MORAY OFFSHORE WINDFARM (WEST) LIMITED

UXO Clearance European Protected Species – Risk Assessment

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Abbreviations and Acronyms

Acronym / Abbreviation	Description
AAA	Anti-aircraft Artillery
AC	Alternating Current
ADD	Acoustic Deterrent Devices
ADD-Op	ADD Operator
AEoSI	Adverse Effect on Site Integrity
CES	Coastal East Scotland
CGNS	Celtic and Greater North Seas
CI	Confidence Interval
CIA	Cumulative Impact Assessment
CV	Coefficient of Variation
cUXO	Confirmed Unexploded Ordnance
EDR	Effective Deterrent Radius
EIA	Environmental Impact Assessment
EOD	Explosive Ordnance Disposal
EPS	European Protected Species
ES	Environmental Statement
FCS	Favourable Conservation Status
FRC	Fast Rescue Craft
GNS	Greater North Sea
HE	High Explosive
HF	High Frequency
IAMMWG	Inter-Agency Marine Mammal Working Group
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
kg	Kilograms
LAT	Lowest Astronomical Tide
LF	Low Frequency
LSE	Likely Significant Effect
MA	Monitoring Area
MC	Medium Capacity
MF	Mid Frequency
ML	Marine Licence
MLA	Marine Licence Application
m	Metre
mm	Millimetres
MMMP	Marine Mammal Mitigation Protocol
MMO	Marine Mammal Observer
MS-LOT	Marine Scotland Licensing Operations Team

Acronym / Abbreviation	Description
MU	Management Unit
NCMPA	Nature Conservation Marine Protected Area
NEQ	Net Explosive Quantity
nm	Nautical Miles
NCMPA	Nature Conservation Marine Protected Area
NMFS	National Marine and Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
NS	North Sea
OfTI	Offshore Transmission Infrastructure
OFTO	Offshore Transmission Owner
OWF	Offshore Wind Farm
OSP	Offshore Substation Platform
OWF	Offshore Wind Farm
PAM	Passive Acoustic Monitoring System
PAM-Op	PAM Operator
PCW	Phocid Carnivores in Water
PTS	Permanent Threshold Shift
pUXO	Potential Unexploded Ordnance
RIAA	Report to Inform an Appropriate Assessment
RIB	Rigid (hull) Inflatable Boat
ROV	Remotely Operated Vehicle
SAC	Special Area of Conservation
SCANS III	The Small Cetaceans in European Atlantic waters and the North Sea III
SEL	Sound Exposure Level
SNCB	Statutory Nature Conservation Body
SNH	Scottish Natural Heritage
SNS	Southern North Sea
SPL	Sound Pressure Level
TI	Transmission Infrastructure
TNT	Trinitrotoluene
TTS	Temporary Threshold Shift
UK	United Kingdom
UXO	Unexploded Ordnance
VHF	Very high-frequency
WTGs	Wind Turbine Generators

1 Introduction

1.1 Background

The Moray West Offshore Wind Farm and associated Offshore Transmission Infrastructure (OfTI) (referred to as 'the Development') is being developed by Moray Offshore Windfarm (West) Limited (known as 'Moray West'; see **Appendix A** for defined terms). Consent for the Development was granted on 14 June 2019 under Section 36 (S36) of the Electricity Act 1989 (as amended), Part 4 of the Marine (Scotland) Act 2010 and the Marine and Coastal Access Act 2009 from Scottish Ministers. One S36 consent was granted by Scottish Ministers for the wind farm (012/OW/MORLW-8) and two Marine Licenses were granted by Scottish Ministers, one for the wind farm and another for the offshore transmission infrastructure.

Variations of the S36 consent and wind farm Marine Licence were granted by the Scottish Ministers on 7 March 2022, and further variations of the Wind Farm Marine Licence (licence number: MS-00009774) and OfTI Marine Licence (licence number: MS-00009813) were granted on 7 March 2022 and 11 April 2022. The revised S36 consent and associated Marine Licences are referred to collectively as 'offshore consents'.

The Moray West Site covers an area of approximately 225 km^2 on the Smith Bank in the Outer Moray Firth approximately 22 km from the Caithness coastline (**Figure 1**). The Moray West Offshore Wind Farm will comprise 60 wind turbine generators (WTGs), associated substructures and seabed foundations, inter-array cables, one offshore substation platform (OSP) inter-connector cable and any scour protection around substructures or cable protection. The OfTI comprises up to two OSPs which will be located within the Moray West Site, and two offshore export cable circuits which will be located within the OfTI Corridor and will be used to transmit the electricity generated by the offshore wind farm to shore.

The offshore export cable circuits will come ashore at Sandend Bay, which is located on the Aberdeenshire Coast at Broad Craig, approximately 65 km south of the Moray West Site. There will be two underground circuits from landfall at Sandend Bay to Whitehillock where the onshore substation will be located. There will also be further underground cabling between Whitehillock substation and Blackhillock substation. Moray West will transfer ownership of the transmission asset to an Offshore Transmission Owner (OFTO) who will manage the transmission infrastructure.

The development is aiming to be fully operational in 2024/25 with an operational life of 25 years from the date of final commissioning of the Development.

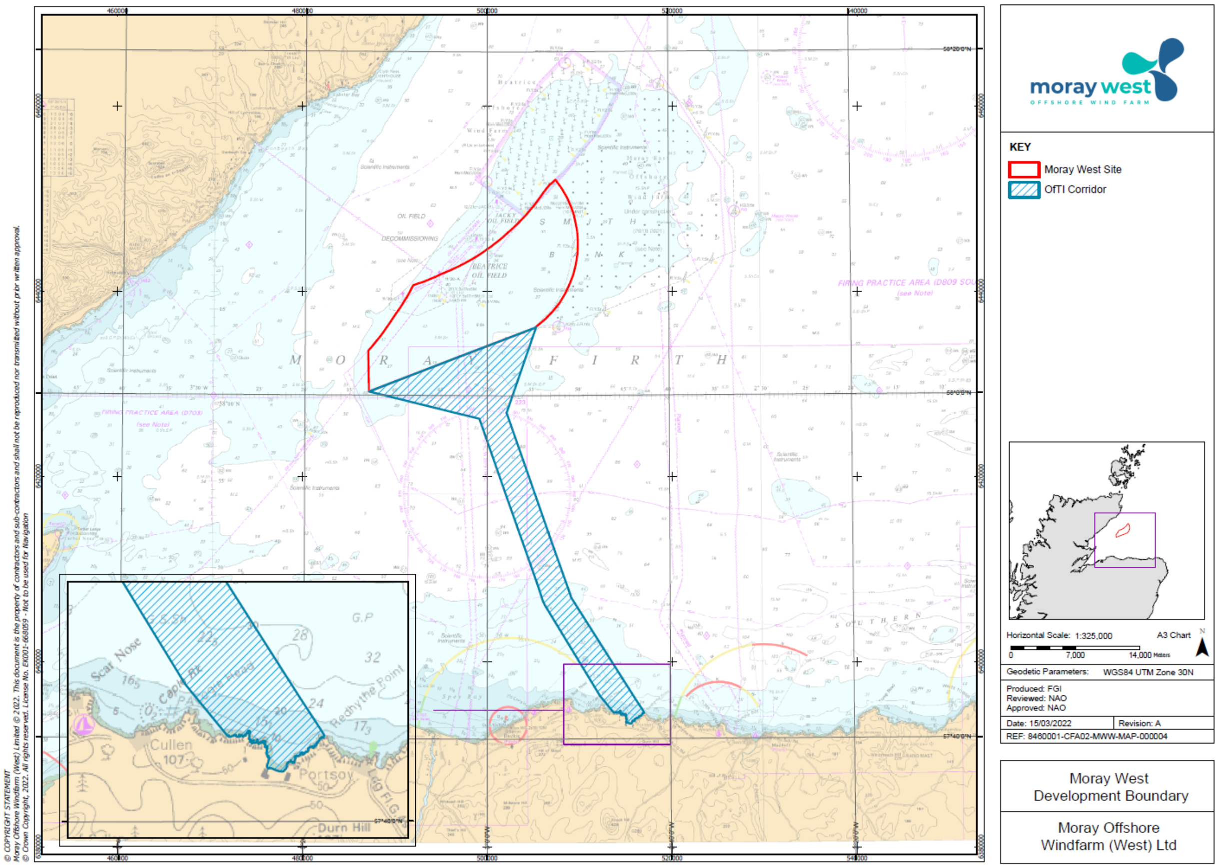

Figure 1 Geographical location of the Moray West Site and OfTI Corridor.

1.2 Purpose of the Risk Assessment

In order to safely undertake unexploded ordnance (UXO) clearance at the Development Site, a European Protected Species (EPS) Licence is required and an application for a licence to disturb or injure marine EPS will be applied for from Marine Scotland Licensing Operations Team (MS-LOT). An overview of the of the decision making process associated with the UXO activities is provided in **Section 2.1** and the methods associated with the licensable activities are detailed in **Section 2.2** and **Section 2.3.** This Risk Assessment is submitted in support of the EPS Licence application submitted by Moray West for UXO clearance and the use of acoustic deterrent devices (ADDs).

2 Description of the Proposed Works

The following section provides a description of the UXO clearance activities, including the number, size and location of UXO that may be found and the activities that are licensable under the Marine (Scotland) Act 2010 and the Marine and Coastal Access Act 2009.

2.1 Potential for UXO

2.1.1 Background

All military technology has a baseline failure rate, meaning that a subset of all ordnance used will not function as the designer intended, either during training or operational use. Consequently, the totality of military activities and conflicts over the 20th century has resulted in munitions contamination of the marine environment, and now it is not uncommon to encounter UXO during intrusive seabed activities.

During WWII, the failure rate of aerially delivered bombs was at least 10%. In addition, bombs often missed targets or were dumped from aircraft to reduce weight (6 Alpha, 2022). During the conflicts of the 20th century, sea mines were deployed in significant quantities, and there was a common practice of dumping small arms ammunition at sea which occurred without regard to the accurate recording of dumping position (6 Alpha, 2022). This has resulted in a scenario where UXO, particularly WWII UXO, is extant in the marine environment in unknown locations and at a sufficiently high abundance to pose a significant threat to activities interacting with the seabed in the marine environment.

2.1.2 Potential UXO Sources

The potential for UXO to exist within the Development Site has been assessed through a desktop risk assessment (6 Alpha, 2022), which has identified the following key UXO threats that may be encountered across the Development:

- Aerially delivered High Explosive (HE) bombs
- Projectiles (naval and anti-aircraft artillery (AAA))
- Torpedoes
- Naval mines
- Shipwreck related munitions

The likelihood of encountering these UXO sources within the Development, as assessed through the desktop study, is displayed in **Table 2.1**.

Table 2.1 : Summary of Potential UXO Sources (likely sources highlighted in red and marked with *)) (6 Alpha, 2022)		
Potential Sources of UXO	**Likelihood of UXO Contamination**	**Associated UXO Threat Items**
Aerial Bombing*	Likely: A British offshore bombing range was documented across the Development Site.	HE Bombs
Naval Engagements	Unlikely: Although there is evidence of limited submarine activity across the Development Site.	Naval Projectiles and Torpedoes
Naval Minefileds	Unlikely: Although the Development Site was intersected by one WWI-era minefield.	Naval Mines
Military Practice and Exercise Areas*	Likely: Several historic and modern military training areas were recorded intersecting the Development Site.	HE Bombs, Torpedoes and AAA Projectiles
Coastal Armaments*	Likely: An AAA firing range was recorded as intersecting the Development Site.	AAA Projectiles
Munitions Related Shipwrecks and Aircraft	Unlikely: Although, two munitions related shipwrecks were documented within the Development Site.	Shipwreck Related Munitions
Munitions Dumping (within 10km)	Highly Unlikely: No munitions dumps were recorded within 10km of the Development Site.	N/A

UXO in the form of projectiles could be present anywhere in the area. In the Moray West Site, it is most likely that identified targets would be types of aerial bombs or torpedoes, while in the nearshore area of the OfTI Corridor it is predicted to be differing types of artillery and naval projectiles. These are most likely to be smaller calibre shells with a Net Explosive Quantity (NEQ - based upon equivalent Trinitrotoluene (TNT) masses) in the region of 25 kg, but larger projectiles could be encountered and with a slightly larger NEQ of up to 51 kg of Amatol or Pentolite explosives, such as British 250lb Medium Capacity (MC) Bomb (6 Alpha, 2022).

Although any size of could be encountered, most are likely to be small the largest hazard item in the area of UXO clearance is unknown at present. However, based on the type of UXO that could be present it could be possible for up to a 364 kg charge weight to be encountered. This is the assumption that has been used as the worst case for the purposes of this Marine Licence Application (MLA). The worst-case method for UXO clearance is high-order detonation.

Table 2.2 Anticipated worst case UXO items for each category that could be encountered			
UXO item	**Ferrous Mass**	**Net explosive quantity (NEQ)**	**Dimensions**
G7a Torpedo	1,248kg	364kg	7,000mm x 535mm
1,000lb MC Bomb	202-225kg	309.4kg	1,334mm x 451mm
E-Mine	208kg	165kg	1,168mm x 864mm
SC-50 HE Bomb	25-30kg	25kg	762mm x 200mm
6” Artillery Projectile	39.4kg	6kg	582mm x 152mm

2.1.3 Number of UXO

UXO surveys in the Development Site are planned but yet to be completed, and these will provide up-to-date and precise information to inform UXO clearance activities. As this information is not yet available, this report is informed by the Unexploded Ordnance Threat and Risk Assessment (6 Alpha, 2022), which in turn draws upon 6 Alpha’s UXO database, and is benchmarked using the number of confirmed UXO found during the installation works at the nearby Moray East OWF.

From the above sources, on a precautionary basis, it is estimated that a maximum of 30 detonations of UXO may be required within the Development Site during UXO clearance activities. The number, size and locations of any UXO to be cleared by detonation will be confirmed with MS-LOT following investigation of the identified targets and prior to any clearance activities.

2.2 The Moray West Approach

A UXO survey campaign is due to be undertaken June to January 2023 to identify the potential for UXO within the Moray West Site and OfTI Corridor. The results of this campaign will be analysed to identify potential UXO (pUXO) within the Development Site. Should pUXO be identified, the preference is to avoid the pUXO and re-route and / or microsite. Where practicable, taking into account health and safety, any pUXO targets will be avoided by placing an industry standard 15 m radius avoidance zone around the target for the siting of any infrastructure and other “seabed intrusive” activities (e.g., vessel jack-up). The target pUXO will be left in-situ, locations will be noted and relevant authorities notified, where required. Should re-routing not be possible at this stage, the pUXO will be targeted for inspection, and the targets will be confirmed as either UXO or non-UXO debris.

Should the target be confirmed as non-UXO debris, the debris will either be recovered to the deck of the vessel for disposal onshore, or the debris will be repositioned on the seabed. Where debris cannot be repositioned or recovered to the deck of the vessel, they will be avoided through re-routing.

Should the target be confirmed as UXO (cUXO), the preference is to avoid this target where practicable. If avoidance is not possible, the target will be subject to Explosive Ordnance Disposal (EOD) operations. There are three options for UXO disposal which could be used as part of EOD operations:

1. UXO detonation in situ – this is the preferred option for health and safety reasons;
2. Relocation of the UXO on the seabed and then detonation – an example of when this would occur are in instances when detonating in situ could potentially compromise the safety of existing nearby assets. In the instance where third party assets are situated nearby, Moray West will contact the third party prior to detonation in order to establish a safe distance between the asset and detonation site. Another example of this occurrence is where two UXO are located in close proximity to one another, whereby one UXO is relocated nearer to the other UXO, allowing a single detonation to take place rather than two separate detonations; and
3. Recovery of the UXO to the deck of the vessel – this would be undertaken for small items of UXO e.g., hand grenades, or as a last resort for larger items should options 1 or 2 not be possible.

After detonation of the UXO, an as left survey will be conducted to confirm disposal of the target.

2.3 Licensable Activities (UXO Clearance Activities)

2.3.1 Identification Operations

The following describes the pUXO target identification operations, which will be carried out from December 2022 following the UXO survey campaign.

pUXO Target Investigation by ROV

This work will utilise a Remotely Operated Vehicle (ROV) to localise, excavate and identify pUXO based on a master target list generated in the UXO survey campaign. The procedure is as follows:

1. The ROV spread will begin by covering a 10 x 10 m, centred on the target position, using electromagnetic sensors at a height of < 0.5 m above seabed.
2. Once the target is located, localised dredging works will commence and continue until the target is visible. Dredging will be carried out with the dredge-pump attached to the ROV until the target is free from sediment.
3. If the target is confirmed as non-UXO, the object will be checked for being of potential archaeological interest. If it is not of archaeological interest, the object will be relocated either to the vessel, or outside the 10 x 10 m box. This will ensure it is placed outside the clearance corridor.
4. The target location will then be inspected again with the electromagnetic sensor to make sure that no second target is hidden under the first target.
5. If a target inspection results in a confirmed UXO identification, it will be treated according to the protocol outlined below in Section 2.3.2

Dredging of targets will be carried out with a 4” dredge-pump excavation/jetting system (e.g., Tritech Merlin; see **Figure 2-1**) fitted on the ROV. Dredging will excavate up to 3 m (depth) of sediment and deposit it immediately adjacent to the excavated area. No sediment will be brought on the board the launch vessel.

Figure 2-1: Tritech Dredge Pump.

pUXO Target Investigation by Diver (Nearshore area only)

The vessel will transit to the given pUXO position and hold position to provide a stable diving platform. The diver will be deployed with a hand-held magnetometer to pinpoint the location of the target. The survey of the target area will be a conducted as a minimum radial search area covering an initial 5m x 5m area over the given target position, extending by 1 m increments to 10 m if no object is found.

Once the target has been located and suspected to be a potential UXO, the diver will visually inspect the target. The diver will attempt to uncover by hand those pUXO targets that are buried or will use diver-held airlift / high pressure water jet to safely expose the item to enable positive identification of the target. A HD Sonar camera (ARIS) may be utilised to aid safe identification of items located on the seabed and enhance diver safety. The camera can be hand-carried by the diver with a live feed to the surface allowing the Explosive Ordnance Disposal (EOD) Supervisor to assess the target sonar image in low water visibility.

2.3.2 Explosive Ordnance Disposal Operations

The following describes the sequencing of the EOD operations (it should be noted that all EOD operations will be undertaken in accordance with the Marine Mammal Mitigation Protocol (MMMP) as included in **Appendix B**, and the information below is provided as a summary of that procedure only. Please see the full MMMP for all mitigation requirements).

EOD clearance is expected to commence in February 2023 and will be complete by the end of May 2023. A total of 9 targets were identified as pUXO in the nearshore area, and none were confirmed UXO. Nearshore UXO ID works were completed in January 2023, resulting in no confirmed UXO requiring disposal. EOD clearance in the ECC and Wind Farm Site are expected to take place from January 2023 onwards. All clearance works will take place during daylight hours and in sea state no greater than 3 (estimated working limits for disposal operations are wind speed no greater than 25 knots and wave height of 2.5 m).

Firstly, after all the pUXO targets have been inspected (after consideration of whether they can be avoided), the confirmed and unavoidable UXO targets will need to be cleared in a separate EOD campaign. For this campaign, two vessels will be required:

- an inspection/operations vessel from which the (ROV) or diver will be deployed and where the explosives will be stored; and
- a launch vessel.

The ADD and Passive Acoustic Monitoring System (PAM) equipment will be deployed from the operations vessel, along with the Marine Mammal Observers (MMOs) and PAM Operator (PAM-Op).

If a target is confirmed as a UXO by the EOD expert after the UXO inspection, a 250 m radius exclusion zone shall be implemented around the target, the position noted, and all relevant authorities notified.

Once all the target inspections are complete, the vessel will return to the confirmed UXO target, and the geodetic position of the item will be correlated and confirmed with the Client Representative, survey team and EOD Superintendent, at which point the EOD system will be deployed by the ROV (or diver) and placed in the optimum firing position. The method of disposal shall depend on the target identified, with low order deflagration the preferred method and high order detonations considered. Preference shall always be to low order deflagration, followed by high order detonation:

- For low order deflagration, a cone shall penetrate the UXO and burn the explosive material.
- For high order detonation, a charge shall be placed next to the target to dispose of the explosive material.

Whichever EOD system is used by the EOD contractor, the system shall be safe and reliable, and will have undergone a proven safety and performance testing regime.

Low-Order Deflagration

The UXO clearance method preferred to be utilised during the construction of Moray West Offshore Wind Farm is deflagration. Following confirmation by hand-diving or uncrewed vehicle that the anomaly is indeed a UXO requiring clearance by deflagration, the methodology below would be completed:

- A plastic casing would be attached directly to the UXO by hand by a diver or an uncrewed vehicle, containing the materials used to make-safe the UXO.
- Once environmental and safety mitigation has been applied, the initiation of the Deflagration will begin with the contents of the plastic casing causing a ‘rapid burning’ through the UXO.
- This begins the incineration of the UXOs contents which in-turn builds up a gas pressure whilst consuming the UXOs explosive contents.
- Once the contents ignite and the UXO reaches a critical pressure, the case bursts and the UXO is made safe.
- The methodologies employed by EODEX allow for all the remains of the UXO to be concentrated at its original location.

- Once considered safe to do so, the remains of the UXO will be recovered for final safe disposal at an environmentally accredited site ashore, meaning that all parts of the neutralised UXO will be removed from its identified location on the seabed following deflagration action.

Although Deflagration is still a kinetic process, it has greatly reduced effects on the surrounding environment from those created during a clearance by High Order detonation, i.e. detonating the UXO with the same explosive results the UXO was designed for.

High-Order Detonation

When a “live firing” run is ordered, the charge will be drawn from the on-board explosives magazine (bomb-proof storage location for explosives), fitted to an anchoring system (typically a concrete block) and secured in the manipulator arm of the ROV. Also attached to the anchoring system is a float with the firing line (typically a shock tube). It is common for safety features like Non-Electric Detonators and Hydrostatic Safety Breaks to be fitted to the EOD system immediately prior to the launching of the ROV to ensure there is no accidental firing of the charge.

The ROV will be deployed and return to the target at the designated position. When the ROV is 1 m away from the intended target, the anchoring system will be deployed and placed 0.5 m away from the target. In this way, the EOD system will be placed in the optimum firing position without making any physical contact with the target at any time.

Once in position, the float with the firing line will be released from the ROV manipulator and will ascend to the surface paying out the firing line as it ascends. Afterwards, the ROV will be recovered back to the deck.

The EOD system will subsequently be in the optimum firing position with the float and firing line at the surface ready to be fitted to the firing mechanism. This is achieved by deploying the launch vessel (fast rescue craft (FRC) or EOD rigid hull inflatable boat (RIB)), with the EOD Technicians onboard, back to the float to connect the firing line to the firing mechanism.

The launch vessel will move to 200-300 m range from the target. Within a safe distance of the target, the ADD and portable PAM will be deployed, and the MMOs will perform a visual survey from the operations vessel (see **Appendix B**).

On completion of the ADD procedure, the ADD and PAMs hydrophone will be recovered to the operations vessel and return to a safe distance from the UXO detonation and remaining available to advise other vessels in the vicinity if required.

The safety management of vessels and other traffic within the UXO mitigation zone (1,500 m) will be managed and coordinated by the EOD Superintendent and the vessel master who will liaise directly with the authorities for the area. A security radio message will be transmitted to state the vessel name, position of firing, and planned time at six hours, 30 minutes, and 10 minutes before the UXO detonation.

At the agreed firing time, the operation vessel will initiate the firing mechanism and fire the EOD main charge.

