Bowdun Offshore Wind Farm Offshore EIA Report

Volume 4, Appendix 27: Outline Marine Mammal Mitigation Protocol

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Glossary

Defined Term	Definition
Additional Mitigation	Also referred to as secondary mitigation which is defined by The Institute of Sustainability and Environmental Professionals (ISEP) (formerly Institute of Environmental Management and Assessment (IEMA)) as: Actions that will require further activity in order to achieve the anticipated outcome. These may be imposed as part of the planning consent, or through inclusion in the EIA Report (sic).
Array Area	The Array Area is the area in which the Offshore Generation Assets will be located.
Bowdun Offshore Wind Farm Limited (BOWFL)	A Special Purpose Vehicle (SPV) (legal entity) for the purpose of developing the Project. BOWFL are the Developer for the Proposed Development.
Cetacean	Marine mammals that are entirely aquatic. These include whales, dolphins, and porpoises.
Developer (the)	Bowdun Offshore Wind Farm Limited (BOWFL).
Effect	Term used to express the consequence of an impact (i.e. the result of change or changes) on specific environmental resources or receptors. The significance of an effect is determined by correlating the magnitude of the impact with the importance, or sensitivity of the receptor or resource in accordance with defined significance criteria.
Embedded Mitigation	Measures that are adopted as part of the Proposed Development and therefore assessed within the EIA. The proposed approach for the EIA for the Proposed Development is that Embedded Mitigation includes both primary mitigation and tertiary mitigation. These are defined by the ISEP as follows: Primary: Modifications to the location or design of the development made during the pre-application phase that are an inherent part of the project, and do not require additional action to be taken. Tertiary: Actions that would occur with or without input from the EIA feeding into the design process. These include actions that will be undertaken to meet other existing legislative requirements, or actions that are considered to be standard practices used to manage commonly occurring environmental effects.
Environmental Impact Assessment (EIA)	Process for the assessment of likely significant environmental effects of the Proposed Development on the physical, biological, and human environment during construction, Operations and Maintenance (O&M) and decommissioning.
Export Cable Corridor	The area seaward of Mean High Water Springs (MHWS) which connects the Array Area with the Landfall within which the Offshore Export Cables will be installed.
Impact	A change caused by an action that occurs during a project's lifetime.
Inter-Array Cables (IAC)	Cables which link the Wind Turbines to each other and with the Offshore Substation Platforms (OSPs).
Marine Directorate (MD)	The Marine Directorate of the Scottish Government, formerly known as Marine Scotland. The planning and licensing authority for Scotland's seas and custodian of Scotland's National Marine Plan (NMP). The Marine Directorate - Licensing Operations Team (MD-LOT) are specifically responsible for managing Section 36 Consent and Marine Licence Applications seaward of MHWS.

Defined Term	Definition
Marine Licence	A Marine Licence permits the undertaking of different activities in the marine environment, including construction, the deposition or removal of substances or objects, and dredging. The Marine (Scotland) Act 2010 requires Marine Licences to be obtained for licensable activities taking place within Scottish Territorial Waters (MHWS to 12 nm). The Marine and Coastal Access Act (MCAA) 2009 requires a Marine Licence to be obtained for licensable marine activities within the Scottish offshore region (12 nm – 200 nm).
Maximum Design Scenario (MDS)	The scenario within the design envelope likely to result in the greatest impact on a particular topic receptor, and therefore the one that should be assessed for that topic receptor.
Mitigation	Measures to avoid, prevent, reduce or control effects on the environment. See also definitions for Embedded Mitigation and Additional Mitigation.
Offshore Export Cables	Subsea cables used to transmit electricity generated offshore by the Wind Turbines from the OSPs to shore. The Transition Joint Bay is the location where the Offshore Export Cable terminates, and the onshore cabling begins.
Offshore Substation Platform(s) (OSPs)	OSPs comprise the support structure, topside and electrical components used for collecting and/or converting electricity generated by the Wind Turbines for transmission by the Offshore Export Cables.
Operation and Maintenance (O&M)	The phase of the Proposed Development following completion of construction. This phase of development includes routine inspections, repairs and replacement of infrastructure and equipment (including Interconnector Cables and IACs), Scour Protection replenishment or replacement, major component replacement, painting and/or other coating works, removal of marine growth, and replacement of access ladders.
Piling	The action of installing piles: installation can use various methodologies, the most common of which are impact piling (in which the piles are struck by a 'hammer') and drilling (during which a hole is drilled into the seafloor, the drilling tool is removed, and the pile is slotted into that hole).
Plan Option Area (POA)	A location identified in the Sectoral Marine Plan (SMP) as a preferred area for commercial scale offshore wind development.
Proposed Development	Term used to define the Offshore Infrastructure associated with the Project seaward of MHWS for which consent is being sought. Further details of the parameters are included in Volume 1, Chapter 3: Project Description.
Section 36 Consent	Scottish Ministers' consent under Section 36 of the Electricity Act 1989 required for the generating assets of the Proposed Development.
Thistle Wind Partners (TWP)	Company established for the development of the Project.
Wind Turbines	Structures comprising of a tubular tower, rotor blades, and a nacelle which houses the Wind Turbine generator.

