# MachairWind Offshore Windfarm

# Appendix 9 Draft Marine Mammal Mitigation Protocol

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## Glossary of Acronyms

| Term | Definition |
|---|---|
| ADD | Acoustic Deterrent Device |
| Defra | Department for Environment, Food & Rural Affairs |
| EOD | Explosive Ordnance Disposal |
| EPS | European Protected Species |
| HF | High Frequency |
| IAC | Inter-array cable |
| JNCC | Joint Nature Conservation Committee |
| km | Kilometres |
| LF | Low Frequency |
| MA | Monitoring Area |
| MBES | Multibeam Echo-Sounder |
| MD-LOT | Marine Directorate – Licensing Operations Team |
| MMMP | Marine Mammal Mitigation Protocol |
| MMMT | Marine Mammal Monitoring Team |
| MMO | Marine Mammal Observer |
| MU | Management Units |
| MZ | Mitigation Zone |
| NAS | Noise Abatement Systems |
| NPL | National Physical Laboratory |
| OCM | Operations Control Manager |
| OSP | Offshore Substation Platform |
| PAM | Passive Acoustic Monitoring |
| PAM-Op | Passive Acoustic Monitoring Operator |
| PCW | Phocids in Water |
| PTS | Permanent Threshold Shift |
| RA | Risk Assessment |
| ROV | Remotely Operated Vehicle |
| SBP | Sub-bottom Profiler |
| SEL / $L_{E,p}$ | Sound Exposure Level |
| $SEL_{cum}$ / $L_{E,p,t}$ | Cumulative Sound Exposure Level |
| SNCBs | Statutory Nature Conservation Bodies |
| SPI | Shot Point Interval |

| Term | Definition |
|---|---|
| $SPL_{peak}$ / $L_{p,pk}$ | Peak Sound Pressure Level |
| UHRS | Ultra High Resolution Seismic |
| UK | United Kingdom |
| USBL | Ultrashort Base Line |
| UXO | Unexploded Ordnance |
| VHF | Very High frequency |
| WDA | Windfarm Development Area |
| WTG | Wind Turbine Generator |

## Glossary of Terms

| Term | Definition |
|---|---|
| Cable protection | Protective measure to minimise the effects of scour and hazards along the offshore cables (e.g. to prevent cable exposure or snagging of vessel anchors or fishing gear), as well as for protecting these cables at infrastructure crossing points. |
| Embedded mitigation measure | Mitigation measures, including industry good practice measures, that are directly incorporated into the design for the MachairWind Windfarm Development Area to avoid or reduce environmental effects. |
| Environmental Impact Assessment (EIA) | The process of evaluating the likely significant environmental effects of a proposed development over and above the existing circumstances (or 'baseline'). |
| Inter-array cables (IACs) | Armoured cable containing electrical and fibre optic cores which link the wind turbine generators to each other and to the offshore substation platform(s). |
| Landfall | The area from Mean Low Water Springs to a transition bay(s), where the offshore export cable(s) come ashore. |
| MachairWind Offshore Windfarm | An offshore windfarm capable of exporting around 2 GW of renewable energy to the National Electricity Transmission System. MachairWind Offshore Windfarm comprises three Development Areas:<br>• The WDA – located on the west coast of Scotland to the northwest of Islay and west of Colonsay;<br>• The Offshore Export Cable Corridor – a preliminary boundary extending from the WDA to mean high water springs at a landfall location near Girvan, South Ayrshire; and<br>• The Onshore Transmission Development Area – a preliminary boundary which extends landward from mean low water springs and includes the land required for the landfall of the offshore export cables and their route up to but not including the proposed high voltage direct current switching station which will be developed and constructed by Transmission Owner, ScottishPower Transmission.<br>Separate consent and licence applications will be submitted for each Development Area. |
| Management Units (MUs) | The MUs provide an indication of the spatial scales at which impacts of plans and projects alone, cumulatively and in-combination, need to be assessed for the marine mammal species in UK waters, with consistency across the UK. |
| Marine Megafauna | Marine mammals, leatherback turtles and basking sharks. |
| Marine Mammal Mitigation Team (MMMT) | All personnel carrying out mitigation measures offshore; marine mammal observers, passive acoustic monitoring operators and acoustic deterrent device operators. |
| Mitigation Zone | The area within which underwater noise may result in injury to marine megafauna and within which specific mitigation measures are required. |

| Term | Definition |
|---|---|
| Monitoring Area | The area surrounding the mitigation zone that is monitored to detect marine megafauna and inform the application of mitigation measures. |
| Nominated Contact | The individual formally appointed by the Operations Control Manager or Contractor to act as the primary point of contact for communicating mitigation matters with the MMMT. The nominated contact will be responsible for receiving notifications, coordinating responses, and liaising with the MMMT |
| Offshore export cable | Armoured cable containing electrical cores between the offshore substation platform(s) and landfall. Offshore export cables will include bundled fibre optic cables. The offshore export cables are subject to Marine Licence applications under the Marine (Scotland) Act 2010. The portion of the offshore export cable(s) located within the WDA is assessed as part of this MachairWind WDA EIA and a marine licence application to construct, alter or improve this portion has been submitted alongside the WDA application. A separate marine licence application will be submitted for the portion of the offshore export cable(s) from the WDA boundary to mean high water Mean High Water Springs. |
| Offshore Export Cable Corridor (ECC) | The preliminary boundary extending from the WDA to mean high water springs near Girvan, South Ayrshire and within which the offshore export cable(s) will be located. A separate marine licence application will be submitted for the offshore export cable(s) located within the Offshore ECC. |
| Offshore Substation Platform (OSP) | An offshore platform with a fixed foundation located within the WDA which houses electrical equipment such as transformers, switchgear, protection and control systems, and enables the windfarm's renewable electricity to be collected via inter-array cables and exported to the National Electricity Transmission System via offshore export cables. |
| Onshore Transmission Development Area (OnTDA) | The preliminary boundary which extends landward from mean low water springs and includes the land required for the landfall of the offshore export cables and their route up to but not including the proposed high voltage direct current switching station which will be developed and constructed by Transmission Owner, ScottishPower Transmission. This Transmission Owner is responsible for consenting the high voltage direct current switching station. Onward connections to the National Electricity Transmission System will be consented by National Grid Electricity Transmission and ScottishPower Transmission. Where relevant, these are considered as part of cumulative effects assessment in the EIA. |
| Permanent Threshold Shift (PTS) | A permanent total or partial loss of hearing sensitivity caused by acoustic trauma. PTS results in irreversible damage to the sensory hair cells of the ear, and thus a permanent reduction of hearing acuity. |
| Scour protection | Protective measures to avoid sediment being eroded away from the base of the wind turbine generator foundations as a result of the flow of water. |
| The Applicant | The legal entity submitting consent applications for the MachairWind Offshore Windfarm, namely MachairWind Limited. |

| Term | Definition |
|---|---|
| The Project | MachairWind Offshore Windfarm including all its Development Areas and associated infrastructure. |
| Windfarm Development Area (WDA) | The application boundary within the OAA where consent will be sought for the proposed WDA infrastructure. The WDA infrastructure is subject to Section 36 consent and marine licence applications (generation and transmission) which are being applied for separately from the Offshore ECC infrastructure and OnTDA infrastructure. |
| WDA infrastructure | The offshore generation and transmission infrastructure located within the WDA including but not limited to: WTGs, WTG fixed foundations (and associated scour protection), OSP(s), OSP fixed foundations (and associated scour protection), IACs, OSP link and offshore export cable(s) and their associated external cable protection (insofar as these are located within the WDA) and fibre optic cables. |
| Wind Turbine Generator (WTG) | A wind turbine generator which converts wind energy into electrical energy. Each wind turbine generator is a complex system composed of a high number of components. Typically, the main components include the rotor assembly (composed of three blades and a hub); the nacelle (containing a generator, shaft and gearbox, power electronic converter and transformer); and the tower (containing lifting equipment and the switchgear). |

# 1 Purpose of Document

## 1.1 Introduction

1. MachairWind Limited (hereafter referred to as 'the Applicant') is proposing to develop the MachairWind Offshore Windfarm ('the Project'). The Project has been divided into three Development Areas:

   - The Windfarm Development Area (WDA);
   - The Offshore Export Cable Corridor; and
   - The Onshore Transmission Development Area.

2. Due to the delay in the confirmation of the Project's grid connection location, consenting of the WDA is progressing first (see **Chapter 1 Introduction** of the Environmental Impact Assessment (EIA) Report (EIAR)). The WDA covers an area of 448 $km^2$ and is located off the west coast of Scotland, northwest of Islay and west of Colonsay. The WDA infrastructure includes wind turbine generators (WTGs), offshore substation platforms (OSP) and associated fixed foundations and scour protection, Inter-array cable (IACs), OSP link cables and the portion of the offshore export cable located within the WDA and associated cable protection.

3. This document is the Draft Marine Mammal Mitigation Protocol (MMMP) prepared by Haskoning to support the EIAR and Habitats Regulations Appraisal for the WDA. This Draft MMMP will inform:

   - Mitigation measures to be included as part of post consent European Protected Species (EPS) licence application(s) for geophysical surveys (**Section 2**);
   - Mitigation measures to be included as part of a marine licence application for Unexploded Ordnance (UXO) clearance to be submitted post-consent (**Section 3**); and
   - Mitigation for piling to be included as part of the final MMMP for piling / Piling Noise Mitigation Strategy anticipated to be required as a condition of the WDA Section 36 Consent and associated Marine Licences to be produced post-consent as per Marine Directorate – Licensing Operations Team (MD-LOT) guidance (**Section 4**).

4. If non-piled foundation types are selected for WTGs and OSPs, there will be no requirement for a final MMMP for piling / Piling Noise Mitigation Strategy.

5. The Project is entirely within 12 nm of the coast and therefore an EPS Licence may be required under the Conservation (Natural Habitats, &c) Regulations 1994 (as amended) where there is potential for activities to injure or cause disturbance to an EPS. Ahead of any piling, UXO clearance or geophysical surveys, the Applicant would undertake EPS risk assessments (RA) and apply for an EPS Licence if required.

6. This Draft MMMP has been developed to recommend measures for mitigating the potential impact of auditory injury (permanent threshold shift; (PTS)) on marine mammals, leatherback turtle and basking shark (marine megafauna) from piling and UXO clearance during construction and from geophysical surveys during all phases. The mitigation measures presented in this Draft MMMP are informed by the data presented in the following chapters and technical appendices of the EIAR:

   - **Chapter 9 Fish (including Basking Shark) and Shellfish**;
   - **Chapter 10 Marine Mammals and Leatherback Turtle**;
   - **Appendix 10.1 Underwater Noise Modelling Report**; and
   - **Appendix 10.2 Marine Mammals and Leatherback Turtle Baseline**.

7. The Draft MMMP summarises the worst-case scenarios considered in the EIAR together with a summary of impacts and available mitigation measures. These worst-case scenarios may be refined post-consent when more detailed parameters for the WDA are available.

### 1.2 Project Background

8. The key offshore components of the Project are as follows:

- Up to 144 WTGs and their associated fixed-bottom foundations;
- Up to 2 OSP(s) and their associated fixed-bottom foundations;
- Scour protection around foundations;
- Offshore cables comprising:
  - OSP link cables (linking OSPs together);
  - IACs (linking the WTGs together and to the OSP(s)); and
  - Offshore export cable(s) (linking the OSPs to the landfall) and noting that only the portion of the offshore export cable that is located within the WDA has been given defined parameters at this stage given the uncertainty with the landfall location.
- External cable protection on offshore cables as required.