On completion of successful detonation, the launch vessel will return to the target location and recover the surface initiation float. The MMOs will conduct post-detonation MMO routines (see **Appendix B**). The ROV will be deployed and carry out an as-left survey centred on the target location using the ROV sensors. UXO debris greater than 30 cm in size, or debris which may contain explosive material originating from the UXO target will be recovered by the ROV to the deck of the vessel. This will ensure that the area is cleared of any UXO and that no significant metallic objects remain. The ROV will also provide multibeam bathymetry results to quantify the size and shape of any resulting detonation crater, to record any significant environmental impacts and to assist with future engineering plans.

For UXO detonations in shallow waters, (less than 12 m Lowest Astronomical Tide (LAT)), it is possible the target charge may be set by divers or an ROV (as described above). Initiation and firing procedures remain the same.

It is noted that within the 12 nautical mile (nm) zone, the responsibility for UXO clearance is in principle with the UK authorities such as Coastguard and Royal Navy. Therefore, if a UXO item is found within the 12 nm zone, consultation will be held with the Police, Royal Navy, and Coast Guard following completion of the survey and prior to implementation of UXO clearance activities to determine if the Moray West contractor should clear all required UXO, including those within 12 nm. As with UXO items found outside the 12 nm zone, all UXO identified will be reported to MS-LOT and other marine users.

2.3.3 Non-UXO Debris Clearance

In the event a target is identified as non-UXO (debris) by an EOD expert, a decision will be made regarding the threat of the object to construction and operations and maintenance activities, and the object will either be left in situ or relocated. This may be through re-location on the seabed at a pre-determined lay down area or through recovery to the vessel deck with subsequent disposal at an onshore disposal facility. The non-UXO debris may be transported to an alternative location hanging from a crane grab or “held” by the ROV in the water column. Otherwise, the non-UXO item (debris) will be recovered to the deck of the vessel for transport, depending on the size and weight of the target. Items relocated to the seabed will have their coordinates logged. Waste disposal onshore will be undertaken by a suitably registered and licensed contractor.

3 Existing Environment

3.1 Species within the Moray Firth

A total of 19 cetacean species have been recorded in UK waters (Reid *et al.*, 2003). To date, a total of 14 cetacean species have been recorded alive within the Moray Firth (see **Table 3.1**). Other species have been found stranded within the Moray Firth area, but are not discussed here due to the uncertainty of the animals' location before death. Cetaceans found within the Moray Firth can be divided into three groups – those present all year, those that occur seasonally and those which are considered rare visitors.

Species that are considered 'occasional' or 'rare' in **Table 3.1** are included for illustration purposes only and have not been assessed further in this report. However, all mitigation in place will be applicable to all marine mammal species during the UXO clearance activities.

Table 3.1: List of cetaceans recorded within the Moray Firth (adapted from a variety of sources). Species included in this assessment are highlighted in bold.

Common name	Latin name	Occurrence in the Moray Firth
Harbour porpoise	***Phocoena phocoena***	**Common, all year**
Bottlenose dolphin	***Tursiops truncatus***	**Common, all year**
Common dolphin	***Delphinus delphis***	**Common, seasonal**
White-beaked dolphin	***Lagenorhynchus albirostris***	**Common, seasonal**
Minke whale	***Balaenoptera acutorostrata***	**Common, seasonal**
Risso dolphin	*Grampus griseus*	Occasional
White-sided dolphin	*Lagenorhynchus acutus*	Occasional
Killer whale	*Orcinus orca*	Occasional
Pilot whale	*Globicephala melas*	Rare
Humpbacked whale	*Megaptera novaengliae*	Rare
Fin whale	*Balaenoptera physalus*	Rare
Sperm whale	*Physeter macrocephalus*	Rare
Northern bottlenose whale	*Hyperoodon ampullatus*	Rare
Beluga whale	*Delphinapterus leucas*	Rare

A comparison has been made between the results of the original Moray West Environmental Impact Assessment (EIA) Report 2018 and the results of the assessment based on the revised project design parameters. Overall, the results are generally the same as those presented in the Moray West EIA Report 2018.

3.2 Cetacean species potentially present in the Development Site

3.2.1 Harbour porpoise

Harbour porpoise are the most abundant cetacean species in Scottish waters (Reid *et al.* 2003; Hammond *et al.* 2021). They are also the most frequently encountered species in both visual and acoustic surveys in and around the proposed Moray West Offshore Wind Farm Site and are present throughout the Moray Firth all year (Moray West, 2018). The global population of harbour porpoise is listed in the International Union for Conservation of Nature (IUCN) Red List of Threatened Species as *Least Concern*; however, the current population trend is unknown (Braulik *et al*., 2020). In the most recent 2013-2018 reporting by the Joint Nature Conservation Committee (JNCC), the overall assessment of Conservation Status was unknown and the overall trend in Conservation Status is also unknown (JNCC, 2019).

Since the Moray West EIA Report 2018, the harbour porpoise abundance estimate for the North Sea Management Unit (MU)[1] has been updated. The current estimate for the North Sea MU is 346,601 porpoise (95% Confidence Interval (CI): 289,498- 419,967; Coefficient of Variation (CV) = 0.09)), of which 159,632 animals are considered as UK portion (Inter-Agency Marine Mammal Working Group (IAMMWG), 2022). This is slightly higher than the MU reference population estimate used in the Moray West EIA (345,373, 95% CI: 246,526- 495,752).

The density surface used in Moray West EIA was a 4x4 km grid surface density, created for Moray East (Moray Offshore Renewables Ltd, 2012). There is no updated surface density estimate available for harbour porpoise, and thus the same density estimate of 1.468 harbour porpoise per kilometre squared (km^2) is used in the impact assessment presented in this report. This is greater than the density estimate of 0.152 harbour porpoise per km^2 for survey block S which covers the Moray Firth, from Small Cetaceans in European Atlantic waters and the North Sea (SCANS) III survey (Hammond *et al*., 2021) and density estimates of 0.368-0.481 / km^2 in July for the Moray Firth area in Waggitt *et al*. (2019).

3.2.2 Bottlenose dolphin

The Moray Firth is an important habitat to the resident population of bottlenose dolphin in the North Sea, which is in the Coastal East Scotland (CES) MU (Moray West, 2018; IAMMWG, 2021). Whilst occupation of the Moray Firth by this population varies between years, recent survey data has confirmed that approximately half of the estimated population occupy the area regularly (Graham *et al.*, 2016). Designation of the Moray Firth Special Areas of Conservation (SAC) provides protection of bottlenose dolphin and their habitat, with the aim of maintaining the FCS (SNH, 2006; Moray West, 2018). The resident bottlenose dolphin of the Moray Firth SAC predominantly utilise the nearshore environment. Habitat modelling of survey data indicates that the southern coastline of the Firth is particularly important

[1] Management Units (MUs) are agreed upon spatial scales at which the impacts of proposed activities on the UK's seven most common cetacean species are assessed by UK Statutory Nature Conservation Bodies (SNCBs)

habitat to this population (Thompson *et al.*, 2014). Based on the most recent 2013-2018 reporting by the JNCC, the overall Conservation Status for bottlenose dolphin is currently classified as unknown (JNCC, 2019).

Since the Moray West EIA, the estimated CES MU size for bottlenose dolphins has been updated. The current estimate for the CES MU is 224 dolphins (95% CI: 214- 234) (Arso Civil *et al.,* 2021 IAMMWG, 2022). This is slightly higher than the MU estimate used in the Moray West EIA (195, 95% CI: 164-224). The Moray Firth is also part of the wider Greater North Sea (GNS) MU for the bottlenose dolphin which has a current estimate is 2,022 dolphins (CV = 0.75; 95% CI = 548 – 7,453; IAMMWG, 2022).

The surface density estimate of 0.00048/km^2 used in Moray West EIA was a 4x4 km grid surface density, created for Moray West, revised from the density surface used for Moray East (Moray Offshore Renewables Ltd, 2012). There is no updated surface density estimate available for bottlenose dolphins. However, as a precautionary approach the higher density estimate of 0.0037 bottlenose dolphin per km^2 from the SCANS-III survey block S in the Moray Firth (Hammond *et al*., 2021), has been used in the assessments. This is greater than the density estimates of 0.001-0.002 / km^2 for the Moray Firth area in Waggitt *et al*. (2019).

3.2.3 White-beaked dolphin

White-beaked dolphin frequent the eastern extent of the Moray Firth year-round, predominantlyat depths of 50 – 100 m (Reid *et al*., 2003). The density of white-beaked dolphin in the waters inand around the Moray Firth (survey block S) is 0.021 animals/km^2, which is low compared to regions in the east and north of Scotland (Hammond *et al*., 2021). They are usually found in small groups of 10 or less but have also been observed in large groups of 50 and more. Based on the most recent 2013-2018 reporting by the JNCC, the overall Conservation Status and trend in Conservation Status for white-beaked dolphin is currently classified as unknown (JNCC, 2019).

There is a single MU for white-beaked dolphin, the Celtic and Greater North Seas (CGNS) MU. The reference population for white-beaked dolphin in the CGNS MU is 43,951 animals (CV = 0.22; 95% CI = 28,439 – 67,924; IAMMWG, 2022). The density estimates of up to 0.123 white-beaked dolphin per km^2 for the Moray Firth area in Waggitt *et al*. (2019) has been used for the assessments, as this is greater than the SCANS-III density estimate of 0.021/km^2 (Hammond *et al.,* 2021).

3.2.4 Common dolphin

Common dolphin are abundant along shelf breaks and in deeper waters on the west coast of the UK and Europe (Reid *et al*., 2003). Recent data suggests an increasing occurrence of short-beaked common dolphin in the northern North Sea, including the Moray Firth (Robinson *et al.*, 2010; Moray West, 2018). Density estimates for this species occurring in the Moray Firth isapproximately 0.074 individuals/km^2 (Robinson *et al.*, 2010), which is roughly equivalent to density estimates in the waters west of Shetland (Hammond *et al*., 2021). Common dolphin are amongst the most gregarious cetacean species, often forming groups of 50 or more individuals, though groups of 200 or more are not uncommon (Robinson *et* *al.*, 2010). Based on the most recent 2013-2018 reporting by the JNCC, the overall Conservation Status and trend in Conservation Status for common dolphin is currently classified as unknown (JNCC, 2019).

Common dolphin were not recorded in survey block S during the SCANS-III survey (Hammond *et al*., 2021); therefore, the density estimate of 0.074 individuals/km^2 from Robinson *et al*. (2010) is used in the assessments. This is greater than density estimates of 0.024-0.044 / km^2 in July for the Moray Firth area in Waggitt *et al*. (2019). There is a single MU for common dolphin, the CGNS MU. The reference population for common dolphin in the CGNS MU is 102,656 animals (CV = 0.29; 95% CI = 58,932 – 178,822; IAMMWG, 2022).

3.2.5 Minke whale

Minke whale are wide-ranging baleen whales which are present in the Moray Firth primarily in the summer months (June – September) (Reid *et al.,* 2003; Hammond *et al.,* 2021). They often prefer water depths of up to 200 m and are often solitary or found in pairs, though they occasionally form larger groups (up to 15 individuals) while feeding. Based on the most recent 2013-2018 reporting by the JNCC, the overall Conservation Status and trend in Conservation Status for minke whale is currently classified as unknown (JNCC, 2019). Minke whale are also one of the protected features of the Southern Trench Nature Conservation Marine Protected Area (NCMPA), through which the Offshore Export Cable Corridor passes. The Conservation Objectives of this site are to conserve the features, specifically to ensure "*minke whale in the Southern Trench NCMPA are not at significant risk from injury or killing, conserve the access to resources (e.g. for feeding) provided by the NCMPA for various stages of the minke whale life cycle, and conserve the distribution of* minke whale within the site by avoiding significant disturbance".

Since the Moray West EIA, the estimated CGNS MU size for minke whales has been updated. The current estimate for the CGNS MU is 20,118 whales (CV = 0.18; 95% CI: 14,061-28,786; IAMMWG, 2022). This is slightly lower than the MU estimate used in the Moray West EIA (23,528, 95% CI: 13,989-39,572). The density estimate for the SCANS-III survey block S was 0.0095/km^2 (Hammond *et al*., 2021). The density estimates in Waggitt *et al*. (2019) ranges from of 0.008-0.023 / km^2 in July for the Moray Firth area. Therefore, as a precautionary approach, density estimate of 0.023 / km^2 has been used in the assessments.

3.2.6 Summary

The density and abundance of the cetacean species which regularly occur in the Moray Firth is summarised in **Table 3.2.** Reference population for harbour porpoise is the North Sea MU (Hammond *et al*., 2021). The reference population for bottlenose dolphin is the CES MU, the reference population for common dolphin, white-beaked dolphin and minke whale is CGNS MU (IAMMWG, 2021; **Table 3.2**).

Table 3.2: Density and abundance estimates for the five regularly occurring cetacean species in the Moray Firth			
Species	**Density estimates (individuals/km²)**	**Estimated population abundance in the relevant MU**	**References**
Harbour porpoise	1.468*	346,601	Moray West (2018); IAMMWG (2021)
Bottlenosedolphin	0.0037	224	Hammond et al. (2021); Arso Civil et al. (2021); IAMMWG (2022)
White-beaked dolphin	0.123	43,951	Waggitt *et al*. (2019); IAMMWG (2022)
Common dolphin	0.074	102,656	Hammond *et al.* (2021); IAMMWG (2022)
Minke whale	0.023	20,118	Waggitt *et al*. (2019); IAMMWG (2022)

** Maximum density cell within the Moray West Site*

4 Potential Impacts for Marine Mammals

Potential impacts assessed for marine mammals during UXO clearance are:

- permanent change in hearing sensitivity / auditory injury (Permanent Threshold Shift (PTS)) from underwater noise;
- temporary change in hearing sensitivity (Temporary Threshold Shift (TTS)) from underwater noise;
- disturbance from underwater noise from High and Low order clearance;
- potential disturbance from ADD;
- increased collision risk and disturbance from vessels;
- changes to water quality; and
- changes to prey species.

Underwater noise has the potential to impact marine mammals if the frequency is within their hearing range (**Table 4.1**) and / or the sound levels are greater than thresholds for the species (**Table 4.2**) (Southall *et al*., 2019).

The potential for auditory injury is not just related to the level of the underwater sound and its frequency relative to the hearing bandwidth of the animal, but is also influenced by the duration of exposure.

Table 4.1 Marine mammal hearing ranges (from Southall *et al*., 2019)	
Species Hearing Group	**Generalised Hearing Range**
Harbour porpoise Very high-frequency cetaceans (VHF)	275 Hz to 160 kHz
Bottlenose dolphin and white-beaked dolphin High-frequency cetaceans (HF)	150 Hz to 160 kHz
Minke whale Low-frequency cetaceans (LF)	7 Hz to 35 kHz
Grey seal and harbour seal Phocid carnivores in water (PCW)	50 Hz to 86 kHz

Southall *et al*. (2019) gives individual criteria based on whether the noise source is considered impulsive or non-impulsive. Southall *et al*. (2019) categorises impulsive noises as having high peak sound pressure, short duration, fast rise-time and broad frequency content at source, and non-impulsive sources as steady-state noise. Seismic airguns are considered impulsive noise sources. Sonars, vessels and other low-level continuous noises are considered non-impulsive. A non-impulsive noise does not necessarily have to have a long duration.

Southall *et al*. (2019) presents single strike, unweighted peak criteria (SPL_{peak}) and cumulative (i.e. more than a single sound impulse) weighted sound exposure criteria (SEL_{cum}) for both permanent threshold shift (PTS), where unrecoverable hearing damage may occur, and temporary threshold shift (TTS), where a temporary reduction in hearing sensitivity may occur in individual receptors (**Table 4.2**).

The assessments are based on the Southall *et al*. (2019) impact criteria which uses thresholds and weightings in relation to the different marine mammal species hearing sensitivity (**Table 4.2**). The thresholds indicate the risk of PTS and TTS in species of marine mammal that could be present in and around the UXO clearance areas. Note that the Southall *et al*. (2019) Marine Mammal Noise Exposure Criteria are the same as the National Marine and Fisheries Service (NMFS) (2018) criteria, although Southall *et al*. (2019) renames the species groupings: Medium-Frequency (MF) Cetaceans are now classed as High-Frequency (HF) Cetaceans, and previous HF Cetaceans as Very High Frequency (VHF) Cetaceans (**Table 4.2**).

The Sound Exposure Level (SEL) criteria are weighted, which corrects the sound level based on the sensitivity of the receiver, for example, harbour porpoise are less sensitive to low frequency sound than minke whales. The weighting takes that difference into account. Southall *et al.* (2019) also includes criteria based on peak Sound Pressure Level (SPL_{peak}), which are unweighted and do not take species sensitivity into account.

Table 4.2: Marine mammal threshold and criteria for underwater noise (from Southall *et al.,* 2019)						
Species Hearing Group	Unweighted SPL_{peak} (dB re 1 µPa)		Weighted SEL_{cum} (dB re 1 $\mu Pa^2 s$)			
	Impulsive		Impulsive		Non-impulsive	
	PTS	TTS	PTS	TTS	PTS	TTS
Harbour porpoise Very high-frequency cetaceans (VHF)	202	196	155	140	173	153
White-beaked dolphin High-frequency cetaceans (HF)	230	224	185	170	198	178
Minke whale Low-frequency cetaceans (LF)	219	213	183	168	199	179
Grey seal and harbour seal Phocid carnivores in water (PCW)	218	212	185	170	201	181

There is currently no agreed thresholds and criteria for disturbance from underwater noise. However, unweighted impulsive single-strike criteria from Lucke *et al*. (2009) for behavioural response in harbour porpoise, based on impulsive seismic airgun stimuli, is:

- 145 dB re 1 $\mu Pa^2 s$ (SEL_{ss})

Please note that both Sound Pressure Level (SPL) and Sound Exposure Level (SEL) values are included in the results, which are specific to respective criteria used, and should not be confused or compared directly. All decibel SPL values are referenced to 1 µPa; all SEL values are referenced to 1 $\mu Pa^2 s$.

4.1 UXO Underwater Noise Modelling

The risk associated with clearance of UXO associated with the Development has been investigated by 6 Alpha Associates Ltd (**Appendix C**), in respect of the underwater noise produced for high-order clearance. The range of impact in relation to marine mammals and fish injury from UXO detonation has been estimated.

A number of UXO devices with a range of charge weights (or quantity of contained explosive) may be present within the boundary of the Development. These may need to be removed before construction can begin. There are expected to be a variety of explosive types, many of which are likely to have been subject to degradation or burying over time. Two otherwise identical explosive devices are likely to produce different blasts in the case where one has spent an extended period on the seabed. A selection of explosive sizes has been considered based on site surveys and, in each case, it has been assumed that the maximum explosive charge in each device is present and detonates with the clearance.

The noise produced by the detonation of explosives is affected by several different elements, only one of which, the charge weight, can easily be factored into a calculation. In this case the charge weight used for calculations is based on the equivalent weight of TNT. Many other elements relating to its situation (e.g. its design, composition, age, position, orientation, whether it is covered by sediment) and exactly how they will affect the sound produced by detonation are usually unknown and cannot be directly considered in this type of assessment. This leads to a high degree of uncertainty in the estimation of the source noise level (i.e. the noise level at the position of the UXO). A worst-case estimation has therefore been used for calculations, assuming the UXO to be detonated is not buried, degraded or subject to any other significant attenuation from its 'as new' condition.

The consequence of this is that the noise levels produced, particularly by the larger explosives under consideration, are likely to be over-estimated as some degree of degradation would be expected.

The range of equivalent charge weights of the potential UXO devices that could be present the Development Site boundaries have been estimated as less than 6 kg to 365 kg (**Table 2.2** and **Appendix C**) of HE. This is not intended to be a comprehensive list of all devices that could be found, although it includes a broad range of sizes of device which is unlikely to be exceeded.

A comparison has been made with the modelling results produced for the Moray East Offshore Windfarm (OWF) UXO clearance (Moray East, 2019) investigated by Subacoustech Environmental Ltd. For high-order destinations a worst-case approach has been made and the largest impact range across the two projects has applied to the calculations. Comparisons have also been made to similar projects (Seagreen Wind Energy Ltd, 2021; Dogger Bank B; **Appendix C**) to ensure consistency and realistic impacts have been presented.

4.1.1 Low-order clearance

Other techniques are being considered to reduce the impact of noise impacts from high-order UXO clearance, caused by detonation of the main charge of the UXO. Deflagration is such an alternative technique, intended to result in a 'low order' burn of the explosive material in a UXO, which destroys but does not detonate the internal explosive.

Deflagration is a safer technique for UXO disposal as it is intended to avoid the high pressures associated with an explosion, which would lead to an increased risk of adverse effects to marine life. Where the UXO device cannot be moved, deflagration represents the best-case scenario in respect to environmental effects.

Where the technique proceeds as intended, it is still not without noise impact. The process requires an initial shaped explosive charge, typically less than 250 g, to breach the casing and ignite the internal HE material without full detonation. The shaped charge and burn will both produce noise, although it will be significantly less than the high-order detonation of the much larger UXO. It may not destroy all of the HE, necessitating further deflagration events or collection of the remnants. The deflagration may produce an unintentional high-order event.

Underwater noise modelling for low-order clearance has been undertaken for Erebus OWF (Erebus Floating OWF, 2021 and Seagreen Wind Energy Ltd, 2021) (**Appendix C**) which will be applied to the assessment.

4.2 PTS from UXO clearance

The maximum predicted impact ranges for PTS in harbour porpoise, bottlenose dolphin, white-beaked dolphin, common dolphin and minke whale, from a range of possible UXO including charge weights for high-order detonation are presented in **Table 4.3** based on the underwater noise modelling for high-order detonation (see **Appendix C**). This is very precautionary as the impact ranges are based on the worst-case scenario for the largest UXO device that may (or may not) be present and that it is cleared using high-order detonation.

Table 4.3: The maximum predicted impact ranges (km) for PTS in marine mammals, based on the underwater noise modelling for high-order detonation

Species	PTS Criteria and Threshold (Southall *et al.*, 2019)	Possible UXO including charge weights NEQ and maximum predicted impact range (km)		
		25 kg	166 kg	365 kg*
Harbour porpoise (VHF)	PTS SPL_{peak} 202 dB re 1 µPa Unweighted Impulsive criteria	4.96 km	8.86 km	12.20 km ($467.6\ km^2$)
	PTS SEL 155 dB re 1 $µPa^2s$ Weighted Impulsive criteria	0.41 km	0.96 km	1.40 km ($6.2\ km^2$)
Bottlenose dolphin, white-beaked dolphin and common dolphin (HF)	PTS SPL_{peak} 230 dB re 1 µPa Unweighted Impulsive criteria	0.29 km	0.51 km	0.70 km ($1.5\ km^2$)
	PTS SEL 185 dB re 1 $µPa^2s$ Weighted Impulsive criteria	0.015 km	0.035 km	1.20 km ($4.5\ km^2$)
Minke whale (LF)	PTS SPL_{peak} 219 dB re 1 µPa Unweighted Impulsive criteria	0.88 km	1.57 km	2.10 km ($13.9\ km^2$)
	PTS SEL 183 dB re 1 $µPa^2s$	0.015 km	0.035 km	9.00 km ($254.5\ km^2$)

Table 4.3: The maximum predicted impact ranges (km) for PTS in marine mammals, based on the underwater noise modelling for high-order detonation				
Species	**PTS Criteria and Threshold (Southall *et al.*, 2019)**	**Possible UXO including charge weights NEQ and maximum predicted impact range (km)**		
		25 kg	**166 kg**	**365 kg***
	Weighted Impulsive criteria			

*based on Subacoustech modelling of charge weights at Moray East OWF sites (**Appendix C**) as worst-case

All species of marine mammal are considered to have high value and high sensitivity to UXO high-order detonation if they are within the potential impact range PTS.