Acronyms

Acronym	Definition
ADD	Acoustic Deterrent Device
AUD INJ	Auditory injury
BOWFL	Bowdun Offshore Wind Farm Limited
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
DEFRA	Department for Environment, Food and Rural Affairs
EIA	Environmental Impact Assessment
ECoW	Environmental Clerk of Work
EOD	Explosive Ordnance Disposal
EPS	European Protected Species
HF	High Frequency
IAC	Inter-Array Cable
JNCC	Joint Nature Conservation Committee
LF	Low Frequency
MBES	Multibeam Echosounder
MDS	Maximum Design Scenario
MD-LOT	Marine Directorate-Licensing Operations Team
MMO	Marine Mammal Observer
MMMP	Marine Mammal Mitigation Protocol
MZ	Mitigation Zone
NAS	Noise Abatement System
NEQ	Net Explosive Quantity
NMFS	National Marine Fisheries Service
OSP	Offshore Substation Platform
O&M	Operation and Maintenance
PAM	Passive Acoustic Monitoring
PCW	Phocid Carnivores in Water
POA	Plan Option Area
pUXO	Possible Unexploded Ordnance
SBP	Sub-bottom Profiler
SEL	Sound Exposure Level
SEL_{cum}	Cumulative Sound Exposure Level
SPL	Sound Pressure Level
SSS	Side Scan Sonar
TNT	Trinitrotoluene
UHRS	Ultra High-Resolution Seismic
UXO	Unexploded Ordnance
VHF	Very High Frequency

Table of Units

Units	Definition
dB re 1 µPa	Decibel re one micro Pascal
J	Joule
kg	Kilogram
kHz	Kilohertz
kJ	Kilojoule
km	Kilometre
km²	Square kilometre
m	Metre
m/s	Metre per second
°	Degree
%	Percentage

1 Introduction

1.1 Overview

1.1.1 This outline Marine Mammal Mitigation Protocol (MMMP) has been prepared by Bowdun Offshore Wind Farm Limited (BOWFL) (hereafter referred to as 'the Developer') to support the Offshore Environmental Impact Assessment (EIA) Report.

1.2 Purpose

1.2.1 The primary aim of a MMMP is to minimise the risk of auditory injury to marine mammals from noise generating activities resulting from the Proposed Development. The relevant noise generating activities are:

- impact piling;
- unexploded ordnance clearance; and
- geophysical site investigation surveys.

1.2.2 The mitigation detailed in this outline MMMP draws from the Joint Nature Conservation Committee (JNCC) guidelines (JNCC, 2010a; JNCC, 2010b; JNCC, 2017; JNCC, 2025) together with the Joint Position paper on Unexploded Ordnance (UXO) clearance (DEFRA, 2025).

1.2.3 Finalised MMMP(s) specific to each of the identified noise generating activities, will be refined and agreed in consultation with Marine Directorate – Licensing Operations Team (MD-LOT) and NatureScot post consent to reflect the refined project parameters specific to the activity (e.g. within the Piling Strategy for impact piling). Adherence to a finalised MMMP(s) will be a consent condition of the Section 36 Consent/Marine Licences.

