers the charge weight of the UXO or low order clearance charge to predict $L_{p,\mathrm{pk}}$ and $L_{E,p}$ for various types of UXO expected in the area. The predicted sound levels were then interpreted in accordance with the guidelines outlined in Southall *et al.* (2019) for marine mammals in relation to impulsive noise sources, and Popper *et al*. (2014) for fish in relation to explosives.

Using the Southall *et al.* (2019) guidance for marine mammals, the VHF cetacean group is predicted to have the largest PTS impact range. Animals within 990 m of a low order deflagration are predicted to exceed the $L_{p,\mathrm{pk}}$ VHF PTS threshold. When the total noise output is considered, the LF cetacean group is considered to have the largest PTS impact range. As a worst-case, animals within 230 m of a low order deflagration are predicted to surpass the LF cetacean $L_{E,p}$ PTS threshold. For fish, using the Popper *et al.* (2014) guidance, mortality and potential mortal injury is predicted for all fish morphologies that are within 70 m of a low order deflagration. It should be noted that for both marine mammals and fish, the impact ranges are larger for high order detonations, with greater impact ranges associated with greater UXO charge weights, although low order clearance is being prioritised wherever feasible.

Finally, it should be noted that the method by Soloway and Dahl (2014) have been shown to overestimate $L_{p,\mathrm{pk}}$ metrics, but more importantly, underestimate $L_{E,p}$ metrics. Furthermore, the accuracy of predictions decreases with distance from the source, and the model does not consider environmental factors that may contribute to the propagation loss of sound. Therefore, as with most mathematical modelling, the impact ranges presented here should be taken as indicative in determining the effects that may occur in receptors during the proposed operations. However, the results predicted using $L_{p,\mathrm{pk}}$ metrics are likely to provide a more confident prediction of the sound levels likely generated by these activities than the predictions using the $L_{E,p}$ metrics.

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