The MMMP for UXO to reduce the risk of PTS in marine mammals is presented in **Appendix B**.

The risk of PTS in marine mammals would be reduced by using low-order clearance such as deflagration for the clearance of the UXOs.

The maximum predicted impact ranges for PTS from a range of possible charge weights (NEQ) for low-order clearance are presented in **Table 4.4**.

Table 4.4: The maximum predicted impact ranges for PTS in marine mammals from a range of possible charge weights for low-order clearance

Species	**PTS Criteria and Threshold (Southall *et al.*, 2019)**	**Possible charge weights for low-order clearance***			
		0.1kg	**0.25kg**	**0.5kg**	**2.0kg**
Harbour porpoise (VHF)	PTS SPL_{peak} 202 dB re 1 µPa Unweighted Impulsive criteria	0.73 km	0.99 km ($3.08km^2$)	1.2 km	1.9 km ($11.34km^2$)
	PTS SEL 155 dB re 1 μPa^2s Weighted Impulsive criteria	0.05 km	0.08 km ($0.02km^2$)	0.11 km	0.2 km ($0.13km^2$)
Bottlenose dolphin, white-beaked dolphin and common dolphin (HF)	PTS SPL_{peak} 230 dB re 1 µPa Unweighted Impulsive criteria	0.04 km	0.06 km ($0.011km^2$)	0.07 km	0.11 km ($0.038km^2$)
	PTS SEL 185 dB re 1 μPa^2s Weighted Impulsive criteria	<0.01 km	<0.01 km ($0.0003km^2$)	<0.01 km	<0.01 km ($0.0003km^2$)

Table 4.4: The maximum predicted impact ranges for PTS in marine mammals from a range of possible charge weights for low-order clearance					
Species	**PTS Criteria and Threshold (Southall *et al.*, 2019)**	**Possible charge weights for low-order clearance***			
		0.1kg	**0.25kg**	**0.5kg**	**2.0kg**
Minke whale (LF)	PTS SPL_{peak} 219 dB re 1 µPa Unweighted Impulsive criteria	0.13 km	0.17 km ($0.091km^2$)	0.22 km	0.35 km ($0.38km^2$)
	PTS SEL 183 dB re 1 $µPa^2s$ Weighted Impulsive criteria	0.14 km	0.23 km ($0.17km^2$)	0.32 km	0.63 km ($1.25km^2$)

** based on Erebus Floating OWF (2021) Subacoustech modelling of low-order UXO clearance. UXO modelling is not site specific and therefore is appropriate to use for the Moray West site.*

4.2.1 Harbour porpoise

The maximum number of harbour porpoise that could potentially be at risk of PTS during UXO clearance, based on the maximum potential PTS impact ranges for a UXO high-order detonation are presented in **Table 4.5**.

The maximum number of harbour porpoise that could potentially be at risk of PTS for low-order clearance are presented in **Table 4.6**.

Table 4.5: The maximum number of harbour porpoise that could be at risk of PTS from high-order clearance			
Species	**PTS criteria and maximum impact area**	**Maximum number of harbour porpoise and % of reference population based on maximum potential impact area**	**Magnitude**
Harbour porpoise	PTS SPL_{peak} ($467.6 km^2$) unmitigated	686 harbour porpoise (0.20% of North Sea MU) based on site survey density $1.468/km^2$	Medium magnitude (i.e. 0.01%-1% of the North Sea MU reference population anticipated to be exposed to the permanent impact).
	PTS weighted SEL impulsive criteria ($6.2 km^2$) unmitigated	9 harbour porpoise (0.0026% of North Sea MU) based on site survey density $1.468/km^2$	Low magnitude (i.e. 0.01%-0.001% of the North Sea MU reference population anticipated to be exposed to the permanent impact).

Table 4.6: The maximum number of harbour porpoise that could be at risk of PTS from the charge weights for low-order clearance			
Species	**PTS criteria and maximum impact area**	**Maximum number of harbour porpoise and % of reference population based on maximum potential impact area**	**Magnitude**
Harbour porpoise	PTS SPL_{peak} (0.25kg = 3.08 km^2)	5 harbour porpoise (0.0013% of North Sea MU) based on site survey density 1.468/km^2	Low magnitude (i.e. 0.01% to 0.001% of the North Sea MU reference population anticipated to be exposed to the permanent impact).
	PTS SEL (0.25kg = 0.02 km^2)	0.03 harbour porpoise (0.000008% of North Sea MU) based on site survey density 1.468/km^2	Negligible magnitude (i.e. less than 0.001% of the North Sea MU reference population anticipated to be exposed to the permanent impact).
	PTS SPL_{peak} (2kg = 11.34 km^2)	11 harbour porpoise (0.0048% of North Sea MU) based on site survey density 1.468/km^2	Low magnitude (i.e. 0.01% to 0.001% of the North Sea MU reference population anticipated to be exposed to the permanent impact).
	PTS SEL (2kg = 0.13 km^2)	0.13 harbour porpoise (0.000055% of North Sea MU) based on site survey density 1.468/km^2	Negligible magnitude (i.e. less than 0.001% of the North Sea MU reference population anticipated to be exposed to the permanent impact).

PTS in harbour porpoise has been assessed for the worst case, based on the maximum size of potential UXO for PTS from high-order detonation, and the impact significance has been assessed as major adverse for harbour porpoise (**Table 4.7**).

The residual impact of the potential risk of physical injury or permanent auditory injury / change in hearing sensitivity (PTS) to harbour porpoise as a result of any underwater UXO clearance would be negligible magnitude taking into account the proposed mitigation in the MMMP, therefore, with a high sensitivity the potential impact significance for physical injury or permanent auditory injury / change in hearing sensitivity (PTS), is **minor adverse (not significant)**.

The risk of PTS would be reduced by using low-order clearance such as deflagration for the clearance of the UXOs (**Table 4.8**).

Table 4.7: Assessment of impact significance for PTS in harbour porpoise during high-order UXO detonation						
Species	**Potential Impact**	**Sensitvity**	**Magnitude without mitigation**	**Significance**	**Mitigation**	**Residual impact**
Harbour porpoise	Risk of PTS during underwater high-order UXO detonation	High	Medium to Low	Major to Moderate adverse	MMMP	Minor (not significant)

Table 4.8: Assessment of impact significance for PTS in harbour porpoise during low-order UXO clearance						
Species	**Potential Impact**	**Sensitvity**	**Magnitude**	**Significance**	**Mitigation**	**Residual impact**
Harbour porpoise	Risk of PTS during underwater low-order UXO clearance	High	Low to Negligible	Moderate to Minor adverse	MMMP	Minor (not significant)

4.2.2 Bottlenose dolphin

The maximum number of bottlenose dolphin that could potentially be at risk of PTS during UXO clearance based on the maximum potential PTS impact ranges for a UXO high-order detonation are presented in **Table 4.9**.

The maximum number of bottlenose dolphin that could potentially be at risk of PTS for low-order clearance are presented in **Table 4.10**.

Table 4.9: The maximum number of bottlenose dolphin that could be at risk of PTS from the maximum high-order detonation			
Species	**PTS criteria and maximum impact area**	**Maximum number of bottlenose dolphin and % of reference population based on maximum potential impact area**	**Magnitude**
Bottlenose dolphin	PTS SPL_{peak} (1.5 km^2) unmitigated	0.006 bottlenose dolphin (0.0003% of CES MU) based on the density estimate of 0.0037/km^2	Negligible magnitude (i.e. 0.001% or less of the CES MU reference population anticipated to be exposed to the permanent impact).
	PTS weighted SEL impulsive criteria (4.5 km^2) unmitigated	0.017 bottlenose dolphin (0.0008% of CES MU) based on the density estimate of 0.0037/km^2	Negligible magnitude (i.e. 0.001% or less of the CES MU reference population anticipated to be exposed to the permanent impact).

Table 4.10: The maximum number of bottlenose dolphin that could be at risk of PTS from the charge weights for low-order clearance			
Species	**PTS criteria and maximum impact area**	**Maximum number of bottlenose dolphin and % of reference population based on maximum potential impact area**	**Magnitude**
Bottlenose dolphin	PTS SPL_{peak} (0.25kg = 0.011 km^2)	0.00004 bottlenose dolphin (0.000002% of CES MU) based on the density estimate of 0.0037/km^2	Negligible magnitude (i.e. 0.001% or less of the reference population anticipated to be exposed to the permanent impact).
	PTS SEL (0.25kg = 0.0003 km^2)	0.000001 bottlenose dolphin (0.00000005% of CES MU) based on the density estimate of 0.0037/km^2	Negligible magnitude (i.e. 0.001% or less of the reference population anticipated to be exposed to the permanent impact).
	PTS SPL_{peak} (2kg = 0.038 km^2)	0.00014 bottlenose dolphin (0.000007% of CES MU) based on the density estimate of 0.0037/km^2	Negligible magnitude (i.e. 0.001% or less of the reference population anticipated to be exposed to the permanent impact).
	PTS SEL (2kg = 0.0003 km^2)	0.000001 bottlenose dolphin (0.0000005% of CES MU) based on the density estimate of 0.0037/km^2	Negligible magnitude (i.e. 0.001% or less of the reference population anticipated to be exposed to the permanent impact).

PTS in bottlenose dolphin has been assessed for the worst case for high-order detonation, based on the maximum size of potential UXO, and the impact significance prior to mitigation is minor adverse (**Table 4.11**).

The residual impact of the potential risk of physical injury and permanent auditory injury / change in hearing sensitivity (PTS) to bottlenose dolphin as a result of any underwater UXO clearance is negligible magnitude taking into account the proposed mitigation in the MMMP, therefore, with a high sensitivity the potential impact significance for any physical injury or permanent auditory injury / change in hearing sensitivity (PTS), is **minor adverse (not significant)**.

It is also important to note that the assessments for bottlenose dolphin have been based on a very precautionary approach, as there is currently no density estimate for the UXO clearance areas. In addition, bottlenose dolphin are more likely to be present close to shore, rather than the offshore areas. Therefore, the risk of PTS to bottlenose dolphin is likely to be less than in the worst-case assessment.

The risk of PTS would be reduced by using low-order clearance such as deflagration for the clearance of the UXOs (**Table 4.12**).

Table 4.11: Assessment of impact significance for PTS in bottlenose dolphin during high-order UXO clearance detonation						
Species	**Potential Impact**	**Sensitvity**	**Magnitude without mitigation**	**Significance**	**Mitigation**	**Residual impact**
Bottlenose dolphin	Risk of PTS during underwater UXO high-order detonation	High	Negligible	Minor	MMMP	Minor (not significant)

Table 4.12: Assessment of impact significance for PTS in bottlenose dolphin during low-order UXO clearance						
Species	**Potential Impact**	**Sensitvity**	**Magnitude**	**Significance**	**Mitigation**	**Residual impact**
Bottlenose dolphin	Risk of PTS during underwater low-order UXO clearance	High	Negligible	Minor	MMMP	Minor (not significant)

4.2.3 White-beaked dolphin

The maximum number of white-beaked dolphin that could potentially be at risk of PTS during UXO clearance based on the maximum potential PTS impact ranges for a UXO high-order detonation are presented in **Table 4.13**.

The maximum number of white-beaked dolphin that could potentially be at risk of PTS for low-order clearance are presented in **Table 4.14.**

Table 4.13: The maximum number of white-beaked dolphin that could be at risk of PTS from the maximum high-order detonation			
Species	**PTS criteria and maximum impact area**	**Maximum number of white-beaked dolphin and % of reference population based on maximum potential impact area**	**Magnitude**
White-beaked dolphin	PTS SPL_{peak} (1.5 km^2) unmitigated	0.2 white-beaked dolphin (0.0004% of CGNS MU) based on the density estimate of 0.123/km^2	Negligible magnitude (i.e. 0.001% or less of the CGNS MU reference population anticipated to be exposed to the permanent impact).
	PTS weighted SEL impulsive criteria (4.5 km^2) unmitigated	0.56 white-beaked dolphin (0.0013% of CGNS MU) based on the density estimate of 0.123/km^2	Low magnitude (i.e. 0.01% to 0.001% of the North Sea MU reference population anticipated to be

Table 4.13: The maximum number of white-beaked dolphin that could be at risk of PTS from the maximum high-order detonation

Species	PTS criteria and maximum impact area	Maximum number of white-beaked dolphin and % of reference population based on maximum potential impact area	Magnitude
			exposed to the permanent impact).

Table 4.14: The maximum number of white-beaked dolphin that could be at risk of PTS from the charge weights for low-order clearance

Species	PTS criteria and maximum impact area	Maximum number of white-beaked dolphin and % of reference population based on maximum potential impact area	Magnitude
White-beaked dolphin	PTS SPL_{peak} (0.25kg = 0.011 km^2)	0.0014 white-beaked dolphin (0.000003% of CGNS MU) based on the density estimate of 0.123/km^2	Negligible magnitude (i.e. 0.001% or less of the CGNS MU reference population anticipated to be exposed to the permanent impact).
	PTS SEL (0.25kg = 0.0003 km^2)	0.00004 white-beaked dolphin (0.00000008% of CGNS MU) based on the density estimate of 0.123/km^2	Negligible magnitude (i.e. 0.001% or less of the CGNS MU reference population anticipated to be exposed to the permanent impact).
	PTS SPL_{peak} (2kg = 0.038 km^2)	0.005 white-beaked dolphin (0.00001% of CGNS MU) based on the density estimate of 0.123/km^2	Negligible magnitude (i.e. 0.001% or less of the CGNS MU reference population anticipated to be exposed to the permanent impact).
	PTS SEL (2kg = 0.0003 km^2)	0.00004 white-beaked dolphin (0.00000008% of CGNS MU) based on the density estimate of 0.123/km^2	Negligible magnitude (i.e. 0.001% or less of the CGNS MU reference population anticipated to be exposed to the permanent impact).

The impact significance for any permanent auditory injury / change in hearing sensitivity (PTS) in white-beaked dolphin has been assessed as minor to moderate adverse based on the worst case for PTS from high-order detonation of the maximum size of potential UXO (**Table 4.15**).

Table 4.15: Assessment of impact significance for PTS in white-beaked dolphin during high-order UXO detonation						
Species	**Potential Impact**	**Sensitvity**	**Magnitude without mitigation**	**Significance**	**Mitigation**	**Residual impact**
White-beaked dolphin	Risk of PTS during underwater high-order UXO detonation	High	Negligible to low	Minor to moderate adverse	MMMP	Minor adverse (not significant)

The residual impact of the potential risk of physical injury and permanent auditory injury / change in hearing sensitivity (PTS) to white-beaked dolphin as a result of any underwater UXO clearance is negligible magnitude taking into account the proposed mitigation in the MMMP, therefore, with a high sensitivity the potential impact significance for any physical injury or permanent auditory injury / change in hearing sensitivity (PTS), is likely to be less than **minor adverse (not significant)**.

The risk of PTS would be reduced by using low-order clearance such as deflagration for the clearance of the UXOs (**Table 4.16**).

Table 4.16: Assessment of impact significance for PTS in white-beaked dolphin during low-order UXO clearance						
Species	**Potential Impact**	**Sensitvity**	**Magnitude**	**Significance**	**Mitigation**	**Residual impact**
White-beaked dolphin	Risk of PTS during underwater low-order UXO clearance	High	Negligible	Minor	MMMP	Minor (not significant)

4.2.4 Common dolphin

The maximum number of common dolphin that could potentially be at risk of PTS during UXO clearance based on the maximum potential PTS impact ranges for a UXO high-order detonation are presented in **Table 4.17**.

The maximum number of common dolphin that could potentially be at risk of PTS for low-order clearance are presented in **Table 4.18.**

Table 4.17: The maximum number of common dolphin that could be at risk of PTS from the maximum high-order detonation			
Species	**PTS criteria and maximum impact area**	**Maximum number of common dolphin and % of reference population based on maximum potential impact area**	**Magnitude**
Common dolphin	PTS SPL_{peak} (1.5 km^2) unmitigated	0.114 common dolphin (0.0001% of CGNS MU) based on the density estimate of 0.074 /km^2	Negligible magnitude (i.e. 0.001% or less of the CGNS MU reference population anticipated to be exposed to the permanent impact).
	PTS weighted SEL impulsive criteria (4.5 km^2) unmitigated	0.335 common dolphin (0.0003% of CGNS MU) based on the density estimate of 0.074 /km^2	Negligible magnitude (i.e. 0.001% or less of the CGNS MU reference population anticipated to be exposed to the permanent impact).

Table 4.18: The maximum number of common dolphin that could be at risk of PTS from the charge weights for low-order clearance			
Species	**PTS criteria and maximum impact area**	**Maximum number of common dolphin and % of reference population based on maximum potential impact area**	**Magnitude**
Common dolphin	PTS SPL_{peak} (0.25kg = 0.011 km^2)	0.0008 common dolphin (0.0000008% of CGNS MU) based on the density estimate of 0.074 /km^2	Negligible magnitude (i.e. 0.001% or less of the CGNS MU reference population anticipated to be exposed to the permanent impact).
	PTS SEL (0.25kg = 0.0003 km^2)	0.00002 common dolphin (0.00000002% of CGNS MU) based on the density estimate of 0.074 /km^2	Negligible magnitude (i.e. 0.001% or less of the CGNS MU reference population anticipated to be exposed to the permanent impact).
	PTS SPL_{peak} (2kg = 0.038 km^2)	0.003 common dolphin (0.000003% of CGNS MU) based based on the density estimate of 0.074 /km^2	Negligible magnitude (i.e. 0.001% or less of the CGNS MU reference population anticipated to be exposed to the permanent impact).
	PTS SEL (2kg = 0.0003 km^2)	0.00002 common dolphin (0.00000002% of CGNS MU) based on the density estimate of 0.074 /km^2	Negligible magnitude (i.e. 0.001% or less of the CGNS MU reference population anticipated to be exposed to the permanent impact).

The impact significance for any permanent auditory injury / change in hearing sensitivity (PTS) in common dolphin has been assessed as minor adverse (not significant) based on the worst case for PTS from high-order detonation of the maximum size of potential UXO (**Table 4.19**).

Table 4.19: Assessment of impact significance for PTS in common dolphin during high-order UXO detonation						
Species	**Potential Impact**	**Sensitvity**	**Magnitude without mitigation**	**Significance**	**Mitigation**	**Residual impact**
Common dolphin	Risk of PTS during underwater high-order UXO detonation	High	Negligible	Minor	MMMP	Minor adverse (not significant)

The residual impact of the potential risk of physical injury and permanent auditory injury / change in hearing sensitivity (PTS) to common dolphin as a result of any underwater UXO clearance is negligible magnitude taking into account the proposed mitigation in the MMMP, therefore, with a high sensitivity the potential impact significance for any physical injury or permanent auditory injury / change in hearing sensitivity (PTS), is likely to be less than **minor adverse (not significant)**.

The risk of PTS would be reduced by using low-order clearance such as deflagration for the clearance of the UXOs (**Table 4.20**).

Table 4.20: Assessment of impact significance for PTS in common dolphin during low-order UXO clearance						
Species	**Potential Impact**	**Sensitvity**	**Magnitude**	**Significance**	**Mitigation**	**Residual impact**
Common dolphin	Risk of PTS during underwater low-order UXO clearance	High	Negligible	Minor	MMMP	Minor (not significant)

4.2.5 Minke whale

The maximum number of minke whale that could potentially be at risk of PTS based on the maximum potential PTS impact ranges for a UXO high-order detonation are presented in **Table 4.21**.

The maximum number of minke whale that could potentially be at risk of PTS for low-order clearance are presented in **Table 4.22**.

Table 4.21: The maximum number of minke whale that could be at risk of PTS from the maximum high-order detonation with and without the use of			
Species	**PTS criteria and maximum impact area**	**Maximum number of minke whale and % of reference population based on maximum potential impact area**	**Magnitude**
Minke whale	PTS SPL_{peak} (13.9 km^2) unmitigated	0.32 minke whale (0.002% of CGNS MU) based on the density estimate of 0.023/km^2	Low magnitude (i.e. 0.001% - 0.01% the GNS MU reference population anticipated to be exposed to the permanent impact).
	PTS weighted SEL impulsive criteria (254.5 km^2) unmitigated	5.9 minke whale (0.03% of CGNS MU) based on the density estimate of 0.023/km^2	Medium magnitude (i.e. 0.01%-1% of the CGNS MU reference population anticipated to be exposed to the permanent impact).

Table 4.22: The maximum number of minke whale that could be at risk of PTS from the charge weights for low-order clearance			
Species	**PTS criteria and maximum impact area**	**Maximum number of minke whale and % of reference population based on maximum potential impact area**	**Magnitude**
Minke whale	PTS SPL_{peak} (0.25kg = 0.091 km^2)	0.002 minke whale (0.00001% of CGNS MU) based on the density estimate of 0.023/km^2	Negligible magnitude (i.e. 0.001% or less of the CGNS MU reference population anticipated to be exposed to the permanent impact).
	PTS SEL (0.25kg = 0.17 km^2)	0.004 minke whale (0.00002% of CGNS MU) based on the density estimate of 0.023/km^2	Negligible magnitude (i.e. 0.001% or less of the CGNS MU reference population anticipated to be exposed to the permanent impact).
	PTS SPL_{peak} (2kg = 0.38 km^2)	0.009 minke whale (0.00004% of CGNS MU) based on the density estimate of 0.023/km^2	Negligible magnitude (i.e. 0.001% or less of the CGNS MU reference population anticipated to be exposed to the permanent impact).
	PTS SEL (2kg = 1.25 km^2)	0.029 minke whale (0.0001% of CGNS MU) based on the density estimate of 0.023/km^2	Negligible magnitude (i.e. 0.001% or less of the CGNS MU reference population anticipated to be exposed to the permanent impact).

The impact significance for any permanent auditory injury / change in hearing sensitivity (PTS) in minke whale has been assessed as minor adverse (not significant based on the worst case for PTS from high-order detonation of the maximum size of potential UXO (**Table 4.23**).

Table 4.23: Assessment of impact significance for PTS in minke whale during high-order UXO detonation						
Species	**Potential Impact**	**Sensitvity**	**Magnitude without mitigation**	**Significance**	**Mitigation**	**Residual impact**
Minke whale	Risk of PTS during underwater high-order UXO detonation	High	Low to Medium	Minor to Major adverse	MMMP	Minor adverse (not significant)

The residual impact of the potential risk of physical injury and permanent auditory injury / change in hearing sensitivity (PTS) to minke whale as a result of any underwater UXO clearance is negligible magnitude taking into account the proposed mitigation, therefore, with a high sensitivity the potential impact significance for any physical injury or permanent auditory injury / change in hearing sensitivity (PTS), is likely to be less than **minor adverse (not significant)**.

The risk of PTS would be reduced by using low-order clearance such as deflagration for the clearance of the UXOs (**Table 4.24**).

Table 4.24: Assessment of impact significance for PTS in minke whale during low-order UXO clearance						
Species	**Potential Impact**	**Sensitvity**	**Magnitude**	**Significance**	**Mitigation**	**Residual impact**
Minke whale	Risk of PTS during underwater low-order UXO clearance	High	Negligible	Minor	MMMP	Minor (not significant)

4.3 TTS from UXO clearance

The maximum predicted impact ranges for temporary auditory injury / change in hearing sensitivity (TTS) in harbour porpoise, bottlenose dolphin, white-beaked dolphin, minke whale from the maximum possible UXO with charge weights for high-order detonation are presented in **Table 4.25** based on the unmitigated underwater noise modelling (see **Appendix C**).