1.2.4 The development of mitigation measures, including emerging and evolving technologies for marine mammal protection will be actively monitored. Where it is identified that such measures would be appropriate for implementation, the finalised MMMP will be updated accordingly.

1.3 Project Background

1.3.1 The Proposed Development (Figure 1.1) is located in the E3 Plan Option Area (POA) detailed in the Scottish Sectoral Marine Plan (Scottish Government, 2020). The Array Area is located 38 km from the Aberdeenshire coast at its closest point from land and covers an area of 187 km^2. The Export Cable Corridor extends from the Array Area and will make Landfall at Benholm, Aberdeenshire.

1.3.2 The Proposed Development will comprise Wind Turbines and all infrastructure required to transmit the generated power to the shore. The key Offshore Infrastructure of the Proposed Development include:

- up to 67 Wind Turbines, on fixed foundations, located within the Array Area;
- a network of up to 167 km of static Inter-Array Cables (IACs); and
- up to three Offshore Substation Platforms (OSPs) located within the Array Area.

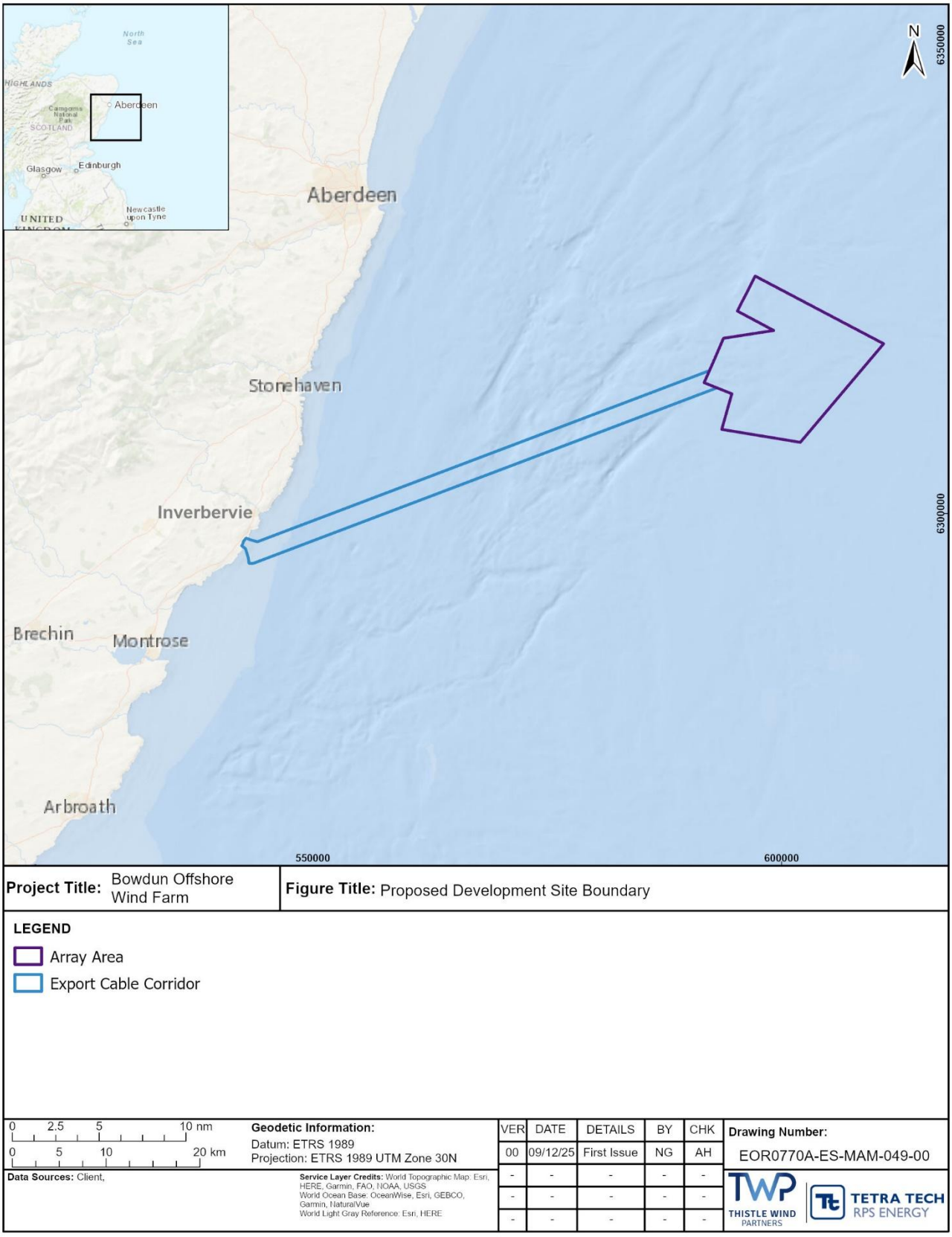

Figure 1.1: Proposed Development Site Boundary

1.3.3 This outline MMMP presents a summary of findings relevant for mitigation as assessed in the Proposed Development's EIA Report. UXO clearance and piling have the potential for impact during the construction phase, whereas site surveys have the potential for impact during both the construction and the Operation and Maintenance (O&M) phases.

1.3.4 This outline MMMP is informed by the following sections of the Offshore EIA Report:

- Volume 2, Chapter 10: Marine Mammals;
- Volume 3, Technical Appendix 10.1: Marine Mammal Technical Report; and
- Volume 3, Technical Appendix 10.4: Subsea Noise Technical Report.

2 Impact Piling

2.1 Scenarios Considered

2.1.1 A range of piling scenarios were modelled for the EIA (see Volume 3, Technical Appendix 10.4: Subsea Noise Technical Report for full details). The scenarios were based on the Maximum Design Scenarios (MDS) (Volume 2, Chapter 10: Marine Mammals) for fixed offshore Wind Turbine foundations (including the OSPs). Impact ranges were modelled from piling locations in the north and south within the Array Area. The greatest injury ranges were predicted from the single monopile foundation MDS scenario modelled at the north location. The piling schedule used for the monopile foundation is presented in Table 2.1.