### 1.3 Marine Megafauna Species

9. Mitigation measures will be applied to any marine mammal, leatherback turtle and basking shark (from here on referred to as marine megafauna species).

### 1.4 Mitigation

10. As part of the project design process, several mitigation measures have been proposed to reduce the potential for impacts on environmental receptors. Those relevant to this Draft MMMP are summarised in **Table 1.1**.

*Table 1.1 Mitigation measures of relevance to the Draft MMMP*

| Mitigation | Type (Embedded or Additional) | How Commitment Secured |
|---|---|---|
| A MMMP will be required for all geophysical surveys, following Joint Nature Conservation Committee (JNCC) (2017) guidelines on minimising risk to marine mammals from seismic and geophysical surveys for marine mammals which will also be included for sea turtles and basking sharks. | **Embedded** mitigation will include a soft-start and ramp up as described in **Section 2.4**. | Included in an EPS RA to be submitted in a separate application post-consent. |
| | **Embedded** mitigation measures include a Marine Mammal Observer (MMO); and Passive Acoustic Monitoring (PAM) equipment and a PAM Operator (PAM-Op) if operations were going to start during hours of darkness or poor visibility following JNCC (2017) guidelines. The JNCC (2023) guidance on PAM will also be followed if PAM is required (**Section 2.4**). | |
| UXO hazards will be avoided where practicable and appropriate. If avoidance is not possible, decision making will relate to removal, with clearance considered if avoidance or removal is not possible. If clearance is required, and where practicable and appropriate, low- | **Embedded** mitigation will include use of low order clearance methods as a default in line with the Department for Environment Food and Rural Affairs (Defra) (2025) supporting guidance on the marine licence application, mitigation and monitoring, reporting and supporting evidence for low noise methods of UXO clearance (**Section 3.5.1**). | Secured in a separate Marine Licence application for UXO clearance to be submitted post-consent. |

| Mitigation | Type (Embedded or Additional) | How Commitment Secured |
|---|---|---|
| order deflagration will be the preferred method. Licensing of UXO clearance works will be subject to a standalone Marine Licence (and EPS licence) application. These applications will provide details of measures to minimise impacts on marine megafauna alongside consideration of alternatives. | **Additional** mitigation is described in **Section 4.4.6.2** if high-order clearance is required.<br><br>**Embedded** mitigation measures include a MMO (**Section 3.5.4**), PAM equipment and a PAM-Op (**Section 65**), following JNCC (2025) guidelines to minimise the risk of injury to marine mammals from piling which will also be applied to sea turtles and basking shark. The JNCC (2023) guidance on PAM will be followed as well. In addition, Acoustic Deterrent Devices (ADD) will be used, as described in **Section 3.5.6**. | |
| Development of and adherence to a MMMP for piling / Piling Noise Mitigation Strategy. This will identify appropriate mitigation measures during offshore activities that are likely to produce underwater noise and vibration levels capable of potentially causing injury or disturbance to marine megafauna. This will be developed alongside the Piling Noise Mitigation Strategy and referred to in EPS licence applications. | **Embedded** mitigation will include a soft-start and ramp up as described in **Section 4.4.3** with options for other primary mitigation described in **Section 4.4.6.1.**<br><br>**Additional** mitigation is described in **Section 4.4.6.2** and includes the optional use of Noise Abatement Systems (NAS).<br><br>**Embedded** mitigation measures include a MMO (**Section 4.4.1.2**), PAM equipment and a PAM-Op (**Section 4.4.1.3**), following JNCC (2010) guidelines to minimise the risk of injury to marine mammals from piling which will also be applied to sea turtles and basking shark. The JNCC (2023) guidance on PAM will be followed as well. In addition, Acoustic Deterrent Device (ADD) will be used, as described in **Section 4.4.2**. | Secured in the Section 36 consent and Marine Licence via the requirement for a MMMP, which will be developed and submitted to Scottish Ministers for approval before commencement of construction. |
| Adherence by vessels to guidelines laid out in the Scottish Marine Wildlife Watching Code. | **Embedded** | Secured through **Appendix 6 Outline Environmental Management Plan (EMP)**. |

# 2 Geophysical Survey Marine Mammal Mitigation Protocol

## 2.1 Introduction

11. This draft geophysical survey MMMP has been prepared to support any upcoming EPS Licence. Prior to any geophysical surveys, an EPS RA will be conducted to determine whether the proposed surveys pose a risk of disturbance or auditory injury to cetacean species.

## 2.2 Scenarios Considered

12. Geophysical surveys may be undertaken to inform project design work. Surveys may comprise the use of Side Scan Sonar, Sub-bottom Profiler (SBP), Multibeam Echo-Sounder (MBES), Single Beam Echo-Sounder Ultrashort Base Line (USBL) and Ultra High Resolution Seismic (UHRS).

## 2.3 Guidance

13. This Draft geophysical survey MMMP follows the guidance provided in JNCC (2017): JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys and guidance for the use of PAM in UK waters for minimising the risk of injury to marine mammals from offshore activities (JNCC, 2023).

14. Geophysical survey equipment such as SBP and UHRS sparkers are currently expected to require mitigation to comply with the Scottish regulations and any potential EPS Licence (if required). The JNCC guidance currently only requires mitigation of MBES during surveys conducted in deep waters (>200 m). Therefore, it is not anticipated that MBES will require mitigation as surveys for the Project will take place in waters <200 m. NatureScot have also advised that if the USBL is operated above 210 decibels (dB) re 1 µPa peak sound pressure level ($SPL_{peak}$), mitigation will be required to minimise the risk of injury. However, if it is operated below this threshold (as is expected during Project surveys), that mitigation will not be needed (NatureScot, 2024).

15. Confirmation of the equipment to be utilised in any geophysical survey will determine whether a MMMP is required, following advice from stakeholders and the issuing of an EPS licence (if required) for geophysical survey activity.

## 2.4 Mitigation Methods

16. The mitigation measures for the proposed surveys, as outlined within the JNCC guidelines (2017) are outlined in the following sections.

### 2.4.1 Monitoring and Soft Start

17. The following monitoring and soft-start measures / procedures will be considered as part of EPS survey licensing for geophysical surveys:

- An MMO;
- If required, PAM could be deployed as an additional mitigation measure if it is feasible and safe to tow a hydrophone array alongside the survey equipment. For example, PAM pre-survey searches would be undertaken during hours of darkness and in poor visibility;
- The MMO / PAM-Op should be located on the source vessel to ensure they are close enough to the survey equipment to effectively monitor the MZ;
- The standard radius of the mitigation zone (MZ) is 500 m, estimated from the centre of the noise source location;

- The MMO / PAM-Op must be informed sufficiently in advance of initiating survey equipment so that a full pre-watch search can be completed for a period of at least 30 minutes prior to use of the survey equipment and prior to the start of operations;
- A 15 to 25 minute soft start is advised if equipment allows and where practicable. A gradual ramp up of the equipment in a uniform manner should be applied where practicable. However, it is acknowledged that this is not always possible. Therefore, when more accurate detail of the noisy equipment to be used is available for consideration as part of the EPS licence application, it will be confirmed whether there will be a soft start or not:
    - The MMO must monitor the MZ for the full duration of the pre-watch search and start of operations or soft start procedure. Where PAM is being used in conjunction with or in place of visual surveys, acoustic monitoring must also occur for the full duration of the pre-watch search and start of operations or soft start procedure. Once the data acquisition begins, monitoring can cease; and
    - If marine megafauna are detected within the MZ during the pre-watch search, the soft start must be delayed until their passage, or the transit of the vessel, results in them being outside of the MZ. There must be a minimum of a 20-minute delay from the time of the last detection within the MZ and the commencement of the full soft start.

### 2.4.2 Line Changes

- If line changes are expected to take longer than 40 minutes:
    - Firing is to be terminated at the end of the survey line;
    - A pre-watch search is to be undertaken during the scheduled line change;
    - The soft start is to be delayed if marine megafauna are seen within the MZ during the pre-watch search; and
    - A full 20-minute soft start is to be undertaken before the start of the next line.
- If line changes are expected to be completed within 40 minutes:
    - Survey equipment firing can continue during the line change. The Shot Point Interval (SPI) should be increased to provide a longer duration between shots, with the SPI not to exceed 5 minutes. The power is increased and the SPI is decreased in uniform stages during the final 10 minutes of the line change, prior to data collection re-commencing.

### 2.4.3 Unplanned Inactive Periods

- In circumstances of an unplanned break, it is imperative the MMO / PAM-Op begin to monitor the MZ as quickly as possible after an unplanned break has occurred:
    - For unplanned breaks of less than 10 minutes, the survey equipment can be restarted and data acquisition resumed in less than 10 minutes, so there is no requirement for a soft start and firing can recommence at the same power level as at prior to the break (or lower), provided no marine mammal(s) have been detected in the mitigation zone during the breakdown period;
    - If a marine mammal, sea turtle or basking shark is detected in the MZ during the inactive/silent period, the MMO / PAM-Op will advise to delay recommencement of the survey line until their passage, or the transit of the vessel, results in the marine megafauna being outside of the MZ. There must be a minimum of a 20-minute delay from the time of the last detection within the MZ and a soft start must then be undertaken;
    - For unplanned breaks longer than 10 minutes, a full pre-watch search and soft start should be carried out before the survey re-commences. If an MMO / PAM-Op has been monitoring during the breakdown period, this time can contribute to the pre-watch search time (30 minutes); and

- If the breakdown occurs at night or during daylight conditions not conducive for a visual search, the MZ should be monitored as described above using PAM. If PAM is not available, the survey must be delayed until conditions are suitable for visual observations.

- The same procedures as above (for unplanned breaks) can be applied for planned breaks. However, if the planned break is for less than 10 minutes, the MMO / PAM-Op must begin monitoring 20 minutes prior to the planned break and continue for the duration of the break.

# 3 UXO Marine Mammal Mitigation Protocol

## 3.1 Introduction

18. This Draft UXO MMMP has been prepared to support both upcoming Marine Licence and EPS Licence applications for the mitigation of Explosive Ordnance Disposal (EOD) operations within the WDA.

19. If UXOs are found within the WDA, a risk assessment will be undertaken and UXO will be either avoided by micro-siting, removed, or disposed of in situ. As the detailed pre-construction surveys have not yet been completed, it is not possible at this time to determine how many UXO will require clearance. As a result, the Applicant will apply for a separate Marine Licence post-consent for the clearance (where required) of any identified UXO.

20. This Draft UXO MMMP details the potential contingency measures which could be used by the Project to limit the risk of PTS auditory injury to marine mammal species arising from UXO clearance operations to a negligible level.

## 3.2 Summary of Clearance Methods

21. Where practicable and safe to do so, the preferred options for UXO management would be as follows, in order of preference:

- UXO would be avoided and left *in situ;*
- Micro-siting of infrastructure, if practicable, to avoid any potential UXO, so clearance is not required;
- If the UXO appears structurally sound and there is no risk, the UXO could potentially be relocated to a location that is not in a sensitive area (e.g. not within a designated site nor in close proximity to existing or planned infrastructure) 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 practicable, and UXO clearance is the only option, then low-order clearance would be the default method; and
- High-order clearance would only be considered as a contingency if low-order clearance was unsuccessful after three attempts or the UXO device is unsafe for low-order clearance.

22. UXO clearance and disposal would be undertaken by specialist contractors, using the minimum number of explosives required to achieve safe disposal of the device.

23. It is important to note these techniques and options are based on current best practice. The mitigation options in the final MMMP, which will be submitted with the Marine licence application for UXO clearance, would be reviewed and updated based on the latest information and guidance.