Table 4.25: The maximum predicted impact ranges for TTS in marine mammals, based on the underwater noise modelling for high-order detonation				
Species	**TTS Criteria Threshold (Southall *et al.*, 2019)**	**Possible maximum UXO with charge weights and maximum predicted impact range (km)**		
		25 kg	**166 kg**	**365 kg ***
Harbour porpoise (VHF)	TTS SPL_{peak} 196 dB re 1 µPa Unweighted Impulsive criteria	9.1 km	16.3 km	22.5 km (1,590.4km^2)

* *based on Subacoustech modelling of charge weights at Moray East OWF sites (**Appendix C**) as worst-case*

Table 4.25: The maximum predicted impact ranges for TTS in marine mammals, based on the underwater noise modelling for high-order detonation				
Species	**TTS Criteria Threshold (Southall *et al.*, 2019)**	**Possible maximum UXO with charge weights and maximum predicted impact range (km)**		
		25 kg	**166 kg**	**365 kg ***
	TTS SEL 140 dB re 1 µPa^{2}s Weighted Impulsive criteria	2.1 km	5.1 km	7.4 km[(3)] (171.1 km^2)
Bottlenose dolphin, white-beaked dolphin and common dolphin (HF)	TTS SPL_{peak} 224 dB re 1 µPa Unweighted Impulsive criteria	0.5 km	0.9 km	1.3 km (5.1 km^2)
	TTS SEL 170 dB re 1 µPa^{2}s Weighted Impulsive criteria	0.08 km	0.2 km	0.51 km (0.8 km^2)
Minke whale (LF)	TTS SPL_{peak} 213 dB re 1 µPa Unweighted Impulsive criteria	1.6 km	2.9 km	4.0 km (50.3 km^2)
	TTS SEL 168 dB re 1 µPa^{2}s Weighted Impulsive criteria	6.1 km	14.4 km	99.3 km (30,977.6 km^2)

The assessments undertaken are based on the worst-case scenario for the largest UXO device that may (or may not) be present. The sensitivity of all marine mammals considered within this section to TTS and flee response / likely disturbance as a result of underwater UXO high-order detonation is considered to be medium in this assessment as a precautionary approach.

Marine mammals within the potential TTS impact range, but beyond the potential impact range for PTS are assessed to have medium sensitivity. Marine mammals within the potential impact area are considered to have limited capacity to avoid such impacts, although any impacts on marine mammals would be temporary and they would be expected to return to the area once the activity had ceased.

The MMMP (**Appendix B**) outlines the mitigation measures to reduce the risk of PTS in marine mammals which would also reduce the number of animals at risk of TTS.

The risk of TTS in all marine mammals would be reduced by using low-order clearance such as deflagration for the clearance of the UXOs (**Table 4.26**). The maximum predicted impact ranges for TTS from a range

[3] *based on 6 Alpha Associates Ltd modelling of charge weights at Moray West Site (**Appendix C**) as worst-case*

of possible charge weights (NEQ) for low-order clearance are presented in **Table 4.26**. However, assessments are based on the worst-case for high-order detonation.

Table 4.26: The maximum predicted impact ranges for TTS in marine mammals from a range of possible charge weights for low-order clearance

Species	TTS Criteria and Threshold (Southall *et al.*, 2019)	Possible charge weights for low-order clearance*			
		0.1 kg	0.25 kg	0.5 kg	2.0 kg
Harbour porpoise (VHF)	TTS SPL_{peak} 196 dB re 1 µPa Unweighted Impulsive criteria	1.3 km	1.8 km	2.3 km	3.6 km ($40.72km^2$)
	TTS SEL 140 dB re 1 $µPa^2s$ Weighted Impulsive criteria	0.54 km	0.75 km	0.93 km	1.3 km ($5.31km^2$)
Bottlenose dolphin, white-beaked dolphin and common dolphin (HF)	TTS SPL_{peak} 224 dB re 1 µPa Unweighted Impulsive criteria	0.08 km	0.1 km	0.13 km	0.21 km ($0.14km^2$)
	TTS SEL 170 dB re 1 $µPa^2s$ Weighted Impulsive criteria	0.01 km	0.02 km	0.03 km	0.05 km ($0.008km^2$)
Minke whale (LF)	TTS SPL_{peak} 213 dB re 1 µPa Unweighted Impulsive criteria	0.23 km	0.32 km	0.41 km	0.65 km ($1.33km^2$)
	TTS SEL 168 dB re 1 $µPa^2s$ Weighted Impulsive criteria	2 km	3.2 km	4.5 km	8.8 km ($243.28km^2$)

** based on Erebus Floating OWF (2021) Subacoustech modelling of low-order UXO clearance. UXO modelling is not site specific and therefore is appropriate to use for the Moray West Site.*

4.3.1 Harbour porpoise

The maximum number of harbour porpoise that could potentially be at risk of TTS during UXO clearance based on the maximum potential TTS impact ranges for high-order detonation are presented in **Table 4.27**.

Table 4.27: The maximum number of harbour porpoise that could be at risk of TTS from the maximum high-order detonation			
Species	**TTS criteria and maximum impact area**	**Maximum number of harbour porpoise and % of reference population based on maximum potential impact area**	**Magnitude**
Harbour porpoise	TTS SPL_{peak} (1,590.4 km^2) unmitigated	2,335 harbour porpoise (0.67% of North Sea MU) based on site survey density of 1.468/km^2	Negligible magnitude (i.e. less than 1% of the North Sea MU reference population anticipated to be exposed to the temporary impact).
	TTS weighted SEL impulsive criteria (171.1 km^2) unmitigated	251 harbour porpoise (0.07% of North Sea MU), based on site survey density of 1.468/km^2	Negligible magnitude (i.e. less than 1% of the North Sea MU reference population anticipated to be exposed to the temporary impact).

The impact significance for TTS from high-order detonation has been assessed as **negligible** (not significant) for harbour porpoise (medium sensitivity and negligible magnitude).

The risk of TTS would be reduced by using low-order clearance such as deflagration for the clearance of the UXOs (**Table 4.26**).

4.3.2 Bottlenose dolphin

The maximum number of bottlenose dolphin that could potentially be at risk of TTS during UXO clearance based on the maximum potential TTS impact ranges for a UXO high-order detonation are presented in **Table 4.28**.

Table 4.28: The maximum number of bottlenose dolphin that could be at risk of TTS from the maximum high-order detonation			
Species	**TTS criteria and maximum impact area**	**Maximum number of bottlenose dolphin and % of reference population based on maximum potential impact area**	**Magnitude**
Bottlenose dolphin	TTS SPL_{peak} (5.1 km^2) unmitigated	0.02 bottlenose dolphin (0.009% of CES MU) based on the density estimate of 0.0037/km^2	Negligible magnitude (i.e. less than 1% of the CES MU reference population anticipated to be exposed to the temporary impact).
	TTS weighted SEL impulsive criteria (0.8 km^2)	0.003 bottlenose dolphin (0.00015% of CES MU) based on the density estimate of 0.0037/km^2	Negligible magnitude (i.e. less than 1% of the CES MU reference population anticipated

Table 4.28: The maximum number of bottlenose dolphin that could be at risk of TTS from the maximum high-order detonation			
Species	**TTS criteria and maximum impact area**	**Maximum number of bottlenose dolphin and % of reference population based on maximum potential impact area**	**Magnitude**
	unmitigated		to be exposed to the temporary impact).

The impact significance for TTS from high-order detonation has been assessed as **negligible** (not significant) for bottlenose dolphin (medium sensitivity and negligible magnitude).

The risk of TTS would be reduced by using low-order clearance such as deflagration for the clearance of the UXOs (**Table 4.26**).

4.3.3 White-beaked dolphin

The maximum number of white-beaked dolphin that could potentially be at risk of TTS during UXO clearance based on the maximum potential TTS impact ranges for a UXO high-order detonation are presented in **Table 4.29.**

Table 4.29: The maximum number of white-beaked dolphin that could be at risk of TTS from the maximum high-order detonation			
Species	**TTS criteria and maximum impact area**	**Maximum number of white-beaked dolphin and % of reference population based on maximum potential impact area**	**Magnitude**
White-beaked dolphin	TTS SPL_{peak} (5.1 km^2) unmitigated	0.63 white-beaked dolphin (0.001% of CGNS MU) based on the density estimate of 0.123/km^2	Negligible magnitude (i.e. less than 1% of the CGNS MU reference population anticipated to be exposed to the temporary impact).
	TTS weighted SEL impulsive criteria (0.8 km^2) unmitigated	0.1 white-beaked dolphin (0.0002% of CGNS MU), based on the density estimate of 0.123/km^2	Negligible magnitude (i.e. less than 1% of the CGNS MU reference population anticipated to be exposed to the temporary impact).

The impact significance for TTS from high-order detonation has been assessed as **negligible** (not significant) for white-beaked dolphin (medium sensitivity and negligible magnitude).

4.3.4 Common dolphin

The maximum number of common dolphin that could potentially be at risk of TTS during UXO clearance based on the maximum potential TTS impact ranges for a UXO high-order detonation are presented in **Table 4.30.**

Table 4.30: The maximum number of common dolphin that could be at risk of TTS from the maximum high-order detonation

Species	TTS criteria and maximum impact area	Maximum number of common dolphin and % of reference population based on maximum potential impact area	Magnitude
Common dolphin	TTS SPL_{peak} (5.1 km^2) unmitigated	0.4 common dolphin (0.0004% of CGNS MU) based on the density estimate of 0.074 /km^2	Negligible magnitude (i.e. less than 1% of the CGNS MU reference population anticipated to be exposed to the temporary impact).
	TTS weighted SEL impulsive criteria (0.8 km^2) unmitigated	0.06 common dolphin (0.0001 % of CGNS MU), based on the density estimate of 0.074 /km^2	Negligible magnitude (i.e. less than 1% of the CGNS MU reference population anticipated to be exposed to the temporary impact).

The impact significance for TTS from high-order detonation has been assessed as **negligible** (not significant) for common dolphin (medium sensitivity and negligible magnitude).

4.3.5 Minke whale

The maximum number of minke whale that could potentially be at risk of TTS during UXO clearance based on the maximum potential TTS impact ranges for a UXO high-order detonation are presented in **Table 4.31.**

Table 4.31: The maximum number of minke whale that could be at risk of TTS from the maximum high-order detonation

Species	TTS criteria and maximum impact area	Maximum number of minke whale and % of reference population based on maximum potential impact area	Magnitude
Minke whale	TTS SPL_{peak} (50.3 km^2) unmitigated	1.2 minke whale (0.006% of CGNS MU) based on the density estimate of 0.023/km^2	Negligible magnitude (i.e. less than 1% of the CGNS MU reference population anticipated to be exposed to the temporary impact).
	TTS weighted SEL impulsive criteria (30,978 km^2) unmitigated	712 minke whale (3.54% of CGNS MU), based on the density estimate of 0.023/km^2	Low magnitude (i.e. 1% to 5% of the CGNS MU reference population anticipated to be exposed to the temporary impact).

The impact significance for TTS from high-order detonation without mitigation has been assessed as **negligible** to **minor adverse** (not significant) and **negligible** with the use of a mitigation for minke whale.

The risk of TTS would be reduced by using low-order clearance such as deflagration for the clearance of the UXOs (**Table 4.26**).

4.4 Potential disturbance from UXO high-order detonation

For the marine mammal species considered there is currently no agreed threshold for disturbance from underwater noise, however, a fleeing response is assumed to occur at the same noise levels as TTS. As outlined in Southall *et al*. (2007), the onset of behavioural disturbance is proposed to occur at the lowest level of noise exposure that has a measurable transient impact on hearing (i.e., TTS). Although, as Southall *et al*. (2007) recognise that this is not a behavioural effect per se, exposures to lower noise levels from a single pulse are not expected to cause disturbance. However, any compromise, even temporarily, to hearing functions could have the potential to affect behaviour.

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

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

The assessments for TTS / fleeing response have therefore been used for assessing the potential disturbance ranges for UXO high-order detonation.

The potential magnitude for disturbance has been assessed as negligible (i.e., less than 1% of the reference population anticipated to be exposed to the temporary impact) for harbour porpoise, bottlenose dolphin, white-beaked dolphin and common dolphin. For minke whale the magnitude of potential impact is low (i.e., less than 5% of the reference population anticipated to be exposed to the temporary impact) without the use of mitigation based on the worst case for the maximum impact range for the maximum potential UXO that could be present.

The sensitivity of marine mammals to disturbance as a result of underwater UXO high-order detonation is considered to be medium, as a precautionary approach.

The impact significance for any disturbance has been assessed as **negligible** for harbour porpoise, bottlenose dolphin, white-beaked dolphin and common dolphin with or without the use of mitigation and as **minor adverse** (not significant) for minke whale without the use mitigation on a precautionary basis and **negligible** with the use of mitigation.

The Statutory Nature Conservation Bodies (SNCBs) currently recommend that a potential disturbance range based on an Effective Deterrent Radius (EDR) of 26 km around UXO high-order detonation is used to assess harbour porpoise disturbance in the SNS SAC (JNCC *et al.*, 2020). The maximum number of animals based on the 26km EDR (an area of up to 2,124km^2) that could be disturbed, based on density outlined in **Table 3.2,** would be;

- 3,118 harbour porpoise (up to 0.90% of North Sea MU)
- 8 bottlenose dolphin (up to 3.5% of CES MU)
- 261 white-beaked dolphin (up to 0.59% of CGNS MU)
- 157 common dolphin (up to 0.15% of CGNS MU)
- 49 minke whale (up to 0.24% of CGNS MU)

The magnitude would be negligible (i.e. less than 1% of the MU reference populations anticipated to be exposed to the temporary impact) for harbour porpoise, white-beaked dolphin, common dolphin and minke whale. The magnitude would be low (i.e. 1 - 5% of the MU reference populations anticipated to be exposed to the temporary impact) for bottlenose dolphin, however, this is a highly precautionary approach, and the impact is expected to be much lower. The impact significance for any disturbance has been assessed as **minor adverse** (not significant) for bottlenose dolphin, and **negligible** (not significant) for all other species.

Disturbance from any UXO clearance would be temporary and for a short duration (i.e. the detonation). The initial assessments have indicated that there could be up to 30 UXO which may require clearance, of which one could require high-order detonation as a precautionary assumption. Therefore, based on a worst-case scenario of one UXO clearance per day, there could be up to 30 days of potential disturbance as a result of UXO clearance. Taking into account the potential magnitude and the number of days of disturbance, it is unlikely that the proposed UXO clearance would result in significant disturbance of marine mammals.

In addition, as previously outlined, the preferred and first option for all UXO that require clearance would be low-order clearance such as deflagration.

No further mitigation measures, other than those proposed in the MMMP to reduce the risk of auditory injury, are required for the potential disturbance from underwater noise during UXO clearance.

4.5 Potential disturbance for low-order clearance

The potential disturbance for low-order clearance using deflagration (the first option and preferred method) is currently unknown; however, as a precautionary approach it has been assumed that there could be an estimated worst-case of 5 km disturbance range (78.54 km^2) including vessels[4]. As a worst-

[4] This figure is based on expert judgement, based on estimated disturbance from vessels and low-order deflagration.

case, marine mammals could be temporarily disturbed from this area for up to 30 days across the UXO campaign, assuming one day for each of the 30 UXO clearances by low-order clearance using deflagration. Using the 5 km EDR for the temporary disturbance of all marine mammal species is a precautionary approach to the assessments.

The sensitivity of marine mammals to temporary disturbance as a result of low-order clearance such as deflagration is considered to be medium in this assessment as a precautionary approach.

The magnitude for temporary disturbance from low-order clearance such as deflagration has been assessed as **negligible** for harbour porpoise, bottlenose dolphin, white-beaked dolphin and minke whale, (**Table 4.32**), with 1% or less of the reference population anticipated to be exposed to the effect.

Table 4.32: The maximum number of marine mammals that could be disturbed during low-order clearance (including vessels)

Species	Low-order clearance Temporary disturbance 5km (78.54 km^2)
Harbour porpoise	115 harbour porpoise (0.03% of North Sea MU) Magnitude = negligible Impact significance = negligible
Bottlenose dolphin	0.3 bottlenose dolphin (0.13% of CES MU) Magnitude = negligible Impact significance = negligible
White-beaked dolphin	9.7 white-beaked dolphin (0.02% of CGNS MU) Magnitude = negligible Impact significance = negligible
Common dolphin	5.8 common dolphin (0.01% of CGNS MU) Magnitude = negligible Impact significance = negligible
Minke whale	1.8 minke whale (0.009% of CGNS MU) Magnitude = negligible Impact significance = negligible

4.6 Potential disturbance from ADD

As outlined in the MMMP (**Appendix C**), Moray West will use Acoustic Deterrence Devices (ADDs) to mitigate the risk of physical or auditory injury to cetaceans from the detonation of UXO; the ADD will be used to ensure marine mammals are beyond the maximum potential impact range for PTS. The ADD will be activated at the appropriate time during the marine mammal observations of the 1 km radius monitoring area prior to any UXO clearance. Timing of ADD activation is dependent on the time required for the UXO clearance method and size of UXO (as outlined in the MMMP).

4.6.1 Efficacy of ADDs

Based on a detailed review and assessment as set out below, it is proposed to use the Lofitech seal scarer. The Lofitech seal scarer has successfully been used in a number of projects for a range of industries, including for aquaculture projects and the offshore wind industry. The Lofitech device has been designed to have a source noise level of 189 dB, with numerous field measurements confirming the device to have recorded source levels of 179 to 194 dB (Coram *et al.,* 2014) with a narrow band frequency output between 10 kHz and 20 kHz, with a peak at 15 kHz (McGarry *et al*., 2017).

Overall, there is good evidence for the effective deterrence ranges of the ADDs on harbour porpoises and harbour seals, but less available for minke whales and none for dolphin species (McGarry *et al*., 2020). The evidence available suggests that the Lofitech is highly effective in deterring harbour porpoise to at least 7.5 km (i.e., near exclusion) with some deterrence observed to 15 km range (Brandt *et al*., 2013a; Brandt *et al*., 2013b). A recent study also showed strong deterrence from a single 15 min ADD exposure, including >50% chance of a porpoise response at distances up to 21.7 km within the 3 hours after exposure (Thompson *et al*., 2020). For minke whale, consistent avoidance to a 15 min exposure has been reported to >1 km, with several animals continuing to swim further away to a distance of between c. 3 km and 4.5 km (McGarry *et al*., 2017). Deterrence to ~1 km has been reported in harbour seals (Gordon *et al.,* 2015; Gordon *et al*., 2019), with suggestions that this can also be applied to grey seals (Sparling *et al*., 2015).

4.6.2 Planned ADD Mitigations for UXO Clearance

ADD use for Low Order Clearance Events

For low-order clearance, ADD would be activated for 23 minutes, during which harbour porpoise would move at least 2.07 km away, based on precautionary swimming speed of 1.5m/s (Otani *et al*., 2000), dolphin species would move at least 2.10 km away, based on precautionary swimming speed of 1.52m/s (Bailey and Thompson, 2006) and minke whale would move 3.17 km, based on swimming speed of 2.3m/s (Boisseau *et al.,* 2021).

ADD use for High Order Clearance Events (of 25 kg or less)

60 minutes of ADD use is expected to displace harbour porpoise to 5.4 km range, which is sufficient for the maximum predicted PTS impact range of 4.96 km for a NEQ UXO size of 25 kg. This ADD use will also be expected to cause deterrence of dolphin sp. and minke whale, which will contribute to reducing the likelihood that individuals of these species are within the 0.29 km and 0.88 km PTS impact ranges, respectively, for this disposal method and the NEQ UXO size.

ADD use for High Order Clearance Events (of more than 25 kg)

For high-order detonation NEQ UXO size above 25 kg, ADD activation time would be up to 100 minutes (9.0 km). After consultation with Statutory Nature Conservation Bodies (SNCB), the ADD will not be activated for longer than 60 minutes, regardless of the size of the UXO and maximum predicted PTS range due to the potential for excessive disturbance.

Distances have been based on precautionary swimming speed of 1.5m/s for harbour porpoise (Otani *et al*., 2000); however, Kastelein *et al*. (2018) recorded swimming speeds of 1.97m/s in harbour porpoise during playbacks of pile driving sounds.

4.6.3 Assessment of Disturbance due to ADD use

The sensitivity of marine mammals to disturbance as a result of ADD is considered to be medium in this assessment as a precautionary approach.

The magnitude for disturbance from ADD has been assessed as negligible for harbour porpoise, bottlenose dolphin white-beaked dolphin, common dolphin and minke whale (**Table 4.33**). The impact significance for disturbance from ADD has been assessed as **negligible** for harbour porpoise, bottlenose dolphin, white-beaked dolphin, common dolphin and minke whale (**Table 4.33**).

ADD would only be activated for the minimum time required to ensure effective mitigation and would only be deployed as a worst case on up to 30 days, based on one UXO clearance per day. Therefore, ADD activation will not result in any significant disturbance of marine mammals. The maximum number of marine mammals that could be temporary disturbed during 100 minutes of ADD use have been provided but the use of the ADD will be capped at 60 minutes during high-order detonation.

Table 4.33: The maximum number of marine mammals that could be temporary disturbed during ADD activation

Species	Low-order clearance	High-order detonation UXO	High-order detonation UXO >25 kg
	23 minutes	Up to 60 minutes	Up to 100 minutes
Harbour porpoise	20 harbour porpoise (0.006% of North Sea MU) Magnitude = negligible Impact significance = negligible	135 harbour porpoise (0.039% of North Sea MU) Magnitude = negligible Impact significance = negligible	374 harbour porpoise (0.11% of North Sea MU) Magnitude = negligible Impact significance = negligible
Bottlenose dolphin	0.051 bottlenose dolphin (0.023% of CES population) Magnitude = negligible Impact significance = negligible	0.35 bottlenose dolphin (0.16% of CES population) Magnitude = negligible Impact significance = negligible	0.97 bottlenose dolphin (0.43% of CES population) Magnitude = negligible Impact significance = negligible
White-beaked dolphin	1.7 white-beaked dolphin (0.004% of CGNS MU) Magnitude = negligible Impact significance = negligible	11.6 white-beaked dolphin (0.026% of CGNS MU) Magnitude = negligible Impact significance = negligible	32.1 white-beaked dolphin (0.073% of CGNS MU) Magnitude = negligible Impact significance = negligible
Common dolphin	1.02 common dolphin (0.001% of CGNS MU) Magnitude = negligible Impact significance = negligible	6.96 common dolphin (0.007% of CGNS MU) Magnitude = negligible Impact significance = negligible	19.3 common dolphin (0.019% of CGNS MU) Magnitude = negligible Impact significance = negligible

Table 4.33: The maximum number of marine mammals that could be temporary disturbed during ADD activation

Species	Low-order clearance	High-order detonation UXO	High-order detonation UXO >25 kg
	23 minutes	Up to 60 minutes	Up to 100 minutes
Minke whale	0.73 minke whale (0.0036% of CGNS MU) Magnitude = negligible Impact significance = negligible	4.95 minke whale (0.025% of CGNS MU) Magnitude = negligible Impact significance = negligible	13.8 minke whale (0.068% of CGNS MU) Magnitude = negligible Impact significance = negligible

It should be noted that the disturbance as a result of ADD activation is within the maximum impact range assessed for TTS / disturbance from UXO clearance and is therefore not an additive effect to the overall area of potential disturbance.

4.7 Impacts due to an Increase in Vessel Presence

4.7.1 Increased Risk of Collision

There is the potential for a small number of vessels to be required for the UXO clearance works, ranging from large vessels to small craft. Dynamic positioning is likely to be the most appropriate method for maintaining location during clearance works.