Table 2.1: Impact Piling Schedule Used in the Assessment – Monopile Wind Turbine Foundations

Activity/Stage	Duration, Minutes	Hammer Energy (kJ)	Strike rate (Strikes per Minute)	Number of Strikes
Initiation	1	200	5	5
Soft start	20	937.5	30	600
Ramp up	30	937.5 to 6,000	40	1,200
Full power piling	465	6,250	50	23,250
Total piling duration, mins	516			
Total piling duration, hours	8.6			
Total no. of strikes	25,055			

2.2 Summary of Impacts

2.2.1 The impact ranges presented in Volume 2, Chapter 10: Marine Mammals (reproduced in Table 2.2) were based on the National Marine Fisheries Service (NMFS) threshold guidance for auditory injury (NMFS, 2024).

2.2.2 Whilst the assessment of injury in the Offshore EIA Report is based upon the dual metric approach (Peak Sound Pressure Level (SPL) and Cumulative Sound Exposure Level (SEL_{cum})), the pre-piling mitigation is based on the instantaneous auditory injury risk. Therefore, for piling, the auditory injury ranges based on peak SPL have been used to inform the Mitigation Zone (MZ) in this outline MMMP.

2.2.3 The maximum predicted instantaneous auditory injury range (based on the peak SPL metric) was 2,016 m, for the Very High Frequency (VHF) functional hearing group (i.e. harbour porpoise *Phocoena phocoena*). All other species group predictions were below 500 m. The maximum auditory injury range predicted for the first strike was 410 m.

Table 2.2: Potential Marine Mammal Injury Ranges for Pile Installation of Monopile Foundations, based on the NMFS (2024) peak SPL Metric

Species/Group	Example Species	AUD INJ Threshold, peak SPL (dB re 1 µPa)	Range (m)	
			First Strike	Highest Energy
Low Frequency cetaceans (LF)	Minke whale *Balaenoptera acutorostrata*	222	92	454
High Frequency cetaceans (HF)	Bottlenose dolphin *Tursiops truncatus*	230	51	250
Very High Frequency cetaceans (VHF)	Harbour porpoise	202	410	2,016
Phocid Carnivores in Water (PCW)	Grey and Harbour seals *Halichoerus grypus* and *Phoca vitulina*	223	85	422

2.3 Mitigation Methods

2.3.1 Standard mitigation protocols will be used to reduce the risk of auditory injury from impact piling to negligible levels (JNCC, 2010a). Should more than one piling vessel be on site at the same time, the mitigation methods detailed will apply per vessel.