### 3.2.1 Low Order

24. Low order UXO clearance techniques, where the ordnance is disposed of or rendered safe without a high-order clearance will be the default option for clearance for this work (e.g. low order deflagration).

25. Deflagration is a technique whereby the explosive within the UXO is rapidly burned at subsonic speeds using plasma from a small, shaped charge that generates insufficient shock to detonate the UXO (Merchant and Robinson, 2020; National Physical Laboratory (NPL), 2020). The explosive material inside the UXO reacts with a rapid burning rather than a chain reaction that would lead to a full explosion (NPL, 2020).

26. Substantial noise reduction is achieved compared to high-order deflagration ($SPL_{peak}$ and Sound Exposure Level (SEL) are more than 20 dB lower) and acoustic output for deflagration only depends on the size of the shaped charge, rather than the size of the UXO (NPL, 2020; Robinson et al., 2020).

27. The technique of low order clearance presents a viable alternative to high-order explosive detonation. Low order techniques, such as deflagration, are relatively new to civilian applications but have been used by the UK military since 2005 (Merchant and Robinson, 2020).

### 3.2.2 High Order

#### *3.2.2.1 High Order with Noise Abatement Systems*

28. If high order clearance is required as a contingency following three unsuccessful attempts to detonate using low order techniques, or in situations where the UXO is too unstable for a safe low order clearance, additional mitigation measures are required. NAS such as bubble curtains or hydro sound dampers would be deployed for any high order clearance to reduce underwater noise impacts from the explosion.

29. Bubble curtains are a flexible system of tubes fitted with special nozzle openings which can be installed on the seabed at a sufficient radius around the UXO. Hydro-sound dampers are essentially a net with air filled elastic balloons. Both types of NAS equipment are designed to cushion in the sound from loud sources such as high order clearance. A specialist vessel that is designed for the launch and recovery of the bubble curtain would be used and fitted with large hose reels and a number of air compressors. Compressed air would be discharged via the hose nozzles prior to and during the detonation, causing a curtain of continually rising air bubbles to surround the water column around the UXO location. This process changes the physical condition of the water column with regard to underwater acoustics. Upon detonation, acoustic waves are repeatedly broken, limiting their spatial extent.

30. Once the NAS system is in place and prior to being activated, an explosive charge would be attached to or placed next to the UXO by a Remotely Operated Vehicle (ROV). The NAS system would then be activated and clearance would be undertaken remotely.

31. Once the charge has been detonated, a visual inspection survey using an ROV would be undertaken to confirm that the UXO has been successfully detonated.

### 3.3 Results from Current Underwater Noise Modelling

32. **Table 3.1** presents the impact ranges for UXO clearance, considering various charge weights and impact criteria using both peak sound pressure level and cumulative sound exposure level ($SEL_{cum}$).

33. A UXO clearance sound source is defined as a single pulse, as such the $SEL_{cum}$ criteria from Southall et al. (2019) have been given as single pulse values in **Table 3.1** and fleeing receptor assumptions have not been applied (see **Appendix 10. 1 Underwater Noise Modelling Report** of the EIAR).

34. Although the predicted impact ranges in **Table 3.1** are large, the duration of the noise must also be considered. For the detonation of a high order UXO clearance, each explosion is a single noise event, compared to the multiple pulse nature and longer durations of impact piling. The predicted impact ranges in bold in **Table 3.1** will be required to be mitigated. For the purposes of this draft MMMP, the proposed mitigation measures are based on low-order clearance with a 1 km impact range. This range reflects the maximum predicted PTS distance of 990 m for harbour porpoise, which represents the largest anticipated PTS impact range for any marine mammal. Consequently, these mitigation measures will be applied to all marine megafauna.

35. For high order clearance, additional mitigation measures such as NAS would be required to mitigate for the worst-case PTS impact range at 14 km.

36. It should be noted that the underwater noise modelling for UXO clearance is very indicative at this stage. A UXO investigation survey will take place to identify the number, location and sizes of the UXO where a more specified approach to underwater noise modelling will take place. It will include noise mitigation such as NAS if high order UXO clearance is considered.

*Table 3.1 PTS impact ranges for marine mammals using the Southall et al. (2019) impulsive criteria for UXO clearance noise (predicted impact ranges in bold will need to be mitigated for)*

| **Southall *et al.* (2019) $L_{p,pk}$** | **PTS (Impulsive) $SPL_{peak}$** | | | | **PTS (Impulsive) $SEL_{cum}$** | | | |
|---|---|---|---|---|---|---|---|---|
| | Low frequency (LF) (219 dB) | High frequency (HF) (230 dB) | Very high frequency (VHF) (202 dB) | Phocids in water (PCW) (218 dB) | LF (213 dB) | HF (224 dB) | VHF (196 dB) | PCW (212 dB) |
| Low order (0.25 kg) | 170 m | 60 m | **990 m** | 190 m | 230 m | < 50 m | 80 m | < 50 m |
| 25 kg (+ donor) | 820 m | 260 m | 4.6 km | 910 m | 2.2 km | < 50 m | 570 m | 390 m |
| 55 kg (+ donor) | 1.0 km | 340 m | 6.0 km | 1.1 km | 3.2 km | < 50 m | 740 m | 570 m |
| 120 kg (+ donor) | 1.3 km | 450 m | 7.8 km | 1.5 km | 4.7 km | < 50 m | 950 m | 830 m |
| 240 kg (+ donor) | 1.7 km | 560 m | 9.8 km | 1.9 km | 6.5 km | < 50 m | 1.1 km | 1.1 km |
| 525 kg (+ donor) | 2.2 km | 730 m | 12 km | 2.5 km | 9.5 km | 50 m | 1.4 km | 1.6 km |
| 698 kg (+ donor) | 2.4 km | 810 m | 13 km | 2.7 km | 10 km | 60 m | 1.5 km | 1.9 km |

| Southall *et al.* (2019) $L_{p,pk}$ | PTS (Impulsive) $SPL_{peak}$ | | | | PTS (Impulsive) $SEL_{cum}$ | | | |
|---|---|---|---|---|---|---|---|---|
| 750 kg (+ donor) | 2.5 km | 830 m | **14 km** | 2.8 km | 11 km | 60 m | 1.5 km | 2.0 km |

### 3.4 Guidance

37. The policy paper Marine Environment: Unexploded Ordnance Clearance Joint Position Statement was updated in January 2025 and states:

- Low noise methods should be the default method of UXO clearance;
- High order methods should be last resort;
- A NAS is required for any high order clearance;
- If high order clearance is the only method considered, an appropriate justification for this should be provided; and
- Regardless of the clearance tool or method used, all applicants should avoid, reduce and mitigate environmental impacts as far as possible.

38. Defra (2025) also published supporting guidance on the marine licence application, mitigation and monitoring, reporting and supporting evidence for low noise methods of UXO clearance. These updated policies, along with the JNCC (2025) guidelines on minimising potential risk to marine mammals from UXO clearance, have been taken into account in the development of this draft MMMP.

### 3.5 Mitigation Methods

39. The Applicant will ensure that the mitigation measures are adequate to reduce the risk of any physical injury or PTS within the MZ during all UXO clearance.

40. The final UXO clearance MMMP would involve the establishment of a suitable MZ around a UXO location before any UXO clearance. The MZ is the entire mitigation area for the maximum PTS ranges.

41. The methods for establishing the MZ and reducing the potential impacts of any UXO clearance would be agreed with MD-LOT in consultation with the relevant Statutory Nature Conservation Bodies (SNCBs) and would be secured as commitments within the final UXO clearance MMMP.

42. The UXO clearance mitigation measures could include:

- Low-order disposal techniques (see **Section 3.5.1**), this will be the default method for all UXO clearance;
- The use of NAS such as bubble curtains if high-order UXO clearance is required (see **Section 3.5.2** taking into account the environmental conditions within which they could be effective);
- The activation of an Acoustic Deterrent Device (ADD) (see **Section 3.5.3**) prior to UXO clearance;
- Establishment of a Monitoring Area (MA) with a minimum of 1 km radius (see **Section 3.5.3**):
    - The observation of the MA would be conducted by two trained, dedicated and at least one experienced MMOs during daylight hours and when conditions allow suitable visibility, pre- and post-detonation (see **Section 3.5.3**); and

- Deployment of PAM in the MA (see **Section 65**), for a PAM-Op to monitor in conjunction with MMOs.

- All UXO clearance would be taking place in daylight and in favourable conditions with good visibility and sea state 4 or less.

### 3.5.1 Low-Order UXO Clearance Techniques

43. Low-order UXO clearance techniques, where the ordnance is disposed of or rendered safe without a high-order detonation is the default option for clearance for this work. Examples of low-order techniques include (NPL, 2020):

- Freezing the munition to render it inactive;
- Water abrasive suspension cutting to physically disrupt the munition;
- Disposal in a Static Detonation Chamber;
- Photolytic destruction of the munition; and
- Low-order deflagration.

44. Low order clearance techniques are further described in **Section 3.2.1**.

### 3.5.2 Noise Abatement Systems

45. If high-order clearance is needed as a contingency, additional mitigation measures are required. NAS such as bubble curtains would be used for any high-order detonations to reduce underwater noise impacts from the explosion (see **Section 3.2.2.1**).

46. It is important to consider the environment in which the bubble curtains would be deployed, to ensure that they are effective, safe to deploy and taking in to account the contractor's limitations and safety restrictions. Key considerations are environmental constraints such as water depth, current speeds and wave height.

47. Currently, it is possible to deploy bubble curtains for UXO detonation under the following scenario:

- Water depths are between approximately 5 m and 40 m;
- Significant wave heights are less than approximately 1 m;
- Maximum wind speed is less than approximately 8 m/s; and
- Current speeds are less than approximately 1.5 knots.

48. The above figures are subject to change depending on available technology at the time of any potential detonations. The exact parameters for the safe deployment of bubble curtains will be confirmed in the final MMMP with the information from the assigned contractor.

49. Once the bubble curtain is in place and prior to the bubble curtain being activated, an explosive charge would be attached to or placed next to the UXO by a ROV. The bubble curtain would then be activated, and detonation would be undertaken remotely.

50. Once the charge has been detonated, a visual inspection survey using an ROV would be undertaken to confirm that the UXO has been successfully detonated.

### 3.5.3 Monitoring Area

51. The MA is the area over which a pre-clearance search would be undertaken by two trained, dedicated and at least one experienced MMO *and* one PAM-Op during daylight hours. The combination of a MMO and PAM-Op prior to ADD activation and UXO clearance during daylight hours is required because the WDA is located next to the Inner Hebrides and the Minches Special Area of Conservation (SAC) for harbour porpoise. The size of the MA will be based on results from the

underwater noise modelling. The worst-case MA established from the current underwater noise modelling (**Table 3.1**) is 14 km for harbour porpoise (*Phocoena Phocoena)* for an unmitigated High order clearance. With a large impact range of 14 km, additional mitigation as such NAS would be required.

52. For low order clearance, the worst-case MA is 990 m for harbour porpoise, therefore, the MA would have a minimum radius of 1 km measured out from the UXO clearance site with a 360° coverage, representing an area of 3.14 km$^2$ (**Plate 3.1** and see **Plate 3.2**).

53. The MA would be monitored for a minimum of one hour prior to UXO clearance by both the MMOs and PAM-Op. See **Plate 3.2** for the mitigation protocol flow chart for low order UXO clearance.

54. If predicted injury ranges (and consequently the MZ) are greater than 1 km, the visual search is still required and the MMOs (and PAM-Op) should focus their search efforts to within 1 km but also record any marine megafauna seen outside of this range. If any marine megafauna appears to be moving towards the UXO clearance location, the MMOs should monitor its movement and behaviour and use their expert judgement to determine if a delay in UXO clearance is required (see **Plate 3.2**).