Marine mammals are able to detect and avoid vessels, although vessel strikes are known to occur. However, it is unlikely that marine mammals present in the UXO clearance area would be at increased collision risk with vessels, as the vessels would be stationary or slow moving. In addition, the number of vessels moving to and from the sites would be very small compared to the existing vessel movements in and around the area. All vessel operators will use good practice to reduce any risk of collisions with marine mammals as outlined in the Scottish Marine Wildlife Watching Code5. Therefore, the potential magnitude for any increased collision risk during the proposed UXO clearance has been assessed as negligible.

Marine mammals present within or around the UXO clearance area are likely to be habituated to the presence of vessels given the existing levels of marine traffic and would therefore be expected to detect and avoid vessels. For this reason, harbour porpoise, bottlenose dolphin, white-beaked dolphin, common dolphin and minke whale that could be present in the area are considered to have a low sensitivity to the risk of a vessel strike.

Taking into account the receptor sensitivity of low for all species and the potential magnitude of the impact of negligible, the impact significance for any potential increase in collision risk with vessels has been assessed as **negligible** (not significant) for marine mammals.

[5] *Available at: https://www.nature.scot/professional-advice/land-and-sea-management/managing-coasts-and-seas/scottish-marine-wildlife-watching-code*

4.7.2 Disturbance from Vessels

Disturbance from underwater noise and the presence of vessels is likely to be restricted to the area around the vessel. For example, underwater noise modelling for the East Anglia TWO ES (SPR, 2019), indicated that the impact range for TTS / fleeing response for marine mammals, including harbour porpoise, dolphin species, minke whale, grey and harbour seal, was less than 100 m for large and medium sized vessels. Therefore, any potential disturbance as a result of vessel noise or the presence of vessels associated with the UXO clearance work would be significantly less than the area of potential disturbance assessed for UXO detonation in **Section 4.2**. Also, these vessels would be within the area of potential disturbance assessed for UXO detonation, therefore there would be no increase in disturbance as a result of vessels. As a result, the potential magnitude for any increased disturbance from vessels during the proposed UXO clearance has been assessed as negligible.

As a precautionary approach, the sensitivity of marine mammals to disturbance as a result of underwater from vessels is considered to be low to medium in this assessment. As such the overall impact significance of any disturbance from vessels is assessed as **negligible** (not significant).

No further mitigation measures are proposed for the potential increased collision risk or increased disturbance from vessels during UXO clearance.

4.8 Changes in water quality

The proposed UXO clearance works will result in the disturbance of small amounts of sediment, on a localised spatial scale. UXO clearance at each location (and overall) will affect a very small percentage of the UXO clearance area for a very short period of time and will be intermittent. Given the small spatial and temporal scale of the UXO clearance works, and that the mitigation put in place through the MMMP will ensure that there are no marine mammals close to the works, there will be no significant effects on marine mammals as a result of any changes in water quality. Therefore, the potential magnitude for any changes in water quality during the proposed UXO clearance has been assessed as negligible for marine mammals.

Taking into account the negligible magnitude and negligible sensitivity, the overall impact significance of any temporary and localised changes to water quality has been assessed as **negligible** (not significant) for all marine mammals.

No further mitigation measures are proposed or required for the potential changes to water quality during UXO clearance for marine mammals.

4.9 Changes in prey availability

The underwater noise modelling (see **Appendix C.1**) indicates that the maximum potential range for potential mortal injury in fish species for the largest potential UXO is less than 1 km without mitigation. Whilst it is recognised that the impact ranges for recoverable injury and disturbance effects will be larger than those presented for mortal injury, given that the potential for impact from underwater noise arising from the UXO clearance works will relate to a limited number of very discrete sources of underwater noise, even for the most sensitive species, the limited scale and temporal nature of the works is not considered likely to be significant for fish species.

Similarly, any potential impacts on fish as a result of disturbance of the seabed are likely to be in close proximity to the clearance activities it is therefore considered that there will be no significant impacts on fish.

As a result, the potential magnitude of effect for any changes in prey availability to marine mammal species as a result of the UXO clearance works has been assessed as low. As only a relatively small number of prey species would be at risk of potential mortal injury in the area around the UXO during clearance and any disturbance of prey species as a result of underwater noise or seabed disturbance would be temporary and localised, with fish expected to return to the area after completion of the UXO clearance works.

Harbour porpoise, bottlenose dolphin, white-beaked dolphin, common dolphin and minke whale feed on a range of prey species and their diet can vary geographically and seasonally depending on available prey resources. Therefore, their sensitivity to any changes in prey availability as a result of the proposed UXO clearance is considered to be low.

Taking into account the low magnitude and low sensitivity, the overall impact significance of any temporary and localised changes to prey availability has been assessed as a precautionary **minor adverse** (not significant) for all marine mammals.

No further mitigation measures, other than those proposed in the MMMP to reduce the risk of auditory injury, are required for the potential changes to prey species during UXO clearance.

4.10 Mitigation

A UXO-specific MMMP has been prepared to support the MLA for the UXO clearance works. The MMMP details the proposed mitigation to avoid or reduce the potential for auditory injury in marine mammals during UXO clearance (see **Appendix B**), this includes:

- Low-order clearance as the preferred method to dispose of UXO;
- All UXO clearance to take place in daylight and, when possible, in favourable conditions with good visibility (sea state 3 or less);
- Establishment of a monitoring area with minimum of 1 km radius.
    - The observation of the monitoring area will be by dedicated and trained Marine Mammal Observers (MMOs) during daylight hours and suitable visibility;
- The deployment of Passive Acoustic Monitoring (PAM) devices, if required, and if the equipment can be safely deployed and retrieved;
- The activation of Acoustic Deterrent Device (ADD); and

- The controlled explosions of the UXO will be undertaken by specialist contractors, using the minimum amount of explosive required in order to achieve safe disposal of the UXO.

4.11 Cumulative Impact Assessment (CIA)

The Cumulative Impact Assessment (CIA) includes both current and proposed projects, plans and activities. The assessment includes other types of development and activities in the wider area as well as other offshore wind farms.

The following projects have been identified and considered for potential cumulative impacts with the UXO clearance, presented in **Table 4.34**. For wide ranging species (such as cetaceans), it is important to consider projects over a wider area. For cetaceans, due to the extent of the MU are associated with, projects are considered if they are located within the Moray Firth, as well as off the east coast of Scotland.

There is the potential for horizontal directional drilling (HDD) for the export cables to occur in the same period as the UXO clearance works. HDD drilling will be undertaken from a shore-based drilling compound and consist of the drilling of a small pilot hole from the onshore entry pit to approximately 50 m from the drill exit point. The pilot hole will then be enlarged several times to produce a bore hole approx. 2.5 times the cable diameter size. The majority of noise from the HDD drilling process will be generated onshore, by the drilling rig itself and, by its nature, is not considered likely to disturb marine EPS. As drilling activity progresses beneath the seabed, there is a potential for underwater noise to be generated due to contact between the drill head and hard ground beneath the seabed. Underwater noise modelling undertaken for an application to the National Oceanographic and Atmospheric Administration (NOAA) in relation to the Port Dolphin Energy LLC Deepwater port (2011), considered HDD drilling and estimated a maximum SEL of 154 dB @ 250 Hz and has a predicted disturbance impact radius of 250 m. It is deemed that levels of underwater noise generated by HDD drilling activity would result in highly localised displacement, with no risk of SELs sufficient to induce physical injury. Drilling noise, when audible, would be continuous noise rather than pulse noise and there would be some masking of drilling noise by vessels. On the basis that any displacement would be highly localised, not within an important foraging area, and not sufficient to represent a barrier to individuals transiting through the area. As there is limited potential for high order UXO clearance in the nearshore region (with micrositing and low order deflagration being the preferred options) and disturbance from any UXO clearance being temporary and for a short duration (i.e. the detonation) it is considered there would be no cumulative impacts with HDD operations.

Table 4.34 Potential for Cumulative Impacts				
Project	**Location (approx. distance from the Development)**	**Stage**	**Date of Activity**	**Included in Assessment**
Moray West Offshore Windfarm	Same Development Site	Construction – HDD works	December 2022	Screened out due to limited impacts
Moray East Offshore Windfarm	Moray Firth, 0 km adjacent to the Development	Operational	Operational since April 2022	Screened out, noise from Moray East OWF will be included in the baseline for the area.
Nigg Energy Park East Quay	Cromarty Firth, approximately 60 km	Under construction	Construction from 2021-2022	Considered further due to proximity (**Table 4.35**)
Sea Wall Repair and Extension – Alexandra Parade	Peterhead, approximately 189 km	Application approved	Construction 2020-2024[6]	Screened out, no potential for significant cumulative impacts due to distance
Seagreen Alpha and Bravo Offshore Wind Farms (Optimised Project)	Forth of Forth, approximately 196 km from windfarm site	Application approved	Expected to be fully commissioned by 2023	Considered further due to potential temporal overlap as worst case (**Table 4.35**)
Inch Cape Offshore Windfarm Revised Design	Firth of Forth, approximately 215 km from windfarm site	Application approved	Construction 2021-2024	Screened out, no potential for significant cumulative impacts due to distance
Neart na Gaoithe Offshore Wind Farm (Revised Design)	Firth of Forth, approximately 255 km from windfarm site	Under construction	Construction from 2019-2022[7]	Screened out, no potential for significant cumulative impacts due to distance

The nearest project screened in with relevant potential effects for marine mammals is the Nigg Energy Park East Quay, at 60 km from the Development Site, the cumulative impacts focus on the potential for cumulative underwater noise impacts only. As each project is required to provide mitigation for any potential for PTS, there is no potential for cumulative PTS impacts to occur. Therefore, the assessment only considers the potential for TTS and disturbance cumulative impacts.

Due to the distance of all projects with potential for cumulative impacts (**Table 4.34**) and the range of the impacts of the UXO clearance within the Development Site (maximum range of 99.3 km for minke whale for TTS with cumulative exposure and without mitigation), it is unlikely any cumulative impacts will occur, and therefore, it is unlikely there would be any potential for significant cumulative impacts to any species, as a result of any other project being undertaken, together with UXO clearance at Moray West, with the

[6] https://marine.gov.scot/sites/default/files/environmental_appraisal_document_redacted.pdf
[7] https://marine.gov.scot/sites/default/files/combined_document_-_revised.pdf

exception of Nigg Energy Park. As a precautionary approach, an assessment has been undertaken for UXO clearance at Moray West with the closest project, which is Nigg Energy Park East Quay, as well as the Seagreen Alpha and Bravo OWF which have potential for construction overlap (**Table 4.35**).

Table 4.35: Cumulative assessment for marine mammals					
Cumulative project	**Moray West UXO Assessment**		**Cumulative Project Assessment**		**Overall Cumulative Assessment**
	Potential Impact	**Assessment**	**Potential Impact**	**Assessment**	
Nigg Energy Park East Quay	TTS (highest potential impact range of TTS Unweighted SPL_{peak} due to high-order removal of 365 kg NEQ UXO as the worse-case) - 1.3 km for dolphin Sp.	Less than 0.02 bottlenose dolphin (0.009% of CES MU) may be at risk of TTS onset, due to unmitigated UXO disposal.	Nigg Energy Park East Quay Expansion includes an area of reclamation, sheet piling, and dredging[8]. An updated ES was submitted in 2019, to include a revised blasting methodology[9]. Potential Impact TTS from blasting & piling	Up to 0.1 bottlenose dolphin may be at risk of TTS onset, due to unmitigated blasting. With a bubble curtain, up to 0.0009 individuals may be at risk of TTS onset. For piling activities, TTS onset could occur up to 3.15 km from the pile location. This would be a temporary effect, and the presence of Girdle Ness will effectively stop underwater noise from travelling up to that distance.	Due to the temporary nature of the UXO disposal at the Development Site, and that any impact to bottlenose dolphin at Nigg Energy Park is a low risk, and would be temporary, it is concluded that there would be **no significant cumulative impact** to bottlenose dolphin due to TTS onset.
Seagreen Alpha and Bravo OWF	Disturbance effects based on an EDR of 26 km around UXO high-order detonation	– 3,118 harbour porpoise (0.9% of North Sea MU) – 7.9 bottlenose dolphin (3.5% of CES MU; or 0.39% of the GNS MU) – 261 white-beaked dolphin (0.59% of CGNS MU) – 157 common dolphin 0.15% of CGNS MU) – 49 minke whale (0.24% of CGNS MU)	Disturbance from piling (as the worst-case) for both monopile and pin-pile concurrently activities	The assessment concludes that total No. individuals disturbed from the piling location may be up to: 1,452 harbour porpoise (0.41% of the assessed reference population) 4.5 bottlenose dolphin (2.3% of the assessed reference population) 590 white-beaked dolphin (1.62% of the assessed reference population) Common dolphin – not assessed 94 minke whale (0.40% of CGNS MU)	Due to the localised and temporary nature of the UXO clearance at the Development, and the limited range to disturb as a result of the piling activities at Seagreen Alpha and Bravo OWF having no special impact, it is concluded that there would be **no significant cumulative impact** as a result of disturbance.

[8] http://marine.gov.scot/datafiles/lot/ahep/es/vol2/Volume%202%20Environmental%20Statement%20Ch%2015.pdf
[9] https://marine.gov.scot/sites/default/files/environmental_impact_assessment_report_redacted.pdf

Table 4.35: Cumulative assessment for marine mammals

Cumulative project	Moray West UXO Assessment		Cumulative Project Assessment		Overall Cumulative Assessment
	Potential Impact	Assessment	Potential Impact	Assessment	
		No potential for significant impact. Full details of assessment in **Section 4.44.3**			

5 Potential Effects on Designated Sites

5.1 Special Areas of Conservation (SACs)

SACs are designated under Regulation 33(2) of the Conservation (Natural Habitats, &c.) Regulations 1994 (as amended in Scotland). Part II of the Habitats Regulations sets out the provisions for the selection of Special Areas of Conservation (SACs) for Annex I habitats and Annex II species. Key to the designation of SACs is Paragraph 7 (2), the relevant part of which states: "...*For aquatic species which range over wide areas, such sites will be proposed only where there is a clearly identifiable area representing the physical and biological factors essential to their life and reproduction*".

7.1.1 Moray Firth SAC

The Moray Firth SAC (approximately 17 km from the Development Site) was designated in 2005 under the European Habitats Directive (92/43/EEC) for bottlenose dolphin. This SAC extends from the inner firths to Helmsdale on the north coast and Lossiemouth on the south coast covers an area of 1,510km^2 (NatureScot, 2021). The Moray Firth supports the only known resident population of bottlenose dolphin in the North Sea, with an estimated 150 individuals. The population is present year-round within the Firth, but they do appear to favour particular areas[10]. The Conservation Objectives are "*to avoid deterioration of the habitats of the qualifying species (bottlenose dolphin) or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained, and the site makes an appropriate contribution to achieving favourable conservation status for the qualifying interest*."

The Moray Firth supports an estimated 209 individuals (95% CI = 198 – 230; Arso Civil *et al.,* 2019). Assessments for bottlenose dolphins from the Moray Firth are put into context of the latest estimate for the east coast of Scotland population of 224 individuals (CV = 0.023; 95% CI = 214 - 234; Arso Civil *et al.,* 2021[11]).

The MMMP (**Appendix B**) for UXO clearance at the Development Site will reduce the risk of PTS in bottlenose dolphin and therefore there would be no potential for any significant effects. As previously stated, the first and preferred option for any UXO that require clearance is low-order clearance such as deflagration.

The assessments in **Section 4.7** indicate that vessels during the proposed UXO clearance at the Development Site will not increase the collision risk or disturbance of bottlenose dolphin, therefore there is no potential for any significant effects.

The assessments in **Section 4.8** and **4.9**, indicate that any changes to water quality or prey resources as a result of the proposed UXO clearance work would be temporary and localised and will not result in significant adverse effects.

[10] https://sac.jncc.gov.uk/site/UK0019808

[11] https://www.nature.scot/doc/east-coast-scotland-bottlenose-dolphins-estimate-population-size-2015-2019

The assessment in **Section 4.6** indicates there would be no significant disturbance from ADD as a result of ADD activation.

There could be the potential for the proposed UXO clearance in the Development Site to disturb bottlenose dolphin. As a precautionary approach it has been assumed that any bottlenose dolphin in the Development Site could be from the Moray Firth SAC, therefore the assessments have been presented in the context of the latest estimate for the east coast of Scotland population of 224 bottlenose dolphin.

1 high-order UXO detonation located in the Development Site without mitigation (5.31km^2) would impact less than 0.02 bottlenose dolphin (0.001% of Coastal East Scotland population). The number of bottlenose dolphin that could potentially be disturbed due to the UXO clearance, based on the precautionary 5 km disturbance range[4], is less than 0.3 animals (0.13% of Coastal East Scotland population).

The assessment indicates that through the application of mitigation as outlined in the MMMP (see **Appendix B**) there is **no potential Adverse Effect on Site Integrity (AEoSI) of the Moray Firth SAC in relation to the conservation objectives for bottlenose dolphin** as a result of any disturbance from underwater noise during UXO clearance.

7.1.2 Dornoch Firth and Morrich More SAC

Although seals are not EPS, an assessment in relation to the nearby Dornoch Firth and Morrich More SAC (approximately 46 km from the Development Site) has been included in this report.

The Dornoch Firth is the most northerly large estuary in Britain and supports a significant proportion of the inner Moray Firth population of the harbour seal. The seals, which utilise sand-bars and shores at the mouth of the estuary as haul-out and breeding sites, are the most northerly population to utilise sandbanks. Their numbers represent almost 2% of the UK population[12]. The Conservation Objectives ensure that the obligations of the Habitats Directive are met; that is, there should not be deterioration or significant disturbance of the qualifying interest. This will also ensure that the integrity of the site is maintained and that it makes a full contribution to achieving favourable conservation status for its qualifying interests. The total population of harbour seals in Scotland was 26,846 in 2016-2019, with an estimated 1,077 within the Moray Firth MU (SCOS, 2020).

The MMMP (**Appendix B**) for UXO clearance at the Development Site will reduce the risk of PTS in seals and therefore there would be no potential for any significant effects. As previously stated, the first and preferred option for any UXO that require detonation is low-order detonation clearance.

As part of the Strategic Regional Marine Mammal Monitoring Programme for the Moray Firth, a total of 57 harbour seals were tagged at Loch Fleet with GPS/GSM tags in September 2014, February 2015 and February-March 2017 (Graham *et al*., 2017). These telemetry data show that harbour seals tagged in the Moray Firth MU do not all remain within the Moray Firth, with seals showing movement out of the Moray Firth and into the North Coast and Orkney MU (Graham *et al*., 2017). Therefore, there is connectivity

[12] *https://sac.jncc.gov.uk/site/UK0019806*

between the two MUs and as such it is most appropriate to consider that the relevant population against which to assess impacts on the Dornoch Firth and Morrich More SAC population is the combined Moray Firth and North Coast and Orkney MUs. Combining the most recent haul-out count for the Moray Firth MU (1,077) with the most recent haul-out count for the North Coast and Orkney MU (1,405), results in a total August haul-out count of 2,482 harbour seals (SCOS, 2020).

The number of harbour seal that could potentially be disturbed due to the UXO clearance, based on the precautionary 5 km disturbance range[4], is up to 1.65 animals (based on the 0.021 individuals per km^2, as calculated from the Carter *et al*., 2020), or 0.07% of the combined Moray Firth and North Coast and Orkney MUs.

The sensitivity of marine mammals to temporary disturbance as a result of low-order clearance such as deflagration is considered to be medium in this assessment as a precautionary approach. The magnitude for temporary disturbance from low-order clearance such as deflagration has been assessed as negligible for harbour seal with less to 1% of the reference population anticipated to be exposed to effect.

The assessment indicates that through the application of mitigation as outlined in the MMMP (see **Appendix B**) there is **no potential AEoSI of the Dornoch Firth and Morrich More SAC in relation to the conservation objectives for harbour seal** as a result of any disturbance from underwater noise during UXO clearance.

5.2 Nature Conservation Marine Protected Area (NCMPA)

Under Section 82 of the Marine (Scotland) Act 2010, MS-LOT is required to consider whether a licensable activity is capable of affecting (other than insignificantly) a protected feature in a Nature Conservation Marine Protected Area (NCMPA), or any ecological or geomorphological process on which the conservation of any protected feature in an NCMPA is dependent. If MS-LOT determine there is or may be a significant risk of a project hindering the achievement of the conservation objectives, then they must notify the relevant conservation bodies. It is an offence to intentionally or recklessly kill, remove, damage, or destroy any protected feature of an NCMPA. Marine Scotland must be sure that consenting/licensing decisions do not cause a significant risk to the conservation objectives of any NCMPA

7.1.3 Southern Trench NCMPA

Southern Trench NCMPA is located on the east coast of Scotland, and is proposed to protect minke whale, burrowed mud, fronts and shelf deeps. Fronts in the Southern Trench are created by mixing of warm and cold waters, which creates an area of high productivity, attracting a number of predators to the area. Minke whale are attracted by the fish species brought to the area by the fronts, as well as the abundance of sandeels in the soft sands. SNH advises that, in order to conserve minke whale, risk of injury and death should be minimised, access to resources within the site should be maintained, and supporting features should also be conserved. The Conservation Objectives of this site are to conserve the features, specifically to ensure "*Minke whale in the Southern Trench NCMPA are not at significant risk from injury or killing, conserve the access to resources (e.g. for feeding) provided by the NCMPA for various stages of the minke whale life cycle, and conserve the distribution of minke whale within the site by avoiding significant* *disturbance"*[13]. The supporting features of the minke whale is also protected under these Conservation Objectives.

Minke whale are wide-ranging baleen whales which are present in the Moray Firth primarily in the summer months (June – September) (Reid *et al.,* 2003; Hammond *et al.,* 2021). They often prefer water depths of up to 200 m and are often solitary or found in pairs, though they occasionally form larger groups (up to15 individuals) while feeding.

The MMMP (**Appendix B**) for UXO clearance at the Development Site will reduce the risk of PTS for minke whale and therefore there would be no potential for any significant effects. As previously stated, the first and preferred option for any UXO that require clearance is low-order clearance such as deflagration. The UXO clearance works are also scheduled to take place outside the summer season (February 2023 – May 2023) when the minke whale population will be at its lowest.

The assessments in **Section 4.7** indicate that vessels during the proposed UXO clearance at the Development Site will not increase the collision risk or disturbance of minke whale, therefore there is no potential for any significant effects.

The assessments in **Section 4.8** and **4.9**, indicate that any changes to water quality or prey resources as a result of the proposed UXO clearance work would be temporary and localised and will not result in significant adverse effects.

The assessment in **Section 4.6** indicates there would be no significant disturbance from ADD as a result of ADD activation.

There could be the potential for the proposed UXO clearance in the Development Site to disturb minke whale associated with the Southern Trench NCMPA. As a precautionary approach it has been assumed that any minke whale in the Development Site could be connected to the Southern Trench NCMPA, therefore the assessments have been presented in the context of the latest estimate for the population in the Moray Firth is based on SCANS-III abundance for survey block S of 383 animals (Hammond *et al.,* 2021).

The number of minke whale that could potentially be disturbed due to the UXO clearance, based on the precautionary 5 km disturbance range[4], is less than 2 animals (0.24% of estimated Moray Firth population).

The assessment indicates that through the application of mitigation as outlined in the MMMP (see **Appendix B**) there is **no potential AEoSI of the Southern Trench NCMPA in relation to the conservation objectives for minke whale** as a result of any disturbance from underwater noise during UXO clearance.