Marine Mammal Observer (MMO)

2.3.2 The MMO(s) will visually monitor the agreed MZ before piling can commence. The MZ is defined in JNCC (2010a) as the area over which an MMO keeps watch for marine mammals. Standard guidance is for the watch period to be no less than 30 minutes pre-piling, with a standard MZ of no less than 500 m. The MMO(s) will visually confirm that the area is clear so that piling can commence. Depending on the Piling Protocol and vessels used, multiple MMOs may be required to ensure that the monitoring is not compromised in terms of 360°-visibility, and/or observer fatigue.

2.3.3 The maximum instantaneous auditory injury onset range predicted is 2,016 m based on the MDS assessed in the Offshore EIA Report. This is beyond the standard MZ of 500 m for piling. The auditory injury range for all other species is within the standard MZ. The finalised MZ will be confirmed once the Piling Strategy has been developed (post consent) and the piling parameters defined.

2.3.4 If marine mammals are detected within the MZ during the pre-piling search, piling will not commence until at least 20 minutes after the last visual detection of the animal. The MMO will track any marine mammals detected and ensure that they have left the MZ before piling commences.

Passive Acoustic Monitoring (PAM)

2.3.5 A PAM system is used by a specialised trained PAM operative to acoustically detect marine mammal presence. This method should be used in conjunction with visual observations, and/or as an alternative during periods of reduced visibility (dusk, night, inclement weather (e.g. above sea state 4) (JNCC, 2010a)). PAM is used to monitor for 30 minutes prior to piling commencing. It is worth

noting the limitations of PAM in relation to detection distances for different species. For harbour porpoise this is typically around 300 m. Therefore, it is important that a suite of complimentary mitigation methods is used (i.e. MMO/PAM/Acoustic Deterrent Devices (ADD)).

2.3.6 If marine mammals are acoustically detected within the MZ during the pre-piling search, piling will not commence until at least 20 minutes after the last detection of the animal.

ADDs

2.3.7 As no one single mitigation method is 100% effective, and because the predicted auditory injury range is 2,016 m, ADD mitigation will be used to supplement MMO/PAM to cover the larger MZ than standard. ADD pre-piling mitigation has successfully been employed at other offshore wind developments (e.g. Beatrice Piling Strategy, 2017; Moray East Piling Strategy, 2019; Seagreen Piling Strategy, 2020; Neart na Gaoithe Piling Strategy, 2020; Moray West Offshore Transmission Infrastructure Piling Strategy, 2022). MMO and PAM mitigation methods are passive, (i.e. the occurrence of marine mammals in the MZ is monitored and if animals are observed, piling is not commenced until the area is clear). ADD pre-piling mitigation is active, such that the sound emitted results in displacement of marine mammals from the MZ in advance of the activity (Annex A).

2.3.8 The duration of ADD activation and the ADD brand will be agreed with MD-LOT and NatureScot for the finalised MMMP for impact piling. Experience gained in the Moray Firth, Scotland (Thompson *et al.,* 2020) was that harbour porpoises exhibited strong responses to the ADD activation (Lofitech). The ADD was active for 15 minutes, and the harbour porpoise response to the ADD was of a similar extent to reported responses to pile driving noise. The authors' conclusion was that the duration of ADD mitigation must be sufficient to allow animals to move away from the nearfield but be minimised to avoid unnecessary disturbance.

Soft Start Procedure

2.3.9 The soft start/ramp up procedure starts following MMO/PAM/ADD mitigation and is the incremental increase in hammer energy over a set period. Soft start/ramp up is an Embedded Mitigation and required by engineers to initially set the pile into the sediment (Thompson *et al.,* 2020). However, the use of lower hammer energies at the beginning of the installation sequence allows marine mammals more time to move away before maximum hammer energies are reached. The noise generated by the soft start/ramp up process is therefore considered to act as a deterrent effect, effectively reducing the modelled maximum MZ (as assessed at highest hammer energy).