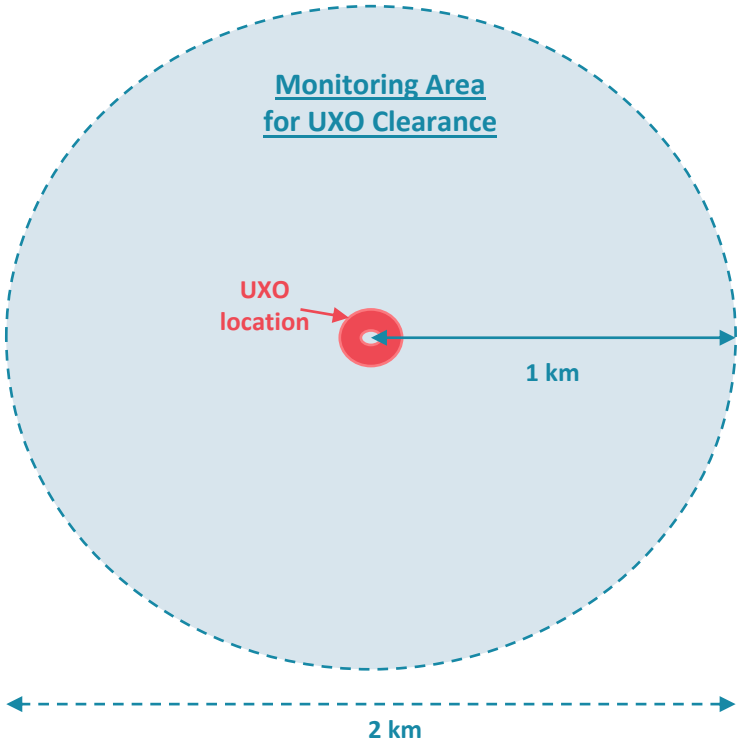


*Plate 3.1 Monitoring area for UXO clearance*

### 3.5.4 Marine Mammal Observers

55. Marine megafauna observations would be undertaken by trained and dedicated JNCC accredited MMOs, with at least one MMO having 20 weeks experience within UK waters over the past ten years.

56. At least two MMOs would conduct surveys from vantage points to allow unobstructed observations of the entire MA to monitor the MA before, during and after UXO clearance.

57. The MMOs would be equipped with binoculars and a tool to estimate distance i.e. range finding stick or binoculars with reticles and reporting forms. The MMOs would scan the MA with the unaided eye and use binoculars when needed to look in detail at an 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.

58. The pre-clearance search would commence at least one hour prior to all clearance events, or after any break in the clearance event, and continue until UXO clearance can commence (**Plate 3.2**).

59. Within the one hour pre clearance search, the MMOs and PAM-Op are required to carry-out a 30 minute pre-activation watch prior to ADD activation (see **Section 3.5.6**). If no marine megafauna have been sighted within 100 m of the ADD after at least 30 minutes of pre-activation watch, the ADD would be activated (see **Section 3.5.6** and **Plate 3.2**). When one hour of pre-clearance search has passed, ADD activation time has been completed, and no marine megafauna have been detected within the MA for at least 20 minutes, the MMOs would advise that the UXO clearance can commence (**Plate 3.2**).

60. If any marine megafauna are detected within 100 m of the ADD, ADD activation will be delayed until the animal moves outside of a 100 m impact area. Once the animal is at least 100 m away from the ADD, the ADD can be switched on. If, at the end of the ADD activation period, the individual(s) remains within the MA, the ADD will be switched off to reduce any excessive noise, and UXO clearance delayed for a minimum period of 20 minutes, and only reactivated if any marine megafauna remains outside the MA for at least 20 minutes. Once the animal is outside the MA, and the ADD has been activated for the required time, and no marine megafauna have been detected inside the MA for at least 20 minutes, UXO clearance can commence (**Plate 3.2**) (see **Section 4.4.2** for ADD activation).

61. All MMOs must be a safe distance from the clearance site prior to any UXO clearance.

62. The MMOs would continue observations during ADD activation, bubble curtain activation (if required), during the UXO clearance as well as a post clearance search for at least 15 minutes after the UXO clearance is complete to record any evidence of injury to marine life, including fish kills. All observations would be noted in the mitigation report (**Section 3.5.6**), and a note included if nothing was sighted.

63. Marine megafauna observations would be carried out to monitor the MA during:

- Pre-activation search;
- Pre-clearance search;
- ADD activation;
- Bubble curtain activation (if it is required);
- UXO clearance; and
- The post-clearance search.

64. The MMOs would record all periods of marine megafauna observations, including start and finish time of observations, when UXO clearance commenced and conditions during observations (e.g. sea state, visibility, weather, etc.). The MMOs would complete the relevant JNCC recording form(s) and reporting (see **Section 3.5.7**).

65. There would be clear communication channels between the Marine Mammal Mitigation Team (MMMT) (*MMOs, the PAM-Op the ADD operator*) and the EOD (see **Section 3.5.8**). The communication procedures would be established and agreed prior to any UXO clearance to ensure

clear communication of any marine mammal observations within the MA, the deployment of ADD, and when the MA is clear for the UXO clearance to commence.

### 3.5.5 Passive Acoustic Monitoring

66. PAM will be deployed to provide continuous monitoring for marine mammals during UXO clearance, in accordance with the guidance for the use of PAM in UK waters for minimising the risk of injury to marine mammals from offshore activities (JNCC, 2023) and the JNCC guidelines for minimising the risk of injury to marine mammals from using explosives (JNCC, 2025).

67. The type of PAM system and equipment to be used will be confirmed in the final MMMP in consultation with MD-LOT and SNCB's and the clearance contractor depending on operational constraints. Hydrophones will be selected to cover the frequency range of interest for all species (e.g. harbour porpoise, fin whale, grey seal vocalisations), with sensitivity appropriate to detect vocalisations at relevant ranges.

68. Deployment of the PAM equipment will be within the MA, positioned to maximise acoustic coverage of the full clearance area. The PAM-Op would be responsible for deployment, maintenance and operation of the equipment, including spare equipment, in relation to all UXO clearance. A detailed description of the PAM equipment and deployment will be included in the final MMMP for UXO clearance.

69. A trained and experienced PAM-Op will be on duty in conjunction with the MMOs during day light. UXO clearance will only occur during day light hours and in good visibility and sea states (sea state 4 or less); in line with the JNCC (2025) guidance.

70. The PAM-Op would record and report all periods of PAM, including start and finish time of monitoring, if and when marine mammals were detected, especially in relation to ADD activation and UXO clearance operations. The PAM-Op would provide the necessary data and information to be included in the reporting (see **Section 3.5.7**).

71. There would be clear communication channels between the PAM-Op, MMOs, the ADD operator and the EOD (see **Section 3.5.8**).

### 3.5.6 Acoustic Deterrent Device

72. An ADD would be activated prior to any UXO low-order clearance or high-order clearance to ensure marine mammals and potentially sea turtles and basking shark are deterred from the area to reduce the risk of any physical or auditory injury.

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

74. The type and model of ADD would be determined in the final MMMP for UXO clearance, based on the latest information and advice, and would provide sufficient evidence to demonstrate that it is effective at deterring the marine mammal species that could be present in the MA. At present it is the Lofitech ADD that has the largest documented deterrent ranges for harbour propose, of up to 7.5 km with an immediate response on activation of the device (Brandt et al., 2012, 2013; Gordon et al., 2015), a maximum deterrent range of 4.5 km for minke whale (Boisseau et al., 2021) and 1 km for harbour seal (Brandt et al., 2012; 2013; Harris et al., 2014; Gordon et al., 2015).

75. The ADD would be tested on deck prior to the pre-clearance search to ensure it is working correctly. If there are any technical problems with the ADD, the UXO clearance could be delayed until these issues are resolved. A back-up ADD would be present onboard; in case there are issues with activation of the primary system.

76. The ADD would be positioned within the water column to ensure that sound can be emitted in all directions. The ADD would be deployed from a vessel in close proximity to the clearance site, where it is safe to be positioned prior to the commencement of the UXO clearance.

77. The best location to deploy the ADD, and the method to provide power to the device, would be decided through a pre-deployment survey of the vessel or vessels by the ADD operator(s), MMMT, EOD supervisor and vessel operational manager. Once the best locations for the ADD have been determined, the control unit and power supply would be temporarily installed. For deployment of the ADD, the transducer part of the device would be lowered over the side of the deck 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.

78. The ADD would be deployed and ready to be activated prior to UXO clearance and activated within the last 30 minutes of the pre-clearance search (approximately no earlier than the last 14 minutes of the pre-clearance search (see **Table 3.3**). This would allow marine mammals, and potentially leatherback turtles and basking sharks to move beyond the area of potential risk of exposure to PTS. If an animal is detected within the MA, the ADD activation will be delayed until the animal is at least 100 m away from the ADD. The pre-ADD activation search is described in **Section 3.5.3**.

79. The ADD activation for low order UXO clearance has been determined based on the maximum potential area for PTS and the animals' swim speed (**Table 3.2**). This same approach will be taken in the final MMMP for UXO clearance.

*Table 3.2 Marine mammal swimming speed used for ADD activation times*

| Species | Swim speed m/s | Reference |
|---|---|---|
| Harbour porpoise (VHF) | 1.4 | Scottish Natural Heritage (SNH), 2016 |
| Delphinid (HF) | 1.52 | Bailey and Thompson, 2006 |
| Mysticete (LF) | 2.1 | SNH, 2016 |
| Pinnipeds (PCW) | 1.8 | SNH, 2016 |

80. The ADD activation durations for low order clearance are presented in **Table 3.3** which shows the minimum ADD activation time required is 14 minutes to ensure all marine mammals, and potentially leatherback turtles and basking sharks are outside of the 1 km impact range prior to low order UXO clearance (see **Plate 3.2**).

*Table 3.3 ADD activation times and deterrent ranges for all marine mammals for low order UXO clearance*

| UXO clearance method | ADD duration (minutes) | Swim speed m/s | Deterrent range | Additional ADD time if marine mammal enters MA or for operational delays (minutes) | Maximum ADD time (minutes) |
|---|---|---|---|---|---|
| Harbour porpoise (VHF) | 14 | 1.4 | 1.2 km | 10 | 22 |
| Delphinid (HF) | 14 | 1.5 | 1.2 km | 10 | 22 |
| Mysticete (LF) | 14 | 2.1 | 2.7 km | 10 | 22 |
| Pinnipeds (PCW) | 14 | 1.8 | 1.5 km | 10 | 22 |

81. After the ADD has been activated for the required duration, the ADD operator would deactivate and recover the ADD and undertake routine checks to ensure it is still working correctly, ready for the next deployment and activation. The ADD would not be activated during transit to another clearance event and would be activated prior to all clearance events.

### 3.5.7 Reporting

82. All reporting 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, time and location, information on charge sizes, start times of clearances, start and end of pre- and post-clearance watches by MMOs and the PAM-Op, details of activity during the relevant watches.

83. Marine Mammal Recording Forms 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.

84. The PAM-Op will be responsible for reporting all details on the PAM equipment, (for example the sensitivity of the hydrophones) including the deployment set up and the configuration of the PAM software, methods for marine mammal detection and localising if feasible. In addition, the MMMT will also be completing the Marine Mammal Recording Forms[1].

85. 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.