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[13] *https://www.nature.scot/sites/default/files/2019-06/Southern%20Trench%20possible%20MPA%20-%20Conservation%20and%20Management%20Advice.pdf*

5.3 Protected Seal Haul-Out Sites

Seal haul-out sites are coastal locations that seals use to breed, moult and rest. Almost 200 seal haul-out sites have been designated through The Protection of Seals (Designation of Haul-Out Sites) (Scotland) Order 2014 which was amended with additional sites in 2017. These haul-out sites are protected under Section 117 of the Marine (Scotland) Act 2010. The Act is designed to assist in protecting the seals when they are at their most vulnerable, and as such provide additional protection from intentional or reckless harassment.

The MMMP (**Appendix B**) for UXO clearance at the Development Site will apply all measures to seals and reduce the risk of PTS and therefore there would be no potential for any significant effects. As previously stated, the first and preferred option for any UXO that require detonation is low-order detonation clearance.

However, considering the location of the planned UXO clearance activities relative to the shore (≥ 22 km) the worst-case TTS impact range of 18.8 km (weighted impulsive SEL; **Appendix C**) and nearest designated haul-out site (≥ 21 km, Dunbeath-Helmsdale and ≥ 22 km, Dunbeath-Wick both designated for grey seal) there is no potential for harassment of seals at designated haul-out sites and such effects are not considered further.

6 Assessment of Potential Offence

Following the Marine Scotland (2020) guidance, relevant to injury and disturbance, which would occur in waters within the 12 nautical mile limit, it can be concluded that, with mitigation for UXO clearance activities, potential impacts are unlikely to result in the harassment, disturbance, injury or killing of an EPS as defined under regulation 39(1) of the Habitats Regulations.

In relation to regulation 39(2) of the Habitats Regulations, the percentage of the reference population of each species, which has the potential to be disturbed during UXO clearance activities at the Development Site, is considered to be negligible (less than 1% for all cetacean species which occur in the area) and therefore not detrimental to the maintenance of the population of the species concerned at a FCS. Any disturbance would be localised and short-term, and with mitigation is considered to be negligible. Disturbance will not be sufficient to cause any population level effects, and thus it is considered that a Marine EPS licence (to disturb) can be issued under regulation 39 of the Habitats Regulations.

6.1 EPS Licencing Tests

Test 1: The licence must relate to one of the purposes referred to in Regulation 44(2).

The Scottish Government can only issue licenses under Regulation 44(2) of the Habitats Regulations for specific purposes. For the purposes of the proposed UXO clearance activities, this purpose is:

- 44(2)(e) preserving public health or public safety or other imperative reasons of overriding public interest including those of a social or economic nature and beneficial consequences of primary importance for the environment.

Offshore wind is a key growth sector in Scotland, and the generation and development of offshore wind infrastructure is a key component for reaching Scotland's target to reduce greenhouse gas emissions (by 75% by 2030), and for being net-zero by 2045. Part of the next round of offshore wind development in Scotland (currently being bid for through the ScotWind process) is to ensure that 25% of the offshore wind industry is provided by local business.

There is an overarching European, UK and Scottish policy requirement for sustainable energy supply from renewables. This need is the subject of national planning and energy policy. The proposed UXO clearance activities are required to ensure the safe construction of the Development. UXO represent a material risk to the safe construction of the Development and therefore their identification, assessment and clearance is essential.

Test 2: There must be no satisfactory alternative (Regulation 44(3a)).

UXO represent a material risk to the safe construction of the Development and, therefore, their identification, assessment and clearance is essential. The proposed approach to UXO clearance activities will, wherever possible, utilise lower-impact alternatives to explosive detonation and, in particular, high-order detonation.

A specific UXO clearance contractor will be selected which offer lower-impact alternative disposal methods to high-order detonation, including low-order (deflagration) disposal. There is an initial preference for leaving the UXO in situ and micro-site construction work and infrastructure around it supplying a do-nothing scenario which would have no impact on EPS species within the vicinity of the Development Site. If it is not possible to safely leave the UXO in situ and micro-site, an appropriate clearance approach will be selected. In order of preference, these are:

- relocation and leave in situ;
- low-order deflagration disposal;
- high-order detonation disposal.

High-order disposal represents the most commonly used approach to date for disposal of underwater UXO in situ. This involves deliberate detonation initiated by a small donor charge placed on the UXO to initiate an explosion of the main charge; therefore, neutralising it. The resulting shock wave and noise level is therefore expected to be proportional to the combined explosive mass of the donor and main charge. By contrast, low-order methods aim to neutralise the UXO without detonation of the main charge and, therefore, the energy generated should relate to the detonation of the donor charge only.

The UXO clearance works are due to be undertaken in the winter period (October to March) when species presence and abundance is lower seasonally when populations will be at there lowest.

Consequently, for a given size of UXO, the potential for impacts to marine life from low-order disposal are considerably less than would be expected from a high-order disposal.

Test 3: The action authorised must not be detrimental to the maintenance of the population of the species concerned at a FCS in their natural range (Regulation 44(3b)).

Regulation 44(3)(b) of the Habitat Regulations 1994 and Regulation 55(9)(c) of the Marine Habitats and Species Regulations 2017 requires the Scottish Ministers to be satisfied that the Licensed Operations must not be detrimental to the maintenance of the population of species concerned at a FCS in their natural range.

The percentage of the reference population of each species, which has the potential to be impacted by the potential UXO clearance at the Development, has been shown to be negligible (less than 1 %[14] of the reference populations for all the cetacean species which occur in the Moray Firth area), and therefore not detrimental to the maintenance of the population of the species concerned at a FCS level.

[14] 1.46% of the minke whale CGNS population when assessing the TTS weighted SEL impulsive criteria which is considered minor adverse (not significant)

7 References

6 Alpha Associates Ltd. (2022) Unexploded Ordnance Threat and Risk Assessment with Risk Mitigation Strategy. Project: Moray West Offshore Wind Farm. Document number: MWW-ALP1-SA-RSK-000001

Arso Civil, M., Quick, N.J., Cheney, B., Pirotta, E., Thompson, P.M. and Hammond, P.S., (2019). Changing distribution of the east coast of Scotland bottlenose dolphin population and the challenges of area-based management. Aquatic Conservation: Marine and Freshwater Ecosystems, 29, pp.178-196.

Arso Civil, M., Quick, N., Mews, S., Hague, E., Cheney, B.J., Thompson, P.M. & Hammond, P.S. (2021). Improving understanding of bottlenose dolphin movements along the east coast of Scotland. Final report. Report number SMRUC-VAT-2020-10 provided to European Offshore Wind Deployment Centre (EOWDC), March 2021 (unpublished).

Bailey, H. and Thompson, P. (2006). Quantitive analysis of bottlenose dolphin movement patterns and their relationship with foraging. Journal of Animal Ecology 75: 456-465.

Boisseau, O., McGarry, T., Stephenson, S., Compton, R., Cucknell, A. C., Ryan, C., McLanaghan, R. and Moscrop, A. (2021). *Minke whales Balaenoptera acutorostrata avoid a 15 kHz acoustic deterrent device (ADD)*. Marine Ecology Progress Series, 667, 191-206..

Brandt, M. J., C. Hoeschle, A. Diederichs, K. Betke, R. Matuschek, and G. Nehls. (2013a). Seal scarers as a tool to deter harbour porpoises from offshore construction sites. Marine Ecology Progress Series 475:291-302.

Brandt, M. J., C. Hoeschle, A. Diederichs, K. Betke, R. Matuschek, S. Witte, and G. Nehls. (2013b). Farreaching effects of a seal scarer on harbour porpoises, *Phocoena*. Aquatic Conservation-Marine and Freshwater Ecosystems 23(2):222-232.

Braulik, G., Minton, G., Amano, M. and Bjørge, A., 2020. Phocoena phocoena. The IUCN Red List of Threatened Species 2020: e. T17027A50369903.

Carter, M., L. Boehme, C. Duck, W. Grecian, G. Hastie, B. McConnell, D. Miller, C. Morris, S. Moss, D. Thompson, P. Thompson, and D. Russell. (2020). Habitat-based predictions of at-sea distribution for grey and harbour seals in the British Isles. Sea Mammal Research Unit, University of St Andrews, Report to BEIS, OESEA-16-76/OESEA-17-78.

Erebus Floating OWF. (2021). Project Erebus Environmental Statement. December 2021. https://www.bluegemwind.com/planning/documents/

Gordon, J., C. Blight, E. Bryant, and D. Thompson. (2015). Tests of acoustic signals for aversive sound mitigation with harbour seals. Sea Mammal Research Unit report to Scottish Government. MR 8.1 Report. Marine Mammal Scientific Support Research Programme MMSS/001/11.

Gordon, J., C. Blight, E. Bryant, and D. Thompson. (2019). Measuring responses of harbour seals to potential aversive acoustic mitigation signals using controlled exposure behavioural response studies. Aquatic Conservation Marine and Freshwater Ecosystems. 29(S1):157-177.

Graham, I. M., B. Cheney, R. C. Hewitt, L. S. Cordes, G. D. Hastie, D. J. F. Russell, M. Arso Civil, P. S. Hammond, and P. M. Thompson. 2016. Strategic Regional Pre-Construction Marine Mammal Monitoring Programme Annual Report 2016. University of Aberdeen.

Graham, I. M., B. Cheney, R. C. Hewitt, L. S. Cordes, G. Hastie, and P. Thompson. (2017). Strategic Regional Pre-Construction Marine Mammal Monitoring Programme Annual Report 2017. University of Aberdeen.

Hammond, P.S., Lacey, C., Gilles, A., Viquerat, S., Boerjesson, P., Herr, H., Macleod, K., Ridoux, V., Santos, M., Scheidat, M., Teilmann, J., Vingada, J., and Oien, N. (2021). Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys. Wageningen Marine Research. Available from: https://synergy.st-andrews.ac.uk/scans3/files/2021/06/SCANS-III_design-based_estimates_final_report_revised_June_2021.pdf

IAMMWG. 2022. Updated abundance estimates for cetacean Management Units in UK waters (Revised 2022). JNCC Report No. 680, JNCC Peterborough, ISSN 0963-8091.

Joint Nature and Conservation Committee (JNCC) (2010). JNCC guidelines for minimising the risk of injury to marine mammals from using explosives. August 2010.

JNCC. (2019) Conservation status assessment for the species. European Community Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC). Fourth Report by the United Kingdom under Article 17 on the implementation of the Directive from January 2013 to December 2018. https://jncc.gov.uk/our-work/article-17-habitats-directive-report-2019-species/

JNCC, Department of Agriculture, Environment and Rural Affairs (DAERA) and Natural England (2020). Guidance for assessing the significance of noise disturbance against Conservation Objectives of harbour porpoise SACs (England, Wales & Northern Ireland). June 2020.

Kastelein, R.A., Van de Voorde, S, and Jennings, N. (2018). Swimming Speed of a Harbour Porpoise (Phocoena phocoena) During Playbacks of Offshore Pile Driving Sounds. Aquatic Mammals: 44(1):92-99.

Lucke, K., Siebert, U., Lepper, P. A. and Blanchet, M. A. (2009). Temporary shift in masked hearing thresholds in a harbor porpoise (*Phocoena phocoena*) after exposure to seismic airgun stimuli, J. Acoust. Soc. Am., 125 (6), pp. 4060-4070.

Marine Scotland. (2020). The protection of Marine European Protected Species from injury and disturbance. Guidance for Scottish Inshore Waters. July 2020. Available at: https://www.gov.scot/publications/marine-european-protected-species-protection-from-injury-and-disturbance/

McGarry, T., O. Boisseau, S. Stephenson, and R. Compton. (2017). Understanding the Effectiveness of Acoustic Deterrent Devices (ADDs) on Minke Whale (*Balaenoptera acutorostrata*), a Low Frequency Cetacean. Report for the Offshore Renewables Joint Industry Programme (ORJIP) Project 4, Phase 2. Prepared on behalf of the Carbon Trust.

McGarry, T., R. De Silva, S. Canning, S. Mendes, A. Prior, S. Stephenson, and J. Wilson. (2020). Evidence base for application of Acoustic Deterrent Devices (ADDs) as marine mammal mitigation, Version 2.0, March 2020, JNCC Report No. 615. Joint Nature Conservation Committe, Peterborough, UK, 107pp.

Moray Offshore Renewables Ltd. (2012). Moray Offshore Renewables Limited Environmental Statement Technical Appendix 7.3 A - Marine Mammals Environmental Impact Assessment. Produced by Natural Power on behalf of Moray Offshore Renewables Ltd.

Moray West (2018) Offshore Environmental Impact Assessment Report. https://marine.gov.scot/data/moray-west-offshore-windfarm-environmental-impact-assessment-report

Moray East (2019). Estimated ranges of impact for various UXO detonations, Moray East OWF. https://marine.gov.scot/sites/default/files/moray_east_uxo_clearance_marine_mammal_assessment_update_19022019.pdf

NatureScot (2020) Southern Trench MPA. Conservation and Management Advice. Available at: https://sitelink.nature.scot/site/10477

NatureScot (2021). Conservation and Management Advice, Moray Firth SAC. March 2021. https://apps.snh.gov.uk/sitelink-api/v1/sites/8327/documents/59

NMFS (National Marine Fisheries Service) (2018). 2018 Revisions to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Dept. of Commer., NOAA. NOAA Technical Memorandum NMFS-OPR-59, 167 p.

Otani, S., Naito, T., Kato, A. and Kawamura, A. (2000). Diving behaviour and swimming speed of a free-ranging harbour porpoise (*Phocoena phocoena*). Marine Mammal Science, Volume 16, Issue 4, pp 811-814, October 2000.

Port Dolphin Energy LLC (2011). http://www.nmfs.noaa.gov/pr/pdfs/permits/portdolphin_loa_application2011.pdf

Reid, J.B, Evans, P.G.H. and Northridge, S.P. (2003). Atlas of cetacean Distribution in North west European waters. JNCC, Peterborough.

Robinson, K.P., Eisfeld, S.M., Costa, M. and Simmonds, M.P. (2010). Short-beaked common dolphin (Delphinus delphis) occurrence in the Moray Firth, north-east Scotland. Marine Biodiversity Records, 3.

SCOS. (2020). Scientific Advice on Matters Related to the Management of Seal Populations: 2020

ScottishPower Renewables (SPR) (2019). East Anglia TWO Offshore Windfarm Environmental Information Statement. Volume 1. Document Reference: EA2-DWF-ENV- REP-IBR-000903 Rev 01.

Seagreen Wind Energy Ltd. (2021) Seagreen Alpha and Bravo Site UXO clearance – European Protected Species Risk Assessment and Marine Mammal Mitigation Plan. Document Reference LF000009-CST-OF-LIC-REP-0007. https://marine.gov.scot/sites/default/files/eps_risk_assessment_3.pdf

Sparling, C., C. Sams, S. Stephenson, R. Joy, J. Wood, J. Gordon, D. Thompson, R. Plunkett, B. Miller, and T. Götz. (2015). ORJIP Project 4, Stage 1 of Phase 2: The use of Acoustic Deterrents for the mitigation of injury to marine mammals during pile driving for offshore wind farm construction. Final Report. SMRUC-TCT-2015-006, Submitted To The Carbon Trust, October 2015 (Unpublished).

Southall, B.L., Bowles, A.E., Ellison, W.T., Finneran, J.J., Gentry, R.L., Greene Jr., C.R., Kastak, D., Ketten, D.R., Miller, J.H., Nachtigall, P.E., Richardson, W.J., Thomas, J.A., and Tyack, P.L., (2007). Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. Aquatic Mammals, 33 (4), pp. 411-509.

Southall, B., J. J. Finneran, C. Reichmuth, P. E. Nachtigall, D. R. Ketten, A. E. Bowles, W. T. Ellison, D. Nowacek, and P. Tyack. (2019). Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects. Aquatic Mammals **45**:125-232.

Southall, B.L., Nowacek, D.P., Bowles, A.E., Senigaglia, V., Bejder, L. and Tyack, P.L., (2021). Marine mammal noise exposure criteria: assessing the severity of marine mammal behavioral responses to human noise. Aquatic Mammals, 47(5), pp.421-464. DOI 10.1578/AM.47.5.2021.421.

Thompson, D. (2015). Parameters for collision risk models. Report by Sea Mammal Research Unit, Univ St Andrews, Scottish Natural Heritage.

Thompson, P. M., K. L. Brookes, and L. S. Cordes. 2014. Integrating passive acoustic and visual data to model spatial patterns of occurrence in coastal dolphins. ICES Journal of Marine Science:11.

Thompson, P. 2015. Annex 3. Framework for a risk-based assessment to underpin the adoption of alternative mitigation measures during piling at the BOWL and MORL Offshore Wind Farms. 28th July 2015. In: Beatrice Offshore Windfarm Ltd. (2015). Beatrice Offshore Wind Farm Piling Strategy. Prepared by RPS, GoBe Consultants Ltd and Brown and May Marine. Report number LF000005. November 2015.

Thompson, P. M., I. M. Graham, B. Cheney, T. R. Barton, A. Farcas, and N. D. Merchant. (2020). Balancing risks of injury and disturbance to marine mammals when pile driving at offshore windfarms. Ecological Solutions and Evidence 1(2) doi: 10.1002/2688-8319.12034

Waggitt, J.J., Evans, P.G., Andrade, J., Banks, A.N., Boisseau, O., Bolton, M., Bradbury, G., Brereton, T., Camphuysen, C.J., Durinck, J. and Felce, T. (2019). Distribution maps of cetacean and seabird populations in the North-East Atlantic. Journal of Applied Ecology, 57(2), pp.253-269

Appendix A – Defined Terms

Term	Description
Design Envelope	The range of design parameters used to inform the assessment of impacts.
Marine Licence for the Generating Station	Marine Licence for the Moray West Offshore Wind Farm - Licence Number: MS-00008731 - granted under the Marine and Coastal Access Act 2009, Part 4 Marine Licensing for marine renewables construction works and deposits of substances or objects in the Scottish Marine Area and the UK Marine Licensing Area granted to Moray West on 14 June 2019 and varied on 7 March 2022 and 11 April 2022.
Marine Licence for the Transmission Works	Marine Licence for the Offshore Transmission Infrastructure – Licence Number MS-06764/19/0 – granted under the Marine and Coastal Access Act 2009, & Marine (Scotland) Act 2010, Part 4 Marine Licensing for marine renewables construction works and deposits of substances or objects in the Scottish Marine Area and the UK Marine Licensing Area (referred to as the "OfTI Marine Licence"), granted to Moray West on 14 June 2019 and varied on 11 April 2022.
Moray Offshore Windfarm (West) Limited	The legal entity submitting this environmental report supporting the marine licence application for UXO clearance activities.
Moray West EIA Report	The Environmental Impact Assessment Report for the Moray West Offshore Wind Farm and Associated Transmission Infrastructure, submitted July 2018. Additional information was provided in the Moray West Report to Inform an Appropriate Assessment (RIAA) July 2018 and Moray West Application Addendum Document November 2018.
Moray West Offshore Wind Farm	The wind farm to be developed in the Moray West site (also referred as the Wind Farm).
Offshore Consents	Collective term for the two Marine Licences and the Section 36 consent.
Offshore Consent Conditions	Collective term for the conditions attached to the Section 36 Consent and Marine Licences.
Offshore Transmission Infrastructure (OfTI)	The offshore elements of the transmission infrastructure.
OfTI Corridor	The export cable route corridor, i.e., the OfTI area excluding the Moray West site.
Section 36 Consent	Section 36 consent under Section 36 of the Electricity Act 1989 for the construction and operation of the Moray West Offshore Wind Farm was granted on 14 June 2019 and varied on 7 March 2022.
The Development	The Moray West Offshore Wind Farm and OfTI.
The Development Site	The area outlined in Figure 1 attached to the Section 36 Consent Annex 1, Figure 1 attached to the two Marine Licences, and Figure 1 of this report.

The Moray West Site	The area in which the Moray West Offshore Wind Farm will be located. Section 36 Consents and associated Marine Licence to construct and operate generating stations on the Moray West site were granted in June 2019 and varied in March 2022.
The Works	The construction and O&M activities undertaken for the Development.
Transmission Infrastructure (TI)	Includes both offshore and onshore electricity transmission infrastructure for the consented wind farm. Includes connection to the national electricity transmission system near Broad Craig in Aberdeenshire encompassing Alternating Current (AC) Offshore Substation Platforms (OSPs), AC export cables offshore to landfall point at Broad Craig, near Sandend in Aberdeenshire continuing onshore to the AC collector station (onshore substation) at Whitehillock and the additional regional Transmission Operator substation at Blackhillock near Keith. A Marine Licence for the OfTI was granted in June 2019 and varied on 11 April 2022.

Appendix B - Marine Mammal Mitigation Protocol

B.1 Introduction

This UXO Marine Mammal Mitigation Protocol (MMMP) has been prepared to support both the Marine License (ML) and EPS License application by Moray Offshore Windfarm (West) (the Development) for the mitigation of Explosive Ordnance Disposal (EOD) operations within the Development Site; comprised of the Moray West Site and the OfTI Corridor. Further details on the EOD operations planned, including the number and type expected to be found within the Development Site, can be found in **Section 2** of the Environmental Report. A worst-case of 30 UXO devices may require detonation, with up to 22 in the Moray West Site, and up to 8 in the OfTI Corridor. This is planned to take place with one detonation per day anytime from February 2023 to May 2023.

The MMMP outlines the methods and procedures required for the effective mitigation of impacts associated with the clearance of any UXO for marine mammal species expected to be found in the area. In particular, the MMMP will mitigate against the potential risk of physical injury and / or trauma, and PTS exposure on marine mammals.

The JNCC guidance for "*minimizing the risk of injury to marine mammal from use explosives*" (JNCC, 2010[15]) has been consulted in the process of developing this MMMP to determine the best approach for mitigation, and to ensure best practice measures are followed (JNCC, 2010). In addition, this UXO MMMP has been informed by the mitigation implemented during previous work undertaken for the Moray East and the Beatrice OWF UXO protocol included in the MMMP (Moray East, 2018).

The mitigation procedures outlined in this MMMP include;

- the establishment of a mitigation zone of 1 km;
- the monitoring of the mitigation zone by dedicated and trained MMOs during daylight hours and when conditions allow suitable visibility, pre- and post-detonation;
- the deployment of PAM devices, if required, and if the equipment can be safely deployed and retrieved;
- the activation of ADDs;
- all detonations to take place in daylight and, when possible, in favourable conditions with good visibility (sea state 3 or less);
- the controlled explosions of the UXO will be undertaken by specialist contractors, using the minimum amount of explosive required in order to achieve safe disposal of the device; and
- the fusing of multiple devices - if there are multiple UXO in close proximity (e.g., within 20 m of each other) then one may be moved to be detonated with the other. In this case, the

[15] https://data.jncc.gov.uk/data/24cc180d-4030-49dd-8977-a04ebe0d7aca/JNCC-Guidelines-Explosives-Guidelines-201008-Web.pdf

charges should be fused together, allowing for a millisecond of delay between the device detonations in order to reduce the cumulative impact of the shock wave.

B.2 UXO Clearance Techniques

Current mitigation methods, for the protection of mammals and fish, are well established and have been shown to be effective in removing mammals and fish from the areas where they would be negatively affected by UXO detonations, providing them with sufficient protection and safeguarding from the noise of EOD operations. Where possible and safe to do so the preferred options would be as follows, in order of preference:

1. UXO will be avoided and left in-situ.
2. Micrositing of infrastructure, if possible, to avoid any potential UXO, so clearance is not required.
3. Relocation of UXO to where it is not in close proximity to existing or planned infrastructure, so that the UXO can be cleared in a less sensitive area (i.e., outside of a designated site). If the UXO appears structurally sound and there is no risk, the UXO could potentially be moved to a location that is not in a sensitive area for subsequent clearance, subject to a proportional assessment of the risk posed to the vessel and staff from a health and safety perspective.

If these options are not possible, and UXO clearance is the only option, then low-order disposal (deflagration) will be the preferred clearance method. In the unlikely event that low-order clearance is not possible, for example, if the UXO specialist determines that it is not possible due to damage to the UXO, the final option would be the use of high-order detonation. The decision-making hierarchy when clearing a UXO will be as follows:

1. An agreed number of low-order disposal attempts at each UXO clearance will take place; the number is dependent on the surrounding environment and situation and will be determined by the UXO clearance contractor.
2. If none of the low-order disposal clearance attempts work, high-order detonation will take place.
3. If clearance of the UXO is unsuccessful, it will be declared safe, removed from the seabed and disposed of at a licenced facility onshore.

Acoustic and explosive deterrent methods have been seen to disperse mammals to a distance of 1 km from a scheduled detonation site (the mitigation zone), as shown below, as well as numerous reports from live operations where mammal observations are undertaken as standard procedure. In addition, it has been noted within JNCC literature (JNCC, 2010) that the limited exposure of noise and pressure caused by UXO detonations has not been seen to negatively affect marine mammals.

No marine mammal injuries or deaths have been observed or reported by UXO and EOD consultancies or contractors when not using bubble curtains, nor have any been reported within industry press (Ordtek, 2019). In addition, the cost and time associated with bubble curtain use should be considered against any merits to ensure the mitigation is reasonable in relation to the risk presented. The deployment of bubble curtains is costly, due to the requirement of an additional vessel, as well as being highly weather sensitive, which can cause delays to operations preventing additional stages of development progressing (Ordtek, 2019).

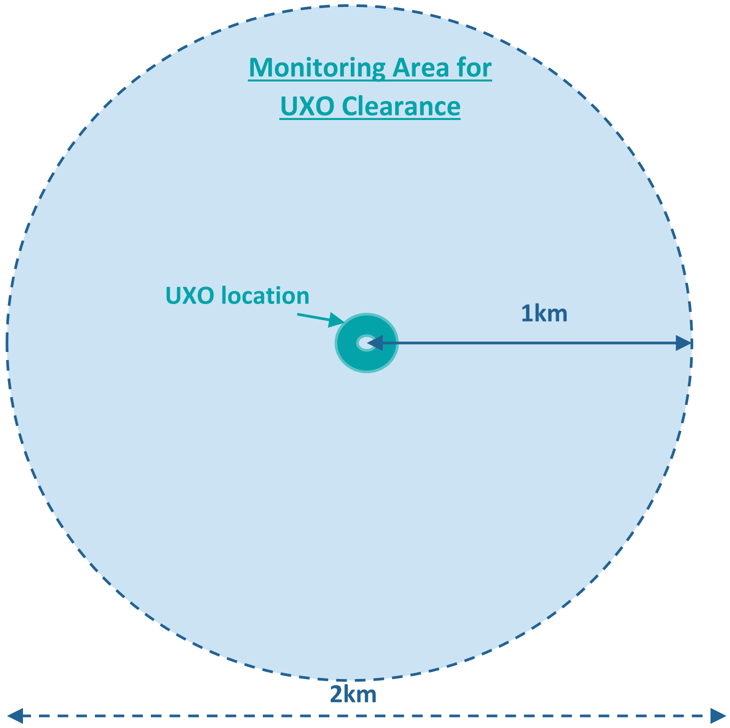
In light of the foregoing together with the conclusion that there are no LSE or significant effects predicted where the proposed mitigation without the use of bubble curtains is adopted, then it is considered that the proposed mitigation is adequate to reduce the risk to marine mammals.

B.3 UXO Mitigation Procedures

Mitigation Zone

The monitoring area (MA) is the area which a pre-clearance search is required to be undertaken by trained, dedicated and experienced MMOs. The MA with 1 km radius is measured out from the UXO clearance site with a 360° coverage, with the overall diameter of the monitoring area of 2 km. **Figure 2** provides a simple diagram of the monitoring area in relation to the UXO clearance site.

Figure 2 MA of 1 km around each UXO clearance location prior to UXO clearance event.



Surveys of the MA will be conducted by dedicated and trained MMOs during daylight hours and suitable visibility and sea states[16] prior to UXO clearance, regardless of clearance method, to minimise the potential for marine mammals to be present within the MA prior to UXO clearance activity taking place, in order to reduce the risk of PTS.

The pre-clearance search will commence at least one hour prior to the start of the clearance event and continue until the clearance event takes place, with dedicated and trained MMOs positioned so the entire

[16] Good visibility means being able to see at least 2 km in all directions, and suitable sea states are 3 or below.

MA can be monitored at all times. For low order clearance a pre-clearance search will last at least one hour (with the ADD activated after 37 minutes) for high order clearance the pre-clearance search will last at least 1.5 hours (with the ADD activated after 30 minutes). The MMOs will be in close contact with each other to ensure any sighting of a marine mammal within the MA is communicated.

Where possible as best practice PAM should be employed for all pre-clearance searches. In the event of periods of low visibility (due to adverse weather and/or sea states of 4 or higher), the use of PAM will be required as a measure to monitor the mitigation zone. The PAM hydrophones should be located as close as possible to the detonation site. It is possible to deploy from the vessels already located at the site, however it should be noted that they may be too far from the detonation site at point of explosion to provide effective monitoring of the entire mitigation zone. Preference will be given to clearance operations to take place in good viewing conditions during daylight.

A PAM system may not always be able to determine the range of a marine mammal detection, or for all species expected to be present in the area. If this is the case, the PAM-Op will need to use experience and expert judgement to determine the range of the individual/s detected and whether it is within the 1 km mitigation zone. If the PAM-Op is unsure of whether an individual/s is within the mitigation zone or not, the precautionary principle should always be applied and it therefore should be assumed that the marine mammal/s is within the mitigation zone.

The pre-clearance search will commence prior to all clearance events or sequences, or after any break in the clearance event or sequence, and at the end of a clearance event or sequence. The visual observations by the MMOs will commence at least one hour prior to the clearance event. This will continue until one hour has passed and no marine mammals have been detected within the MA within the previous 30 minutes, the MMOs will then advise that UXO clearance can commence.

If a marine mammal has been sighted within the MA, it will be monitored and tracked until it is clear of the MA, and the Explosive Ordnance Disposal (EOD) team notified. The marine mammals must be clear of the MA for at least 30 minutes before low-order clearance or high-order detonation.

The ADD will be activated at the appropriate time during the pre-clearance search of the MA, whether there is marine mammal presence or not. Timing of ADD activation is dependent on the time required for the UXO clearance method and size of UXO (see **Section A.4**)[17]. If a marine mammal is detected within the MA during the pre-clearance search, the commencement of the ADD activation will continue at the required time.

If the ADD activation period is greater than the required pre-watch time of one hour, then both the ADD activation and pre-watch should commence at the required ADD activation time prior to UXO clearance activities[18].

[17] For example, if the ADD activation time is 25 minutes, the pre-watch will be undertaken for 35 minutes, then the ADD activated, and the remaining 25 minutes pre-watch time is undertaken simultaneously to the ADD activation period.

[18] For example, if the required ADD activation time is the maximum of 100 minutes, both the pre-watch and ADD activation should commence simultaneously, at 100 minutes prior to the UXO detonation time.

If the marine mammal(s) remains clear of the MA for at least 30 minutes and the one hour pre-search has been completed, then the UXO clearance can proceed.

A precautionary approach should always be used. Therefore, if the MMOs cannot be sure whether the individual is within the MA or not, or whether there is a confirmed sighting of a marine mammal within the MA, then the operation should be delayed accordingly until the MMOs are sure that there are no marine mammals present within the MA.

The mitigation team must be a safe distance from the clearance site prior to any UXO clearance.

B.4 Acoustic Deterrent Device

ADD will be activated prior to any UXO low-order or high-order detonation to ensure marine mammals are deterred from the area and reduce the risk of any physical or auditory injury.

ADDs have proven to be effective mitigation for harbour porpoise, dolphin species, minke whale, grey and harbour seal (Sparling *et al.,* 2015; McGarry *et al.,* 2017, 2020; Boisseau *et al*., 2021). ADDs have been widely used as mitigation to deter marine mammals during offshore wind farm piling and UXO clearance at sites in Europe (for example, Brandt *et al.,* 2011, 2012, 2013a,b) and offshore wind farm sites in the UK, including but not limited to, Galloper, Dudgeon, East Anglia ONE, Moray East.

Pre-deployment tests

The ADD will be tested prior to each pre-clearance search to ensure they are working correctly. If there are any technical problems with the ADD then the pre-clearance search should be delayed until these issues are resolved.

The ADD-Op will also ensure that the communications are in place between themselves, the MMOs and the EOD supervisor.

The ADD would be deployed and ready to be activated once at the correct time prior to or during the one-hour pre-clearance search.

ADD locations

The ADD will be positioned within the water column in close proximity to the clearance site. It is proposed that the ADD will be deployed from vessels within the MA at a location where it is safe to be positioned prior to the commencement of the UXO clearance.

The best location to deploy the ADD, and the method to provide power to the devices, will be decided through a pre-deployment survey of the vessel or vessels by the ADD operator, MMOs, EOD supervisor and vessel operational manager. Once the best location for the ADD has been determined, the control unit and power supply should be temporarily installed. For deployment of the ADD, the transducer part of the device will be lowered over the side of the deck (they should not be activated at this time) to a water depth that is below the draft of the vessel to ensure the sound can be emitted in all directions and not dampened by the presence of the vessel.

ADD activation times

ADD activation will commence during the one-hour pre-clearance search of the monitoring area and immediately prior to the clearance event to allow marine mammals to move beyond the area of potential PTS risk (if the ADD activation period is greater than one hour, both the ADD activation and the pre-watch will commence at the same time, for the required ADD activation time).

If more than one UXO clearance is required in a 24 hour period the ADD will not be activated during transit to another clearance event, and will be activated prior to all clearance events or sequences.

After the ADD has been activated for the required duration, the ADD operator will deactivate and recover the ADD and undertake routine checks to ensure it is still working correctly, ready for the next deployment and activation.

The MMOs will maintain their pre-clearance search during the ADD activation time. If any marine mammals are sighted within the MA during the ADD activation time, the ADD should remain activated until the required activation time has been completed.

If a marine mammal is still observed in the MA after the ADD activation, then the UXO clearance must be delayed and the ADD paused, and a further one-hour pre-clearance search should be undertaken, and the ADD can be re-activated at the appropriate time (i.e. the standard procedure should be re-started). In the case that the required ADD activation time is longer than the 1 hour pre-clearance search, there should always be a break of at least 15 minutes between ADD activations before the mitigations are re-started.

The ADD activation times for low-order clearance and high-order detonation are based on swim speed of 1.5m/s are presented in **Table 7.1** and **Table 7.2.**

The ADD activation times have been based on a swim speed of 1.5 m/s for harbour porpoise, 1.52 m/s dolphin species (Bailey and Thompson, 2010), 1.8m/s seal species (Thompson, 2015), and of 2.3m/s for minke whale, based on Boisseau *et al.,* 2021. However, Kastelein *et al*. (2018) recorded swimming speeds of 1.97m/s in harbour porpoise during playbacks of pile driving sounds. The distance at which marine mammal species are expected to travel within the ADD activation periods are shown in the following tables.

As per consultation with SNCBs, ADD will not be activated for longer than 60 minutes, regardless of the size of the UXO and maximum predicted PTS range.

Table 7.1 ADD activation times for low-order clearance

Mitigation	Low-order clearance
Maximum PTS range (worst-case of harbour porpoise)	**Up to 2 km**
ADD activation	23 minutes = 2.07 km

Table 7.2 ADD activation times for high-order clearance				
Mitigation	**High-order clearance**			
Maximum PTS range (worst-case of harbour porpoise)	**25 kg**	**166 kg**	**309 kg**	**364 kg**
	4.96 km	*8.86 km*	*10.85 km*	*12.20 km*
ADD activation (for harbour porpoise swim speeds)	60 minutes = 5.4 km High-order detonation of large UXO is only undertaken if low-order clearance is not possible.			

B.5 Post-clearance search

The MMOs will maintain a post-clearance search within the monitoring area **for at least 15 minutes** after the final clearance to look for evidence of injury to marine life, including any fish kills (following the JNCC (2010) guidance). Any other unusual observations will also be noted within the report.

B.6 Roles and Responsibilities

There are a number of people that would be required in the compliance with this MMMP for UXO detonation activities, including;

- Marine Mammal Observers (MMOs)
- Passive Acoustic Monitoring Operator (PAM-Op)
- Acoustic Deterrent Device Operator (ADD-Op)
- Explosive Ordnance Disposal Technician

More information on each of the above's specific responsibilities are outlined below, including information on the experience of each that would be required.

Marine Mammal Observers

Dedicated and JNCC accredited MMOs will need to be present and on-watch for the pre-detonation and for the post-detonation searches (see **Section B.3**). Dedicated means that this should be the persons sole responsibility (however in this case it should be noted that the MMO could also act as the ADD operator, although the ADD procedure would more likely be undertaken by the PAM-Op). Two MMOs will be required to cover the entire mitigation zone, with good viewing platforms to allow for 360° coverage. The MMOs must be able to determine the extent of the 1 km mitigation zone from their location, unless poor visibility does not allow.

If only a limited view of the mitigation zone is possible due to the use of a smaller vessel with lower elevation the use of an additional non-dedicated observer on the main UXO clearance vessel will be used. The main UXO clearance vessel will be positioned at the opposite side of the mitigation zone boundary to provide improved confidence in the MMO mitigation.

The MMOs will need to be equipped with binoculars, and a tool to estimate distance i.e. range finding stick or binoculars with reticules and the JNCC reporting forms. The MMOs should scan the mitigation zone with the unaided eye and use binoculars when needed to determine detail (such to look in detail at the area where a possible sighting has been made). Binoculars should not be used continually as they restrict peripheral vision and views close to the vessel.

Marine mammal observations will be carried out to monitor the MA:

- during the pre-detonation search;
- during ADD activation;
- during UXO clearance; and
- during the post-detonation search.

There will be clear communication channels between the MMOs, the PAM-Op (if present), the ADD-Op and the EOD team. The communication procedures will be established and agreed prior to any UXO clearance with regards to the communication of any marine mammals observed within the MA, the deployment of the ADD, and when the MA is clear for the clearance to commence.

The MMOs and ADD operator will be notified and ready to begin the mitigation protocol at a minimum of:

- 2 hours prior to UXO clearance, for any clearance by low-order disposal (deflagration); or
- 3.5 hours prior to UXO clearance, for any clearance by high-order detonation.

The MMOs will record all periods of marine mammal observations, including start and finish time of pre-detonation searches, ADD activation, use of PAM (if required), and conditions during observations (e.g., sea state, visibility, weather, etc.). Any sightings of marine mammals around the vessel(s) will also be recorded.

“Dedicated” means trained MMOs who are employed for the sole purpose of undertaking visual observations to detect marine mammals and advising on and monitoring the implementation of the guidelines.

“Non-dedicated” is a trained MMO who may undertake other roles on the vessel when not conducting their mitigation role. This person can be a member of vessel’s crew providing they do not undertake other roles during mitigation periods.

Experienced MMOs will have a minimum of 20 weeks’ experience of implementing JNCC guidelines in UK waters within the previous five years. Furthermore, they will be experienced at identifying UK marine mammal species and be familiar with their behaviour.

Passive Acoustic Monitoring Operator

PAM is able to detect the vocalizations of marine mammals, and works best for echolocating species that are near-continually vocalizing such as harbour porpoise and dolphin species. PAM will be required in periods of low visibility to complement the monitoring by the MMOs. PAM-Ops should be experienced and trained in PAM hardware and software, as they will be required to determine the range of a detected marine mammal to the hydrophone location (note that this will be located between 100 and 300 m from the EOD operation) if the PAM software is unable to, and to interpret the detected sounds.

The PAM-Ops responsibilities will be the same as those for the MMO outlined above. A dedicated PAM-Op will also be responsible for the deployment, maintenance and operation of the PAM hydrophone, including any spares, and notifying the ADD operator of any issues during the testing of the ADD.

ADD operator

ADD-Op will be responsible for deployment, maintenance and operation of the ADD, including spare equipment, in relation to all UXO activities.

An ADD-Op may be:

- An existing member of the EOD team, who has received the appropriate training in both the MMMP and ADD operation, and would be available to carry out the required duties as a priority in addition to their existing role, or
- An additional member of trained staff employed with the sole responsibility of ADD operation, or
- Undertaken in combination with another environmental role, e.g. fisheries liaison officer or member of the mitigation team.

The ADD-Op duties would be to verify the operation of the ADD before deployment, to operate the ADD throughout the pre-clearance period, ensure batteries are fully charged and that spare equipment is available in case of any problems, and record and report on all ADD and UXO clearance activity.

The ADD-Op will ensure that the ADD devices and spares are functioning correctly before the vessel leaves port. If practical, and in agreement with the Nominated Contact (EOD Supervisor or other appropriate member of the EOD team), testing should also be achieved through an initial deploy and test from the vessel, whilst docked. On site, the ADD will be re-tested prior to the start of the mitigation sequence.

The ADD-Op will also be required to record any marine mammal observations prior to and during ADD deployment.

As outlined in **Section B.4**, the ADD-Op will maintain a detailed record of all ADD deployments and activation. These reports will include a record of all ADD start and stop times, a record of each verification of ADD activation and a record of any issues with ADD deployment and activation.

A list of tasks to be undertaken by the ADD-Op include, but is not limited to:

- preparation and update of risk assessment for ADD in collaboration with vessel personnel;
- maintain, test and operate ADD, including spares;

- keep an inventory of spares and advise on any required repairs necessary to ADD including back-ups;
- deploy, test and monitor ADD;
- liaise and communicate with the EOD Supervisor or other nominated appointee to ensure compliance with the mitigation procedure;
- instruct vessel personnel during mitigation procedure to ensure smooth running of tasks;
- update database / reports at the end of each shift with records, including when the ADD was deployed and activated, in relation to UXO clearance, and any marine mammal observations; and
- provide reports to the Client Representative or other nominated appointee as outlined in **Section B.8** to ensure compliance reporting to the Marine Scotland – Licensing Operations Team (MS-LOT).

For every shift one ADD-Op will be required for the ADD deployment and activation.

It is anticipated that the ADD-Op, taking into account their primary ADD duties, would also be able to undertake marine mammal observations, if their position as ADD operator allows them uninterrupted views of the MA and they are fully trained.

If crew members are to be the ADD-Op, they also must have undertaken the required JNCC MMOs course, if being used in both roles, as well as the required MMMP and ADD training.

The ADD-Op will be suitably trained to required standards, with an appropriate level of experience. Details of the ADD operators will need to be supplied in advance for notification to the MMO in accordance with consent conditions.

Explosive Ordnance Disposal Supervisor

The EOD Supervisor has the overall responsibility for the detonation operation and will be based on the inspection vessel. The EOD Supervisor will be the main point of communication between the mitigation team (MMOs, PAM-Op (if present) and the ADD-Op) and the EOD support teams (who are responsible for carrying out the UXO clearance activities). The EOD Supervisor will be in control of initiating, delaying or pausing the detonation activities.

B.7 Reporting

Reports will be completed detailing the marine mammal mitigation activities and timings, and any detections, and will be submitted to JNCC after the operation has been completed. These reports will include information on the relevant UXO clearance activities, date and location, information on charge sizes, start times of clearances, start and end of pre- and post-clearance watches by MMOs, details of activity during the relevant watches.

Marine Mammal Recording Forms[19] will be completed (including the cover page, operations sheet, effort sheet, and sightings sheet). Deck forms can be used if preferred with the information transferred to the spreadsheet at the end of the watch. Details of ADD used and observations of their efficacy, and any problems encountered and instances of non-compliance with the JNCC guidelines and variations from the agreed procedure will also be reported.

The ADD operator will maintain a detailed record, including all ADD deployment, activation and recovery times, a record of each verification of ADD activation and a note of any issues encountered with regard to the ADD deployment and activation.

After each UXO clearance event, a summary of monitoring and mitigation activities will be prepared and sent to the Client Representative or other nominated responsible person.

In the event of a marine mammal sighting and/or detection, the MMOs will report the following information:

- species, number of individuals, age, sex and size (e.g., juvenile or adult);
- physical description of individual features if unable to identify to species level;
- behaviour when first sighted (e.g., travelling, foraging, resting);
- bearing and distance;
- time, vessel position, vessel speed, vessel activity;
- water depth (if known), sea state, visibility, glare; and
- any other vessels in the area.

Weekly reports will be collated and provided to the MS-LOT on a monthly basis.

In addition to the weekly reports, a final report will be provided which will be submitted to the MS-LOT. The final report will include any data collected during UXO clearance operations, details of ADD deployment and activation, a detailed description of any technical problems encountered and what, if any, actions were taken. The report will also discuss the protocols followed and put forward recommendations on the use of ADD as mitigation during the construction period that could benefit future construction projects.

B.8 Communication protocol

Clear communication channels between the MMOs, PAM-Op (if present), the ADD-Op and the EOD team are required, and the communication procedures will be established and agreed prior to any clearance event with regard to the communication of any detection within the monitoring area, the deployment of ADD, and when the monitoring area is clear for clearance to take place. The EOD team will assign a person responsible for communication with the Lead Operator of the mitigation team.

[19] https://hub.jncc.gov.uk/assets/24cc180d-4030-49dd-8977-a04ebe0d7aca

A member of the mitigation team (ADD-Op, MMO) will be nominated as **Lead Operator** and will liaise directly with the **Nominated Contact** (EOD Supervisor or other appropriate member of the EOD team) via VHF/UHF radio or mobile phone. They will also ensure that information is relayed to the rest of the mitigation team.

The Nominated Contact will keep the Lead Operator updated with timings for UXO clearance events as appropriate to allow sufficient time to commence the ADD deployment and activation in accordance with the procedures set out in this MMMP.

The Lead Operator will inform the Nominated Contact of any delays in the ADD deployment or if any marine mammals are observed not moving out of the MA during the ADD activation period and therefore if a delay in clearance is required.

A communications protocol will be developed between the mitigation team and the Nominated Contact.