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

87. In the event of a marine mammal sighting and/or detection, the MMOs/PAM-Op will report the following information:

- Species or species group;
- Number of individuals, age, sex and size (e.g., juvenile or adult) (MMOs only);

[1] https://data.jncc.gov.uk/data/24cc180d-4030-49dd-8977-a04ebe0d7aca/marine-mammal-recording-form-spreadsheet-explosives-uxo-2025-01.xlsx

- Physical description of individual features if unable to identify to species level (MMOs only);
- Behaviour when first sighted (e.g., travelling, foraging, resting) (MMOs only);
- 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 (MMOs only).

88. A final report will be provided which will be submitted to the MD-LOT, NatureScot and the JNCC. The final report will include any data collected during UXO clearance operations, details of PAM equipment, deployment and software configuration; ADD deployment and activation, a detailed description of any technical problems encountered and what, if any, actions were taken. The report will also include MMOs/PAM effort and discuss the protocols followed and put forward recommendations on the use of the mitigation measures during the UXO clearance that could benefit future construction projects.

### 3.5.8 Communication and Responsibilities

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

90. A communications protocol will be developed between the MMMT and the Nominated Contact.

91. 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; and
- Procedure to notify the Lead Operator that the UXO clearance operations have been successfully completed.

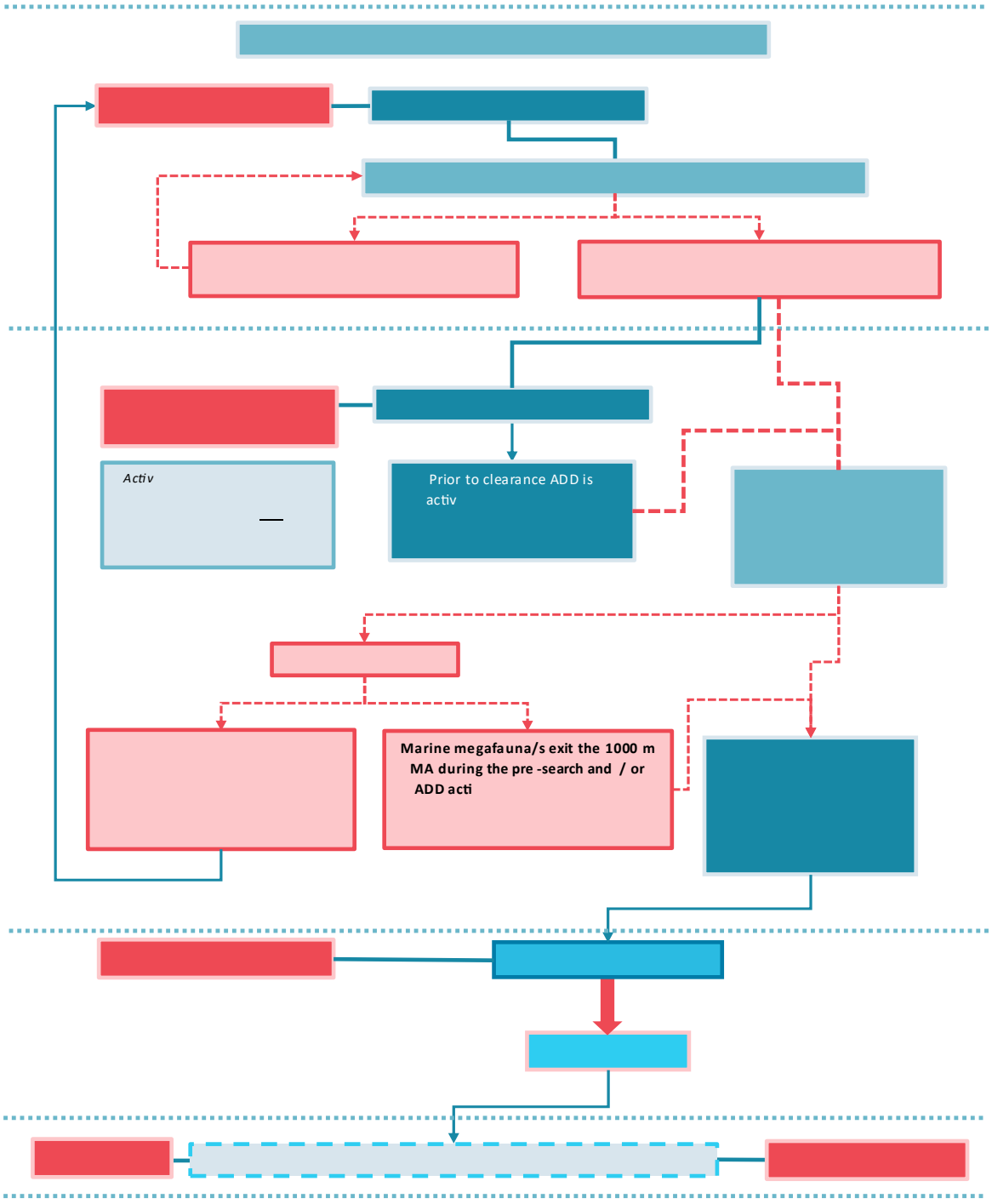


*Plate 3.2 Mitigation protocol for low order UXO clearance*

# 4 Piling Marine Mammal Mitigation Protocol

## 4.1 Introduction

92. This Draft MMMP for piling has been prepared to support both the Marine Licence application and upcoming EPS licence application for the mitigation of pile driving operations within the WDA.

93. This Draft MMMP for piling outlines the proposed mitigation to reduce the likelihood of any injury, including any PTS, to marine megafauna during all piling operations.

94. The final MMMP / Piling Noise Mitigation Strategy will be developed in the pre-construction period, when there will be more detailed information on the final Project design, and will incorporate the most appropriate mitigation measures based upon the latest and best available information, proven methodologies and including information presented in the updated underwater noise modelling, if required. The final MMMP / Piling Noise Mitigation Strategy will include details of the embedded mitigation, such as the soft-start and ramp-up, as well as details of the MA and MZ and any additional mitigation measures required to minimise potential impacts of any physical injury or PTS to marine megafauna. The final MMMP / Piling Noise Mitigation Strategy will be developed in consultation with MD-LOT and relevant SNCBs.

## 4.2 Results from Underwater Noise Modelling

95. **Table 4.1** presents the predicted effect ranges and areas for instantaneous PTS from a single strike ($SEL_{ss}$ / $L_{E,p,ss}$) of the maximum hammer energy and is highest for harbour porpoise, with a maximum PTS range of 980 m for monopiles. If a 10 dB noise reduction was used which could be some form of embedded and/or additional mitigation, the predicted impact range for harbour porpoise would be reduced to 220 m for monopiles.

96. **Table 4.1** presents the predicted PTS impact ranges from cumulative exposure from a single monopile installation. The $SEL_{cum}$ / $L_{E,p,t}$ is a measure of the total received noise over the whole piling operation. The $SEL_{cum}$ / $L_{E,p,t}$ range indicates the distance from the piling location a receptor would have to be, if it were to start fleeing in a straight line from the noise source, for that receptor to not receive a noise exposure in excess of the criteria threshold; and if the receptor were to start fleeing from a location closer to the modelled range, it would receive a noise exposure above the criteria threshold (see **Appendix 10.1 Underwater Noise Modelling Report** of the EIAR for more information).

97. To assess the potential for decreasing PTS impact ranges and the respective ADD duration, additional underwater noise modelling has been undertaken with a 10 dB noise reduction. This level of noise reduction could be achieved by embedded, additional or a combination of both measures. The potential effect range for cumulative PTS exposure is highest for LF cetaceans (mysticetes) for monopiles, with a potential cumulative PTS range of 27 km, for a single installation in a 24-hour period. With noise mitigation, the predicted effect range for cumulative exposure for LF cetaceans would be less than 10 m for monopiles.

98. This Draft MMMP includes a maximum MA of 1,000 m for harbour porpoise which will be applied to all marine megafauna if no additional mitigation was used.

*Table 4.1 Predicted PTS impact ranges at the WDA from single strike $SPL_{peak}$ / $L_{p,pk}$ and cumulative SEL / $L_{E,p}$ at maximum hammer energy for monopile with and without noise mitigation (PTS ranges in bold to be mitigated)*

| Species | Maximum impact for monopiles using $PTS_{peak}$ from single strike at full energy (6,600 kJ) | | Maximum impact range for monopiles using $SEL_{cum}$ from piling at full energy (6,600 kJ) | |
|---|---|---|---|---|
| | Without noise mitigation | With noise mitigation (-10 dB) | Without noise mitigation | With noise mitigation (-10 dB) |
| Harbour porpoise (VHF) | 980 m | 220 m | 8,000 m | 110 m |
| Delphinid species (HF) | <10 m | <10 m | <50 m | <10 m |
| Mysticetes (LF) | 80 m | <10 m | 27,000 m | <10 m |
| Pinnipeds (PCW) | 90 m | <10 m | <50 m | <10 m |
| Leatherback turtle and basking shark* | <10 m | <10 m | <50 m | <10 m |
| *Predicted impact ranges from HF cetaceans have been applied to turtles due to similar PTS thresholds | | | | |

### 4.3 Guidance

99. The current guidance on minimising the risk of injury to marine mammals from piling noise is provided by the JNCC (2010). These mitigation guidelines are supplemented by the JNCC guidance for the use of PAM in UK waters (JNCC, 2023).

100. Despite the additional guidance on the use of PAM, it is noted that guidance specific to piling has not been updated since 2010 and, therefore, is outdated. It does not take into consideration the considerable developments in our understanding of the effects of noise on marine mammals, and increased evidence that ADDs are effective at deterring marine mammals from the instantaneous PTS mitigation zone. For example, the use of ADDs as the sole mitigation measure without the need for additional visual and/or acoustic monitoring was used at Beatrice Offshore Wind Farm, Moray East Offshore Wind Farm and Moray West Offshore Wind Farm, all in the Moray Firth, and was shown to be effective for marine mammal mitigation. McGarry (2020) carried out a review of ADDs and therefore there is a good level of knowledge of the efficiency of devices, with the Lofitech having the largest deterrent ranges as described in **Section 3.5.6**. Furthermore, the JNCC has advised that an addendum to provide updates to the JNCC (2010) piling guidelines is currently in preparation and, therefore, new advice may be available prior to the finalisation of the MMMP for piling / Piling Noise Mitigation Strategy.

101. Therefore, various potential options for the mitigation of instantaneous PTS are outlined below. The final MMMP / Piling Noise Mitigation Strategy will commit to specific mitigation measures.

## 4.4 Mitigation Methods

102. The final MMMP / Piling Noise Mitigation Strategy will involve the establishment of a MA based on the maximum PTS range ($SPL_{peak}$ / $L_{p,pk}$) and a MZ around the pile location before each pile driving activity, based on the maximum predicted distance for cumulative PTS ($SEL_{cum}$ / $L_{E,p,t}$).

103. The Applicants would ensure that the mitigation measures are adequate to minimise the risk of any physical or auditory injury (PTS) to marine megafauna.

104. The methods for establishing the MA and MZ and reducing the potential impacts of piling operations would be agreed with MD-LOT and NatureScot and others in consultation with the relevant SNCBs and would be secured as commitments within the final MMMP / Piling Noise Mitigation Strategy.

105. This Draft MMMP is providing mitigation measures based on the results from **Appendix 10.1 Underwater Noise Modelling Report** of the EIAR.

106. The Draft piling mitigation measures therefore could include:

- Establishment of a MA with a minimum 1,000 m radius (see **Section 4.4.1.1**):
  - The observation of the MA would be conducted by trained, dedicated and experienced MMOs during daylight hours and when conditions allow suitable visibility (visibility of entire MA; sea state 4 or less); and
  - Deployment of PAM devices and a PAM-Op in the MA in conjunction with MMO and during poor visibility or at night.
- The activation of ADD (see **Section 4.4.2**);
- Soft-start and ramp-up (see **Section 4.4.3**); and
- Procedure for breaks in piling (see **Section 4.4.4**).

### 4.4.1 Monitoring

#### *4.4.1.1 Monitoring Area*

107. The radius of the MA would be greater than the maximum predicted impact range for single strike PTS ($SPL_{peak}$ / $L_{p,pk}$) for marine mammal species that could be present in or around the WDA.

108. This Draft MMMP involves the establishment of a MA with a minimum radius of 1 km around each WTG location before piling in the WDA (**Plate 4.1**).

109. The MA would be monitored for a minimum of 30-minutes by MMOs *and* PAM-Op during daylight hours (due to the WDA being located next to the Inner Hebrides and the Minches SAC for harbour porpoise) prior to ADD activation and soft start commencing. See **Plate 4.2** for the mitigation protocol flow chart for piling.

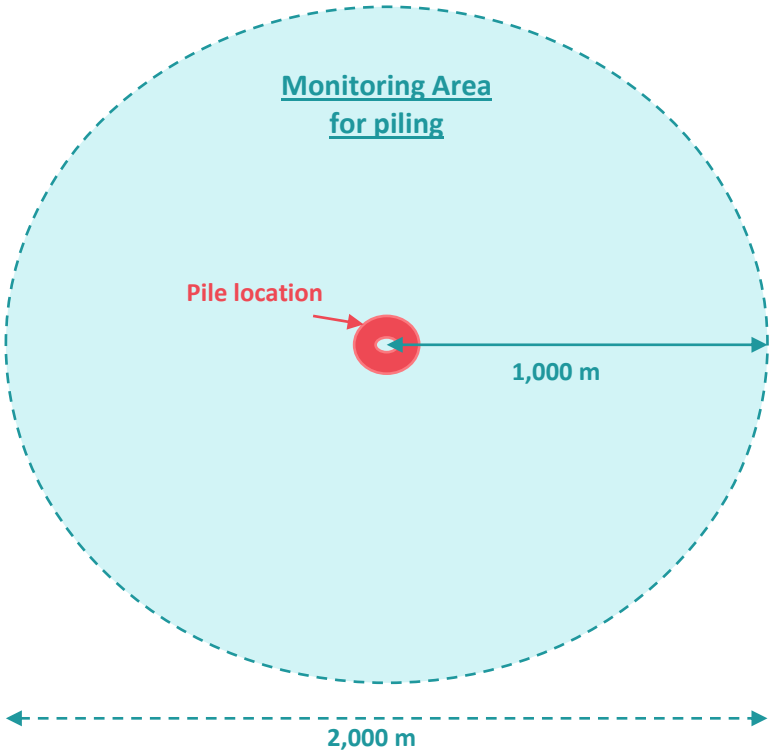


*Plate 4.1 Monitoring area for piling*

#### *4.4.1.2 Marine Mammal Observers*

110. Marine megafauna observations would be undertaken by two JNCC accredited dedicated MMOs with at least one experienced MMO. 'Dedicated' is defined as a trained MMO with the sole purpose of undertaking visual observations to detect marine mammals, with at least one MMO being experienced. 'Experienced' is defined as minimum of 20 weeks experience of implementing JNCC guidelines in UK waters within the previous five to ten years.

111. At least two MMOs would conduct surveys to cover the entire MA around each pile location. Marine megafauna observations would be carried out from vantage points to allow unobstructed observations of the entire MA.

112. The MMOs would be equipped with binoculars and a tool to estimate distance i.e. range finding stick or binoculars with reticles and reporting forms. The MMOs would scan the MA with the unaided eye and use binoculars when needed to look in detail at an 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.

113. Marine megafauna observations (with two MMOs) would be carried out to monitor the MA:

- Prior to and during ADD activation;
- During the soft start and ramp-up procedure;
- With at least one MMO on watch at any time during the full piling procedure; and
- During any breaks in piling prior to piling recommencing.

114. The pre-piling search would commence prior to all piling events, or after any break in piling. The visual observations by the MMOs would commence at least 30 minutes prior to the ADD activation followed by the soft start (see **Plate 4.2**).

115. ADD activation will be delayed if any marine megafauna has been detected within 100 m of the ADD. Once the animal is at least 100 m away from the ADD, the ADD can be switched on. If, at the end of the ADD activation period, the individual(s) remains within the MA, the ADD will be switched off to reduce any excessive noise, and piling will be delayed for a minimum period of 20 minutes. Once the animal is outside the MA, the ADD has been activated for the required time, and no other marine megafauna has been detected inside the MA, piling can commence, which the soft start will commence immediately (see **Plate 4.2** and **Section 4.4.2**).

116. The MMOs would record all periods of marine megafauna observations, including start and finish time of observations, when soft start and piling commenced and conditions during observations (e.g. sea state, visibility, weather, etc.). Any sightings of marine megafauna around the piling vessel would be recorded. The MMOs would complete the relevant JNCC recording form(s) and reporting (see **Section 4.4.7**).

117. There would be clear communication channels between the MMMT and the Operations Control Manager (OCM) (see **Section 4.4.8**). The communication procedures would be established and agreed prior to any piling to ensure clear communication of any marine mammal observations within the MA, the deployment of ADD, and when the MA is clear for the piling soft-start to commence.

#### *4.4.1.3 Passive Acoustic Monitoring*

118. The use of PAM would be undertaken by at least one experienced and dedicated PAM-Op. PAM will be used concurrently with MMOs during daylight hours due to the WDA being located next to the Inner Hebrides and the Minches SAC (see **Plate 4.2**). Additionally, the PAM-Op would enable monitoring during periods of poor visibility and darkness prior to piling in line with the JNCC (2023) guidance.

119. The PAM-Op would be trained to JNCC standards, with an appropriate level of field experience. The PAM equipment would be appropriate to detect vocalising cetaceans in the MA. The PAM-Op would need a good level of marine mammal detection and identification due to the wide range of cetacean species potentially present in the area. The PAM-Op would be responsible for deployment, maintenance and operation of the equipment, including spare equipment, in relation to all piling activities. The PAM-Op would ensure that the equipment and spares are functioning correctly prior to the start of the mitigation.

120. Hydrophones and software should be configured to detect the species relevant to the area (including harbour porpoise, dolphin species and fin whale). If the PAM equipment is to be deployed from the deck of the piling vessel, a survey of the piling vessel would be conducted, prior to when deployment may be needed, to agree the best locations for deployment and monitoring. PAM-Ops would assist in preparation and update of risk assessment for hydrophone deployment in collaboration with vessel personnel. The PAM equipment used for mitigation and deployment method will be confirmed in the final MMMP for piling / Piling Noise Mitigation Strategy.

121. If required, PAM would be carried out to monitor the MA:

- During pre-piling monitoring period;
- During ADD activation;
- During the soft start and ramp-up procedure; and
- During any breaks in piling prior to piling recommencing.

122. Where possible, PAM would continue monitoring during piling to allow for any breaks in piling.

123. The PAM-Op would record and report all periods of PAM, including start and finish time of monitoring, if and when marine mammals were detected, especially in relation to when ADDs were activated and, when soft start, ramp-up and piling was underway. The PAM-Ops would provide the necessary data and information to be included in the reporting (see **Section 4.4.7**).

124. There would be clear communication channels between the PAM-Ops, MMOs, the ADD operator and the OCM (see **Section 4.4.8**).

### 4.4.2 Acoustic Deterrent Device

125. The type and model of ADD would be determined in the final MMMP for piling / Piling Noise Mitigation Strategy, based on the latest information and advice, and would provide sufficient evidence to demonstrate that it is effective at deterring the marine mammal species that could be present in the MA. The Lofitech ADD have proven to be effective mitigation for harbour porpoise, minke whale, grey and harbour seal (Sparling et al., 2015; McGarry et al., 2017, 2020; Boisseau et al., 2021). Studies have shown the Lofitech seal scarer to be effective for harbour porpoise at ranges of 7 to 9 km. 9 km is the maximum distance that has been recorded using a portable hydrophone cluster within 10 km off the ADD deployment (Graham et al., 2023). This 2023 study supports findings of previous studies, which have detected immediate response on activation of the device (Brandt et al., 2012, 2013; Gordon et al., 2015).

126. An ADD would be activated after a pre-activation search and prior to the soft start as mitigation to reduce the risk of PTS during piling. If a marine megafauna is detected in the MA within 100 m from the ADD prior to activation of the ADD, the ADD will not be activated until the animal has left. Although there is no data on how an ADD impacts sea turtles or basking shark, as a precautionary approach, the mitigation for ADD will follow as applied to marine mammals (see **Section 4.4.1.2** for more detail).

#### *4.4.2.1 Acoustic Deterrent Device* Pre-Deployment Test

127. The ADD will be tested on site to ensure it is working correctly. If there are any technical problems with the ADD, then the pre-piling search should be delayed until these issues are resolved. The Project will have backups to prevent any delays in piling.

128. The ADD operator will also ensure that the communications are in place between themselves, the MMOs, PAM-Op and the OCM supervisor (as described in **Section 4.4.8**).

129. The ADD will be deployed and ready to be activated once the 30-minute pre-piling search is completed. PAM can be used to confirm that the ADD is working correctly.

#### *4.4.2.2 Acoustic Deterrent Device Locations*

130. The ADD will be positioned within the water column in close proximity to the piling event as far as practically possible. It is proposed that the ADD will be deployed from the piling vessel at a location where it is safe to be positioned close to the piling event prior to the commencement of the pre-piling search.

131. 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/PAM-Op, OCM 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.

#### *4.4.2.3 Acoustic Deterrent Device Activation Times*

132. As a result of consultation with NatureScot (see Table 10.2 in **Chapter 10 Marine Mammals and Leatherback Turtle** of the EIAR), it has been agreed that $SPL_{peak}$ / $L_{p\text{-}pk}$ will be used to determine ADD activation times. Further consultation will be undertaken post-consent during the finalisation of the final MMMP / Piling Noise Mitigation Strategy.

133. The ADD activation times have been based on a precautionary swimming speed of 1.4m/s for harbour porpoise (**Table 4.2**) (SNH, 2016). **Table 4.2** presents the required ADD activation duration to mitigate PTS impact range of 1 km. The minimum ADD activation time required is 15 minutes (see **Plate 4.2**).