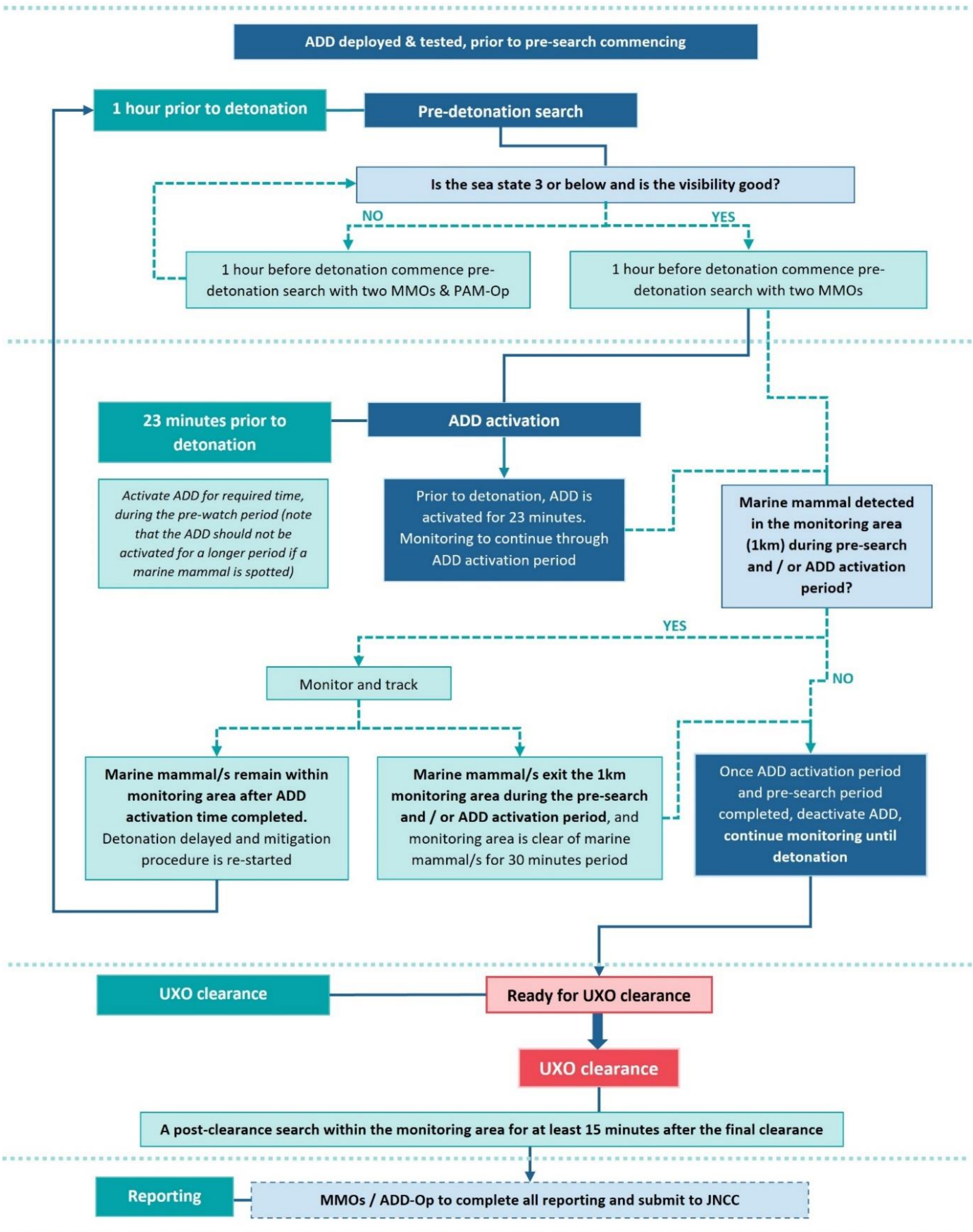
This communications protocol will include, but not be limited to:

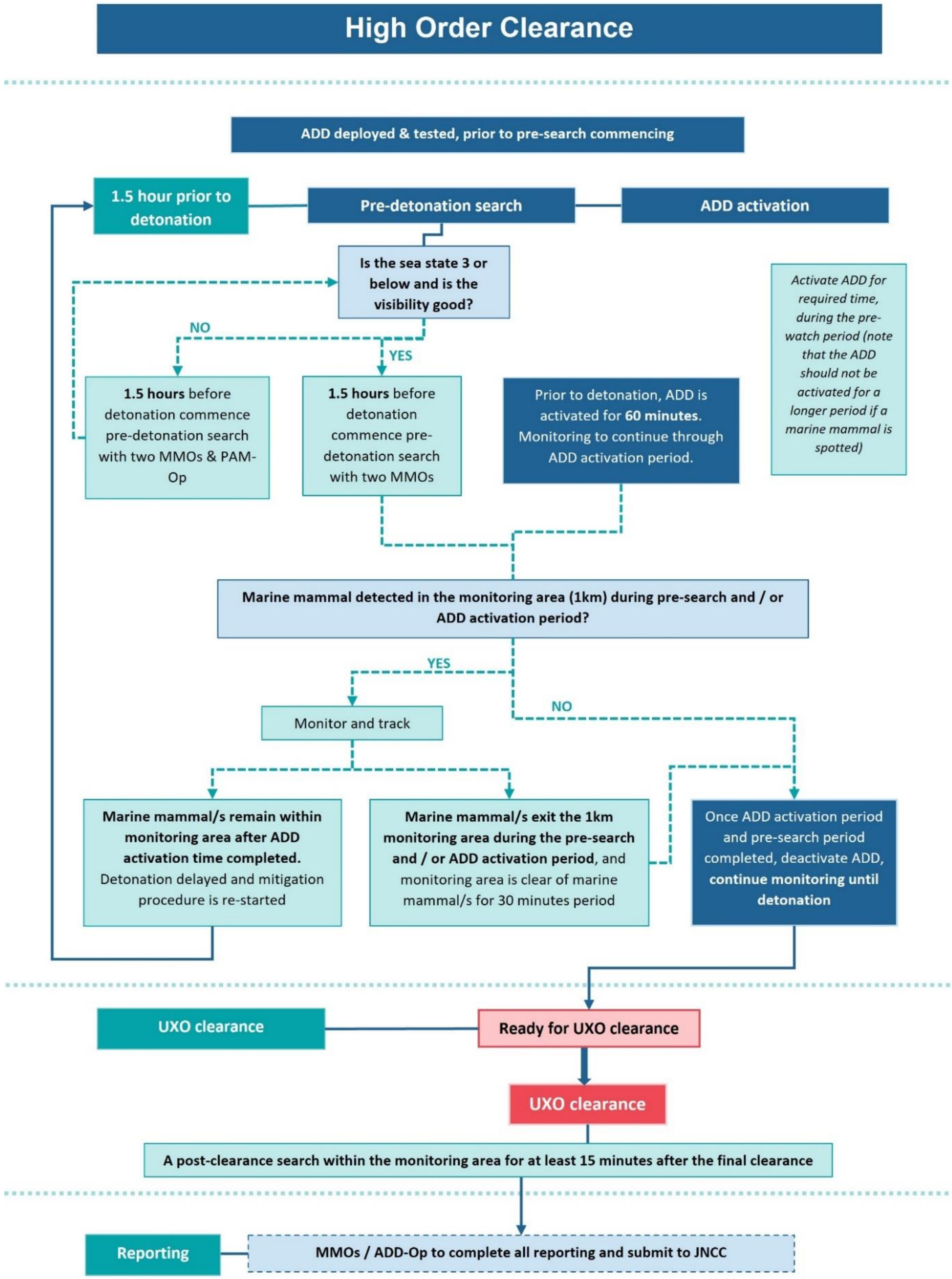
- Notification required prior to UXO clearance vessel deployment to ensure ADD and all equipment required is tested and ready for deployment.
- Once on board, the notification required to set-up equipment, test and deploy ADD to allow for the required activation prior to UXO clearance commencing.
- Procedure to notify the Nominated Contact that deployment of ADD and activation for the required time has been successful, and next steps in the mitigation can commence, or if deployment of ADD and activation has not been successful that clearance activities will be delayed.
- Procedure to notify the Lead Operator that each stage of the mitigation is successfully underway, and when the ADD can be switched off and retrieved from the water.
- Procedure to notify the Lead Operator that further ADD activation is required.
- Procedure to notify the Lead Operator that the UXO clearance operations have been successfully completed.

B.9 Summary of Mitigation Procedures

The outline mitigation procedure (as outlined above) is summarised below in the respective flow charts.

Low Order Clearance




High Order Clearance
ADD deployed & tested, prior to pre-search commencing
1.5 hour prior to detonation
Pre-detonation search
ADD activation
Is the sea state 3 or below and is the visibility good?
NO
YES
1.5 hours before detonation commence pre-detonation search with two MMOs & PAM-Op
1.5 hours before detonation commence pre-detonation search with two MMOs
Prior to detonation, ADD is activated for 60 minutes. Monitoring to continue through ADD activation period.
Activate ADD for required time, during the pre-watch period (note that the ADD should not be activated for a longer period if a marine mammal is spotted)
Marine mammal detected in the monitoring area (1km) during pre-search and / or ADD activation period?
YES
NO
Monitor and track
Marine mammal/s remain within monitoring area after ADD activation time completed. Detonation delayed and mitigation procedure is re-started
Marine mammal/s exit the 1km monitoring area during the pre-search and / or ADD activation period, and monitoring area is clear of marine mammal/s for 30 minutes period
Once ADD activation period and pre-search period completed, deactivate ADD, continue monitoring until detonation
UXO clearance
Ready for UXO clearance
UXO clearance
A post-clearance search within the monitoring area for at least 15 minutes after the final clearance
Reporting
MMOs / ADD-Op to complete all reporting and submit to JNCC

B.11 References

Bailey, H., Senior, B., Simmons, D., Rusin, J., Picken, G. and Thompson, P.M. (2010). *Assessing Underwater Noise Levels during Pile-Driving at an Offshore Windfarm and Its Potential Effects on Marine Mammals*. Marine Pollution Bulletin 60 (6): 888–97.

Boisseau, O., McGarry, T., Stephenson, S., Compton, R., Cucknell, A-C., Ryan, C., McLanaghan, R. and Moscrop, A., 2021. Minke whales *Balaenoptera acutorostrata* avoid a 15 kHz acoustic deterrent device (ADD). Marine Ecology Progress Series, 667, 191-206. https://doi.org/10.3354/meps13690.

Joint Nature and Conservation Committee (JNCC), 2010. JNCC guidelines for minimising the risk of injury to marine mammals from using explosives. August 2010.

JNCC, 2017, JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys. April 2017.

Kastelein, R.A., Van de Voorde, S, and Jennings, N., 2018. Swimming Speed of a Harbour Porpoise (*Phocoena phocoena*) During Playbacks of Offshore Pile Driving Sounds. Aquatic Mammals: 44(1):92-99.

McGarry, T., Boisseau, O., Stephenson, S. and Compton, R., 2017. Understanding the Effectiveness of Acoustic Deterrent Devices (ADDs) on Minke Whale (*Balaenoptera acutorostrata*), a Low Frequency Cetacean. ORJIP Project 4, Phase 2. RPS Report EOR0692. Prepared on behalf of The Carbon Trust. November 2017.

McGarry, T., De Silva, R., Canning, S., Mendes, S., Prior, A., Stephenson, S. and Wilson, J., 2020. Evidence base for application of Acoustic Deterrent Devices (ADDs) as marine mammal mitigation (Version 2.0). *JNCC Report No. 615*, JNCC, Peterborough. ISSN 0963-8091.

Morey East. 2018. UXO Clearance Cetacean Risk Assessment Moray East Offshore Wind Farm. https://marine.gov.scot/data/moray-east-offshore-windfarm-unexploded-ordinance-eps-licence-application https://marine.gov.scot/data/piling-strategy-2016-moray-east-offshore-wind-farm

Otani S., Naito T., Kato A. and Kawamura A., 2000. Diving behaviour and swimming speed of a free-ranging harbour porpoise (*Phocoena phocoena*). Marine Mammal Science, Volume 16, Issue 4, pp 811-814, October 2000.

Ordtek, 2019. Unexploded Ordnance (UXO) Hazard and Risk Assessment with Risk Mitigation Strategy, Creyke Beck A & B Offshore Wind Farms – Main Array.

Sparling, C., Sams, C., Stephenson, S., Joy, R., Wood, J., Gordon, J., Thompson, D., Plunkett, R., Miller, B. and Gotz, T., 2015. The use of Acoustic Deterrents for the mitigation of injury to marine mammals during pile driving for offshore wind farm construction. ORJIP Project 4, Stage 1 of Phase 2. Final Report.

Thompson, P. 2015. Annex 3. Framework for a risk-based assessment to underpin the adoption of alternative mitigation measures during piling at the BOWL and MORL Offshore Wind Farms. 28th July 2015. In: Beatrice Offshore Windfarm Ltd. (2015). Beatrice Offshore Wind Farm Piling Strategy. Prepared by RPS, GoBe Consultants Ltd and Brown and May Marine. Report number LF000005. November 2015.

Appendix C - Detonation Impact Rages

C.1 Modelling output from 6 Alpha Associates Ltd. For the Development

Impact Ranges:

Impact ranges and areas for Permanent Threshold Shift (PTS) and Temporary Threshold Shift (TTS) for very high, high and low frequency cetaceans and pinnipeds in water, based on impulsive thresholds for SPL_{peak} and SEL_{ss}in the Southall *et al*. (2019) impulsive criteria.

Based on *Southall, et al. (2019) impulse criteria (weighted SEL_{ss}), the threshold distances for TTS and PTS are as follows:*

Artillery Shell (7kg NEQ, incl. 0.85 kg charge)

NEQ (kg): 7	Hearing Group	Impulse Criteria	Threshold Distance [m]
TTS Onset (weighted SEL_{ss}) dB re 1 µPa²s	LF	168	2977
	HF	170	38
	VHF	140	1042
	PCW	170	1251
TTS Onset (SPL_{peak}) dB re 1 µPa	LF	213	995
	HF	224	324
	VHF	196	5625
	PCW	212	1102
PTS Onset (weighted SEL_{ss}) dB re 1 µPa²s	LF	183	566
	HF	185	7
	VHF	155	198
	PCW	185	238
PTS Onset (SPL_{peak}) dB re 1 µPa	LF	219	540
	HF	230	176
	VHF	202	3052
	PCW	218	598

SC50 (30 kg NEQ, incl. 5 kg charge)

NEQ (kg): 30	Hearing Group	Impulse Criteria	Threshold Distance [m]
TTS Onset (weighted SEL_{ss}) dB re 1 µPa²s	LF	168	6106
	HF	170	77
	VHF	140	2138
	PCW	170	2566
TTS Onset (SPL_{peak}) dB re 1 µPa	LF	213	1617
	HF	224	527
	VHF	196	9137
	PCW	212	1790
PTS Onset (weighted SEL_{ss}) dB re 1 µPa²s	LF	183	1160
	HF	185	15
	VHF	155	406
	PCW	185	488
PTS Onset (SPL_{peak}) dB re 1 µPa	LF	219	877
	HF	230	286
	VHF	202	4958
	PCW	218	971

E Mine (171 kg NEQ, incl. 5 kg charge)

NEQ (kg): 171	Hearing Group	Impulse Criteria	Threshold Distance [m]
TTS Onset (weighted SEL_{ss}) dB re 1 µPa²s	LF	168	14417
	HF	170	182
	VHF	140	5047
	PCW	170	6058
TTS Onset (SPL_{peak})	LF	213	2888

NEQ (kg): 171	Hearing Group	Impulse Criteria	Threshold Distance [m]
dB re 1 µPa	HF	224	942
	VHF	196	16322
	PCW	212	3197
PTS Onset (weighted SEL_{ss}) dB re 1 $µPa^2s$	LF	183	2740
	HF	185	35
	VHF	155	959
	PCW	185	1151
PTS Onset (SPL_{peak}) dB re 1 µPa	LF	219	1567
	HF	230	511
	VHF	202	8857
	PCW	218	1735

Air Dropped Weapon (314 kg NEQ, incl. 5 kg charge)

NEQ (kg): 314	Hearing Group	Impulse Criteria	Threshold Distance [m]
TTS Onset (weighted SEL_{ss}) dB re 1 $µPa^2s$	LF	168	19460
	HF	170	246
	VHF	140	6813
	PCW	170	8177
TTS Onset (SPL_{peak}) dB re 1 µPa	LF	213	3536
	HF	224	1153
	VHF	196	19987
	PCW	212	3915
PTS Onset (weighted SEL_{ss}) dB re 1 $µPa^2s$	LF	183	3698
	HF	185	47
	VHF	155	1295

NEQ (kg): 314	Hearing Group	Impulse Criteria	Threshold Distance [m]
PTS Onset (SPL_{peak}) dB re 1 µPa	PCW	185	1554
	LF	219	1919
	HF	230	626
	VHF	202	10846
	PCW	218	2125

G7 Torpedo (369 kg NEQ, incl. 5 kg charge)

NEQ (kg): 369	Hearing Group	Impulse Criteria	Threshold Distance [m]
TTS Onset (weighted SEL_{ss}) dB re 1 µPa²s	LF	168	21074
	HF	170	266
	VHF	140	7378
	PCW	170	8855
TTS Onset (SPL_{peak}) dB re 1 µPa	LF	213	3732
	HF	224	1217
	VHF	196	21092
	PCW	212	4132
PTS Onset (weighted SEL_{ss}) dB re 1 µPa²s	LF	183	4005
	HF	185	51
	VHF	155	1402
	PCW	185	1683
PTS Onset (SPL_{peak}) dB re 1 µPa	LF	219	2025
	HF	230	660
	VHF	202	11445
	PCW	218	2242

Impact ranges and areas for possible avoidance of harbour porpoise based on Lucke *et al*. (2009) unweighted SEL_{ss} of 145 dB re 1 µPa^2s.

Based on *Lucke, et al. (2009) impulse criteria, the avoidance distances for harbour porpoise - unweighted* SEL_{ss} *of 145 dB re 1 µ*Pa^2*s:*

Lucke et al., (2009) Unweighted SEL_{ss}	Impulse Criteria	Munition	NEQ [kg]	Threshold Distance [m]
Avoidance	145 dB re 1 µPa^2s	Artillery Shell	7	38255
		SC50	30	78460
		E Mine	171	185241
		Air Dropped Weapon	314	250042
		G7 Torpedo	369	270777

Impact ranges and areas for fish based on the Popper *et al*. (2014) criteria, including behavioural contours for fish.

Based on *Popper, et al. (2014) impulse criteria, impact ranges for mortality and potential mortal injury on fish at* SPL_{peak}*229-234 dB re 1 µPa:*

Popper, et al., 2014. SPL_{peak}	Impulse Criteria	Munition	NEQ [kg]	Threshold Distance [m]
Mortality and Potential Mortal Injury	Lower Threshold 229 dB re 1 µPa	Artillery Shell	7	195
		SC50	30	317
		E Mine	171	566
		Air Dropped Weapon	314	693
		G7 Torpedo	369	731
	Upper Threshold 234 dB re 1 µPa	Artillery Shell	7	117
		SC50	30	190
		E Mine	171	340
		Air Dropped Weapon	314	416

Popper, et al., 2014. SPL_{peak}	Impulse Criteria	Munition	NEQ [kg]	Threshold Distance [m]
		G7 Torpedo	369	439

Comparison modelled of impact ranges

The maximum predicted impact ranges (in km) for PTS and TTS in marine mammals, based on the underwater noise modelling for high-order detonation across projects – figures in red have been applied to the assessment													
Species	Sound Exposure Criteria		Moray West					Moray East		Seagreen OWF		Dogger Bank B	
			6 kg	25 kg	166 kg	309 kg	364 kg	220 kg	365 kg	300 kg	500 kg	226 kg	700 kg
Harbour porpoise (VHF)	Unweighted SPL$_{peak}$	PTS 202 dB	3.05	4.96	8.86	10.85	11.45	10.50	12.20	10.70	12.70	10.50	14.60
		TTS 196 dB	5.63	9.14	16.32	19.99	21.09	19.30	22.50	19.70	23.30	19.30	26.80
	Weighted SEL	PTS (Impulsive) 155 dB	0.20	0.41	0.96	1.30	1.40	1.20	1.40	-	-	1.20	1.60
		TTS (Impulsive) 140 dB	1.04	2.14	5.05	6.81	7.38	3.60	3.90	-	-	3.60	4.20
Dolphin Species (HF)	Unweighted SPL$_{peak}$	PTS 230 dB	0.54	0.29	0.51	0.63	0.66	0.60	0.70	0.60	0.70	0.60	0.84
		TTS 224 dB	0.32	0.53	0.94	1.15	1.22	1.10	1.30	1.10	1.30	1.10	1.50
	Weighted SEL	PTS (Impulsive) 185 dB	0.007	0.015	0.035	0.047	0.051	<0.05	1.20	-	-	1.20	2.00
		TTS (Impulsive) 170 dB	0.04	0.077	0.18	0.25	0.26	0.43	0.51	-	-	0.43	0.62

The maximum predicted impact ranges (in km) for PTS and TTS in marine mammals, based on the underwater noise modelling for high-order detonation across projects – figures in red have been applied to the assessment													
Species	**Sound Exposure Criteria**		**Moray West**					**Moray East**		**Seagreen OWF**		**Dogger Bank B**	
			6 kg	**25 kg**	**166 kg**	**309 kg**	**364 kg**	**220 kg**	**365 kg**	**300 kg**	**500 kg**	**226 kg**	**700 kg**
Minke whale (LF)	Unweighted SPL_{peak}	PTS 219 dB	0.54	0.88	1.57	1.92	2.03	1.80	2.10	1.90	2.20	1.80	2.50
		TTS 213 dB	0.99	1.62	2.89	3.54	3.73	3.40	4.00	3.50	4.10	3.40	4.70
	Weighted SEL	PTS (Impulsive) 183 dB	0.57	1.16	2.74	3.70	4.01	7.20	9.00	-	-	7.20	11.60
		TTS (Impulsive) 168 dB	2.98	6.11	14.42	19.46	21.08	82.80	99.30	-	-	8.30	12.10
Seal species (PCW)	Unweighted SPL_{peak}	PTS 218 dB	0.60	0.97	1.74	2.13	2.24	2.00	2.40	2.10	2.50	2.00	2.80
		TTS 212 dB	1.10	1.79	3.20	3.92	4.13	3.70	4.40	3.90	4.60	3.80	5.20
	Weighted SEL	PTS (Impulsive) 185 dB	0.24	0.49	1.15	1.55	1.68	1.20	1.60	-	-	2.00	1.20
		TTS (Impulsive) 170 dB	1.25	2.57	6.06	8.18	8.86	15.50	18.80	-	-	15.60	23.30

The maximum predicted impact ranges (km) for PTS and TTS in marine mammals from a range of possible charge weights for low-order clearance								
Species	**Sound Exposure Criteria**		**Erebus OWF**				**Seagreen OWF**	
			0.1 kg	**0.25 kg**	**0.5 kg**	**2.0 kg**	**0.5 kg**	**1.5 kg**
Harbour porpoise (VHF)	Unweighted SPL_{peak}	PTS 202 dB	0.73	0.99	1.20	1.90	1.30	1.80
		TTS 196 dB	1.30	1.80	2.30	3.60	2.30	3.40
	Weighted SEL	PTS (Impulsive) 155 dB	0.05	0.08	0.11	0.20	-	-
		TTS (Impulsive) 140 dB	0.54	0.75	0.93	1.30	-	-
Dolphin Species (HF)	Unweighted SPL_{peak}	PTS 230 dB	0.04	0.06	0.07	0.11	<0.10	0.10
		TTS 224 dB	0.08	0.10	0.13	0.21	0.10	0.20
	Weighted SEL	PTS (Impulsive) 185 dB	<0.01	<0.01	<0.01	<0.01	-	-
		TTS (Impulsive) 170 dB	0.01	0.02	0.03	0.05	-	-
Minke whale (LF)	Unweighted SPL_{peak}	PTS 219 dB	0.13	0.17	0.22	0.35	0.20	0.30
		TTS 213 dB	0.23	0.32	0.41	0.65	0.40	0.60
		PTS (Impulsive)	0.14	0.23	0.32	0.63	-	-

The maximum predicted impact ranges (km) for PTS and TTS in marine mammals from a range of possible charge weights for low-order clearance								
Species	**Sound Exposure Criteria**		**Erebus OWF**				**Seagreen OWF**	
			0.1 kg	**0.25 kg**	**0.5 kg**	**2.0 kg**	**0.5 kg**	**1.5 kg**
	Weighted SEL	183 dB						
		TTS (Impulsive) 168 dB	2.00	3.20	4.50	8.80	-	-
Seal species (PCW)	Unweighted SPL_{peak}	PTS 218 dB	0.14	0.19	0.24	0.39	0.50	0.40
		TTS 212 dB	0.26	0.36	0.45	0.72	0.50	0.70
	Weighted SEL	PTS (Impulsive) 185 dB	0.03	0.04	0.06	0.11	-	-
		TTS (Impulsive) 170 dB	0.36	0.57	0.80	1.50	-	-