*Table 4.2 ADD activation time*

| Species | Add duration | Distance (swim speed) | Range (km) | Area ($km^2$) |
|---|---|---|---|---|
| Mysticete (LF) | 15 | 2.1 | 1.9 | 11.3 |
| Delphinds (HF) | 15 | 1.52 | 1.3 | 5.8 |
| Harbour porpoise (VHF) | 15 | 1.4 | 1.2 | 4.9 |
| Pinnipeds (PCW) | 15 | 1.8 | 1.6 | 8.2 |

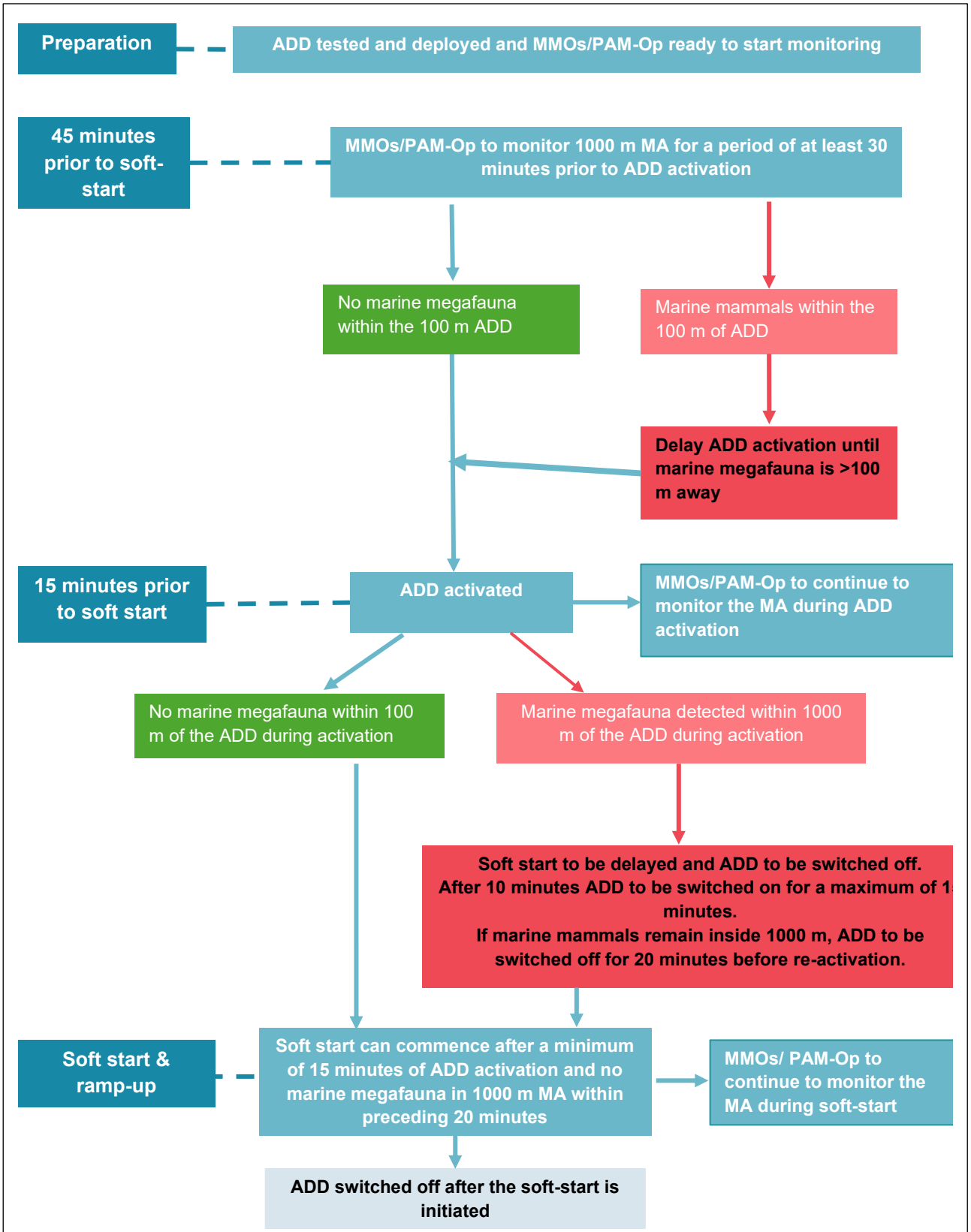


*Plate 4.2 Mitigation flow chart for monitoring*

### 4.4.3 Soft Start and Ramp-Up

134. Following the activation period of the ADD, the soft start procedure would commence. Based on the worst-case modelled scenario, the soft start will start with a duration of five minutes, at a maximum hammer energy of 550 kJ with one to ten strikes per minute.

135. A gradual ramp-up period would follow the soft start, with the energy used per hammer blow gradually increasing so that if any marine megafauna are in the area, despite the pre-piling activation of the ADD, they are encouraged to leave by the initial low levels of underwater noise prior to the noise reaching levels which could cause PTS. The gradual ramp-up will last approximately 25 minutes, increasing hammer energy with 30 to 40 strikes per minute.

136. While the JNCC (2010) piling protocol recommends a minimum soft start duration of 20 minutes, extending the soft start to 25 minutes, with a five-minute slow start reduces the potential peak exposure or the initial noise shock from piling that could injure or disturb marine megafauna. Slow starts can complement soft starts by reducing the distance in which injury can occur (Stephenson et al., 2023). Additionally, it provides additional time for marine megafauna to detect and respond to increasing sound levels, accounting for variability in behavioural responses and uncertainty in the effectiveness of soft-start procedures. This approach is widely used in other offshore windfarms, such as Moray West.

137. The enhanced duration therefore reduces the risk of animals remaining within impact zones when full hammer energy is reached. During the 25 minutes for the soft start and ramp-up it is estimated that marine megafauna would move away from the piling event, at least 2.25 km from the piling location. This would be greater than the maximum predicted distance for PTS from a single strike at the maximum hammer energy:

- During the five-minute soft-start it is estimated that marine mammals would move a minimum of 0.45 km from the piling (based upon a precautionary marine mammal swimming speed of 1.4 m/s (SNH, 2016); and
- During the 20-minute ramp-up it is estimated that marine mammals would move a minimum of 1.8 km from the piling location (based upon a precautionary average marine mammal swimming speed of 1.4 m/s (SNH, 2016).

138. If piling activity is stopped for more than two hours, a full restart of the procedures as stated above is conducted prior to piling re-commencing.

139. The soft start and ramp-up procedure would be embedded/primary mitigation for all piling operations (see **Plate 4.3**).

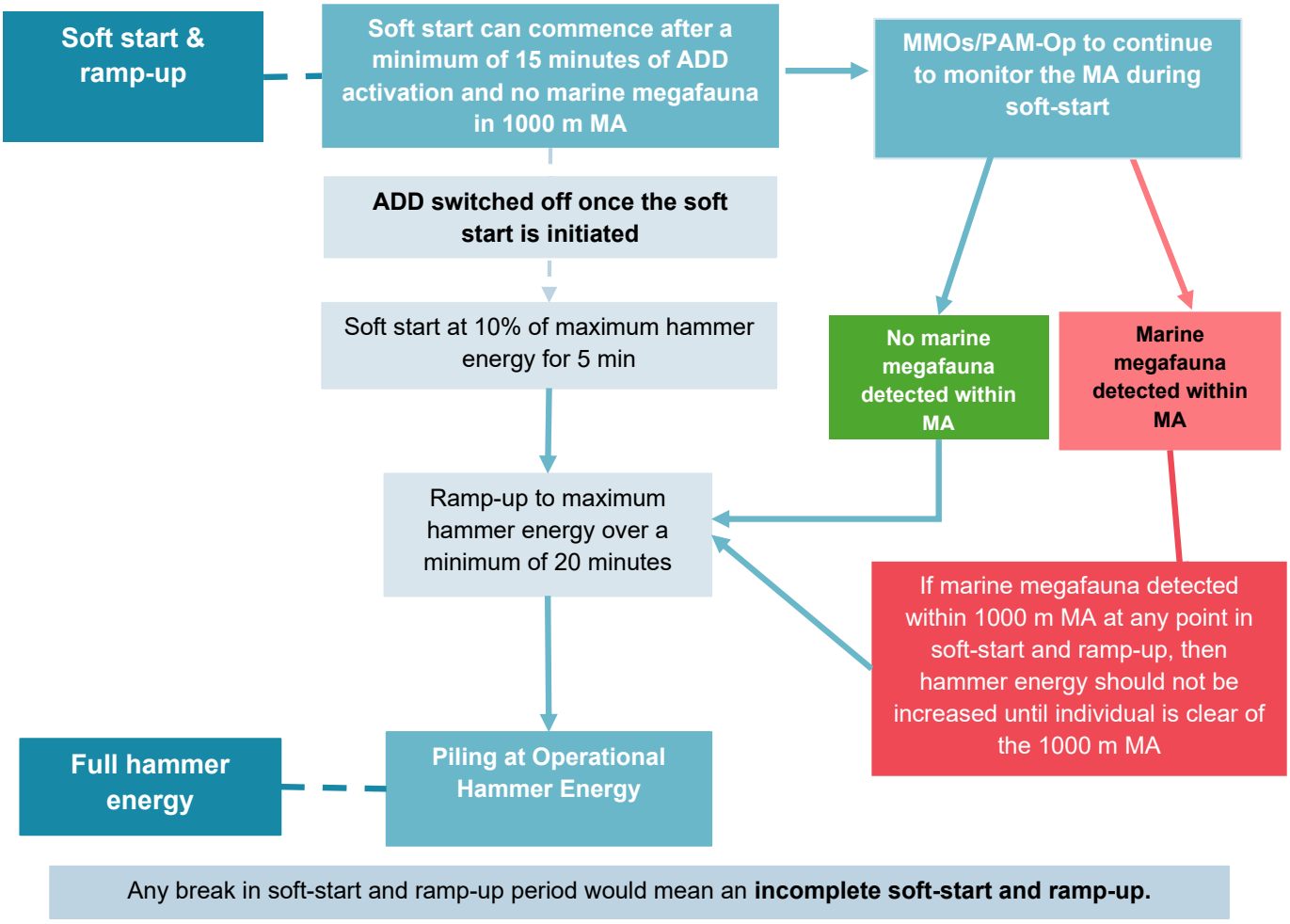


*Plate 4.3 Mitigation protocol for soft start*

### 4.4.4 Breaks in Piling

140. Monitoring of the MA during any breaks in piling would be conducted by MMOs and PAM-Op during daylight hours and suitable visibility or by PAM-Op during poor visibility or at night (see **Plate 4.4**).

141. For any breaks in piling the following mitigation is proposed, depending on the duration of the break:

- For any breaks in piling of less than 10 minutes, piling may continue as required (i.e. as if there was no break) as long as MMOs and/or PAM-Op have been in continuous watch and no marine megafauna are detected within the MA during the break period;
- For any breaks in piling of more than 10 minutes, but less than two hours, as long as MMOs and / or PAM-Op have been on watch and no marine megafauna are detected within the MA during the break period, then piling can recommence with an altered soft start procedure (e.g. five to six blows of the hammer at starting hammer energy) before continuing as required[2], provided there are no marine megafauna within the MA:
  - If there are marine megafauna within the MA, then the full mitigation procedure (as outlined above) would be undertaken, including 30-minute monitoring of the MA by MMOs and / or PAM, ADD deployment and activation for the required time, followed by the soft start and ramp-up procedure (for a minimum of 25 minutes).
- For any breaks in piling of more than two hours then the full mitigation procedure (as outlined above) is required, including 30-minute monitoring of the MA by MMOs and / or PAM-Op, ADD deployment and activation for the required time, followed by the soft start and ramp-up procedure:
  - If monitoring was conducted during piling, prior to any breaks and the MA has been confirmed as having no marine megafauna, then it may be possible to commence the soft start immediately. The soft start and ramp-up procedure would be for a minimum of 20 minutes as outlined in the JNCC guidance.

[2] Based on the evidence that marine mammals do not return to the piling area within two hours of piling ceasing (e.g. Nabe-Neilson et al., 2018, Brandt et al., 2009; 2011).

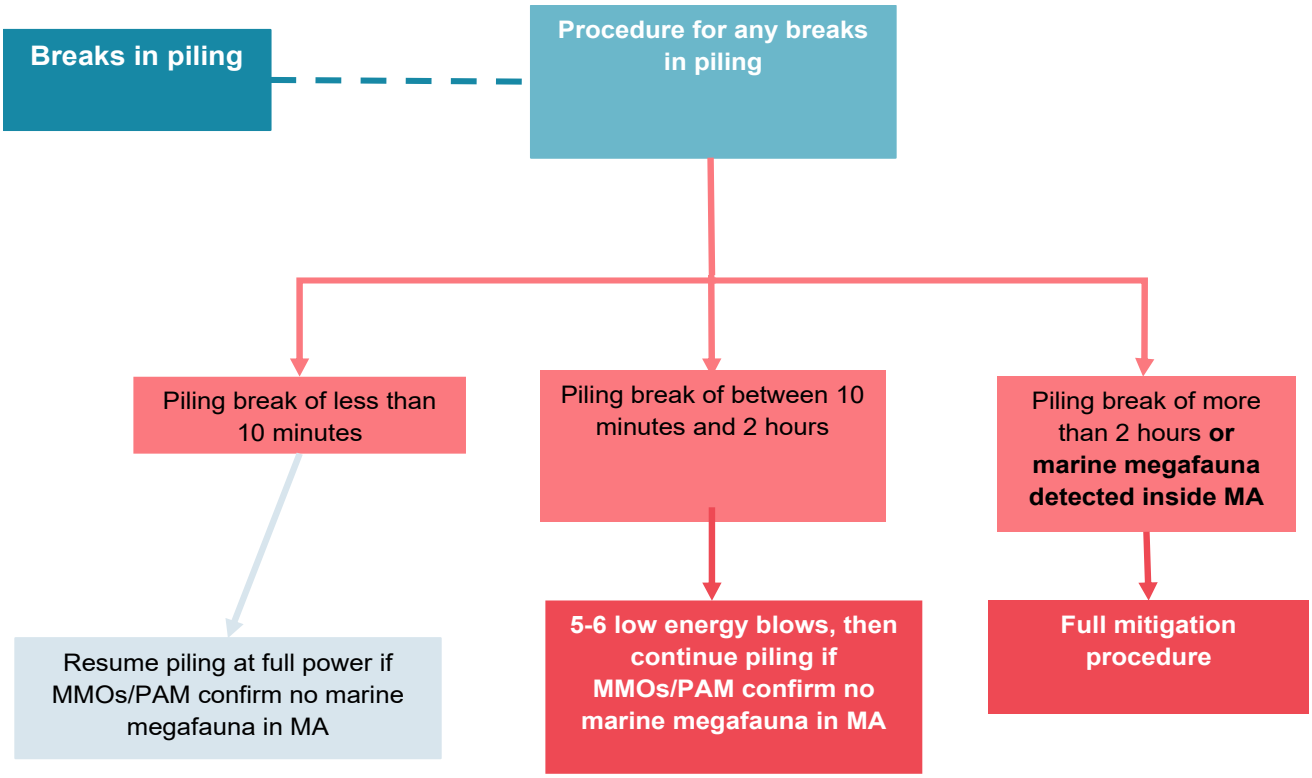


*Plate 4.4 Mitigation protocol for breaks in piling*

### 4.4.5 Piling at Night / Poor Visibility

142. If piling is to commence in poor visibility or at night, the monitoring of the MA would be undertaken by the PAM-Op as outlined in **Section 4.4.1.3**.

143. The deployment and activation of the ADD in poor visibility and at night would follow the same procedure as outlined in **Section 4.4.2**, as would the soft start and ramp-up procedure as outlined in **Section 4.4.3**.

144. If there are any breaks in piling during poor visibility or at night, monitoring of the MA would be done by PAM.

### 4.4.6 Mitigation Measures

Once the project design has been confirmed post consent; the final mitigation requirements would be confirmed in the final MMMP / Piling Noise Mitigation Strategy and through consultation with the relevant SNCBs. These measures may include but are not limited to:

- Primary (embedded) noise reduction methods;
- Secondary (additional) noise reduction systems; and
- Seasonal or spatial restrictions on piling.

#### *4.4.6.1 Noise Reduction Methods Embedded in Project Design*

- Primary noise reduction procedures include the consideration of different foundation types; alternative installation methods other than impact pile driving, which have been documented to reduce sound levels significantly. These methods include but are not limited to:
  - Drilling;
  - Suction bucket;
  - Vibro piling;
  - Blue hammers; and
  - High Frequency low impact piling.

#### *4.4.6.2 Additional Noise Reduction Systems*

145. Another consideration is the use of NAS, including but not limited to, the following types of bubble curtains, such as big bubble curtains, small bubble curtains, and layered (ring) bubble curtains:

- Big bubble curtains involve the layering of perforated flexible tubes onto the seabed around the piling activity prior to piling, via a compressor on board the vessel, a continuous flow of air is pumped in the tubes to then create a curtain of bubbles around the piling event;
- Small bubble curtains are very similar; however, the perforated pipes are hung vertically from a frame around the piling event, with a continuous flow of air being pumped into the pipes to create a curtain of bubbles around the piling event; and
- Layered or ring bubble curtains consist of multiple perforated rings of metal pipes which can be fixed to the foundation, and via the onboard compressor, provides a continuous flow of bubbles close to the piling event.

146. Alternative noise abatement systems to bubble curtains include hydro-sound dampers, which use gas filled containers such as balloons or pieces of foam fixed to a net or frame around the piling event acting as a static bubble curtain, restricting sound propagation.

#### *4.4.6.3 Seasonal or Spatial Restrictions on Piling*

147. Seasonal or spatial restrictions may be considered if the piling schedule could disturb marine megafauna during sensitive biological periods, for example during breeding or migration periods (e.g. seal pupping).

148. The need for any additional mitigation will be determined pre-construction when the final project design is available. Once determined, the mitigation (or combination of mitigation measures) required will be included in the final MMMP and agreed with MD-LOT, and the relevant SNCB. The final MMMP for piling / Piling Noise Mitigation Strategy will be based on the final project design and will consider new and emerging technologies, guidance and advice that may have emerged before construction, in addition to the measures described above.

### 4.4.7 Reporting

149. All reporting will be completed detailing the marine megafauna 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 piling activities, date, time and location, information on hammer energies, number of strikes, start times of piling, start and end of pre-piling search by MMOs and the PAM-Op, and details of activity during the relevant watches.

150. The JNCC Recording Forms 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 usage 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.

151. The PAM-Op will be responsible for reporting all details on the PAM equipment, (for example the sensitivity of the hydrophones) including the deployment set up and the configuration of the PAM software, methods for marine mammal detection and localising if feasible.

152. 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.

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

154. In the event of a marine megafauna sighting and/or detection, the MMOs/PAM-Op will report the following information:

- Species or species group;
- Number of individuals, age, sex and size (e.g., juvenile or adult) (MMOs only);
- Physical description of individual features if unable to identify to species level (MMOs only);
- Behaviour when first sighted (e.g., travelling, foraging, resting) (MMOs only);
- 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 (MMOs only).

155. A final report will be provided which will be submitted to MD-LOT, NatureScot and JNCC. The final report will include any data collected during piling operations, details of PAM equipment, deployment and software configuration; ADD deployment and activation, a detailed description of any technical problems encountered and what, if any, actions were taken. The report will also include MMO/PAM effort and a discussion of the protocols followed and any recommendations on the use of the mitigation measures during piling operations that could benefit future construction projects.

### 4.4.8 Communication and Responsibilities

156. Clear communication channels between the MMMT (MMOs, the PAM-Op the ADD operator) and the OCM are required. Communication procedures will be established and agreed prior to any piling event with regard to the communication of any detection within the MA, the deployment of ADD, and when the MA is clear for piling to start. The OCM will assign a person responsible for communication with the Lead Operator of the MMMT.

157. A communications protocol will be developed between the MMMT and the Nominated Contact.

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

- Notification required prior to piling 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 soft start 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 OCM that soft start can commence;
- Procedure to notify the Lead Operator that further ADD activation is required; and
- Procedure to notify the Lead Operator that the piling operations have been successfully completed.

## References

Bailey H, and Thompson P (2006). Quantitative 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. https://doi.org/10.3354/meps13690 [Accessed April 2026].

Brandt, M.J., Diederichs, A., Betke, K. and Nehls, G. (2011). Responses of harbour porpoises to pile driving at the Horns Rev II offshore wind farm in the Danish North Sea. Marine Ecology Progress Series, 421, pp.205-216.

Brandt, M.J., Höschle, C. Diederichs, A., Betke, K., Matuschek, R., Witte, S. and Nehls. G. (2012). Effectiveness of a seal scarer in deterring harbour porpoises (Phocoena phocoena) and its application as a mitigation measure during offshore pile driving. Bioconsult SH, Husum, Germany. 0-109

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

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

Department for Environment Food and Rural Affairs (Defra). (2025) Guidance Supporting minimising environmental impacts from unexploded ordnance clearance. Available online at: https://www.gov.uk/government/publications/supporting-minimising-environmental-impacts-from-unexploded-ordnance-clearance [Accessed April 2026].

Graham, I.M., Gillespie, D., Gkikopoulou, K.C., Hastie, G.D., Thompson, P.M. (2023). Directional hydrophone clusters reveal evasive responses of small cetaceans to disturbance during construction at offshore windfarms. *Biol. Lett*. 19: 20220101. https://doi.org/10.1098/rsbl.2022.0101 [Accessed April 2026]

Gordon, J., Blight, C., Bryant, E., and Thompson, D. (2015). Tests of Acoustic Signals for Aversive Sound Mitigation with Common Seals. Sea Mammal Research Unit report to Scottish Government

Harris, R. N., Harris, C. M., Duck, C. D., and Boyd, I. L. (2014). The effectiveness of a seal scarer at a wild salmon net fishery. ICES Journal of Marine Science: *Journal du Conseil*, fst216

JNCC (2010). Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise. August 2010. Available at: https://data.jncc.gov.uk/data/31662b6a-19ed-4918-9fab-8fbcff752046/JNCC-CNCB-Piling-protocol-August2010-Web.pdf [Accessed November 2024].

JNCC. (2017). JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys. Joint Nature Conservation Committee. Aberdeen, Scotland pp.28.

JNCC. (2023). JNCC guidance for the use of Passive Acoustic Monitoring in UK waters for minimising the risk of injury to marine mammals from offshore activities. JNCC, Peterborough.

JNCC, (2025) JNCC guidelines for minimising the risk of injury to marine mammals from using explosives. January 2025.

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.

Merchant, N., & Robinson, S. P. (2020). *Noise Abatement Workshop – Technical Feasibility of Applying Noise Abatement Measures to Offshore Windfarm Construction and UXO Detonation*. Centre for Environment, Fisheries and Aquaculture Science (Cefas) & National Physical Laboratory (NPL).

NatureScot. (2024). MS-LOT European Protected Species Case Handling Report.

National Physical Laboratory (NPL). (2020). Final Report: Characterisation of Acoustic Fields Generated by UXO Removal – Phase 2 (BEIS offshore energy SEA sub-contract OESEA-19-107). NPL Report AC 19 June 2020. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/893773/NPL_2020_-_Characterisation_of_Acoustic_Fields_Generated_by_UXO_Removal.pdf [Accessed April 2026]

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

Robinson, S. P., Wang, L., Cheong, S.-H., Lepper, P. A., Marubini, F., & Hartley, J. P. (2020). *Underwater acoustic characterisation of unexploded ordnance disposal using deflagration*. *Marine Pollution Bulletin*, 160, 111646.

Scottish Natural Heritage (SNH). (2016). Assessing collision risk between underwater turbines and marine wildlife. SNH guidance note.

Southall, B.L., Finneran, J.J., Reichmuth, C., Nachtigall, P.E., Ketten, D.R., Bowles, A.E., Ellison, W.T., Nowacek, D.P. and Tyack, P.L. (2019). Marine mammal noise exposure criteria: updated scientific recommendations for residual hearing effects. Aquatic Mammals, 45(2), pp.125-232.

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.

Stephenson, S.J., Lee, R., Birch, C., Cook, S.P. & Jervis, D. (2023). Balancing the use of Acoustic Deterrent Devices (ADDs), slow-start, and soft-start for offshore impulsive piling. In: The Effects of Noise on Aquatic Life, Springer.