2.3.10 If a marine mammal enters the MZ during the soft start then, where possible, the piling operation should either pause, or not increase hammer energy, until the marine mammal leaves the MZ, and there is no further detection for 20 minutes. The feasibility of this approach will be agreed for the finalised MMMP.

3 UXO Clearance

3.1 Overview

3.1.1 The Developer has committed to the use of low order disposal of UXOs (e.g. deflagration) as default in line with the recent Joint Position paper on UXO clearance (DEFRA, 2025). However, the current guidance is to retain consideration of high order clearance as the MDS. This outline MMMP details the mitigation required for a low order detonation and discusses mitigation in the event that a high order detonation is unavoidable.

3.1.2 The finalised MMMP required for the Marine Licence and the European Protected Species (EPS) Licence will be tailored to the identified possible UXOs (pUXO) in terms of charge size and clearance methodology. The finalised MMMP will include detail of the UXOs identified in terms of type and location, and depth. Details of the mitigation tool chosen for clearance will be provided, together with supporting evidence as to the chosen clearance tool's efficacy.

3.1.3 The Developer commits to discussion with MD-LOT and NatureScot at the earliest opportunity if, following the UXO surveys, it transpires that a high order detonation is unavoidable. The requirement for a high order detonation may be due to factors relating to the UXO target in terms of the UXO or its location that far exceed the expected or demonstrated capabilities of the low order clearance tools available.

3.2 Scenarios Considered

3.2.1 The precise details of any UXO types and sizes that may require clearance is unknown at the time of writing. Therefore, subsea noise modelling was undertaken for a range of charge configurations as set out in Table 3.1. It is anticipated that up to 40 pUXOs may require clearance within the site boundary.

Table 3.1: Details of UXO and their Relevant Charge Sizes Employed for Modelling

Charge Size (kg Net Explosive Quantity (NEQ))	Notes/Assumptions
Low Order and Low-Yield Donor Charge Configurations	
0.08 kg	Maximum size of donor charge used for low order technique.
0.5 kg	Maximum size of clearing shot to neutralise any residual explosive material.
Potential UXOs (High Order Disposal)	
227 kg	Realistic maximum design UXO charge weight, based on British WW2 mine Mk XIV.
720 kg	Maximum estimated UXO size that is anticipated to be encountered, based on a 1,000 kg German WW2 mine BM1000.

3.3 Summary of Impacts

3.3.1 The assessment of auditory injury has used the impulsive threshold criteria from NMFS (2024). Auditory injury ranges for high order and low order scenarios are presented in Table 3.2 below.

Table 3.2: Maximum Potential Auditory Injury (AUD INJ) Ranges for Low Order Clearance and High Order Clearance (NMFS, 2024)

Species/Group	Metric	Threshold	Range (m)			
			Low Order Donor Charge (0.08 kg)	Low Order Clearing Shot (0.5 kg)	High Order Realistic (227 kg)	High Order (720 kg)
LF cetaceans	Peak SPL	222 dB re 1µPa	90	165	1,265	1,855
	SEL_{cum}	183 dB re 1µPa^{2}s	51	125	2,415	4,120
HF cetaceans	Peak SPL	230 dB re 1µPa	40	73	560	825
	SEL_{cum}	193 dB re 1µPa^{2}s	N/E	N/E	79	138
VHF cetaceans	Peak SPL	202 dB re 1µPa	685	1,265	9,685	14,230
	SEL_{cum}	159 dB re 1µPa^{2}s	175	395	2,935	3,780
PCW	Peak SPL	223 dB re 1µPa	81	149	1,140	1,675
	SEL_{cum}	183 dB re 1µPa^{2}s	16	39	740	1,245

3.4 Mitigation Methods

3.4.1 Standard JNCC mitigation guidance is available for UXO mitigation (JNCC, 2010b) this follows a similar process to the guidance for piling (MMO/PAM/ADD) but will be tailored for the injury risk from explosives.

MMO

3.4.2 JNCC (2010b, 2025) guidance sets out the minimum requirement of a 1 km MZ for explosives mitigation. At least two dedicated MMOs should work together to monitor the search area. However, it is possible that three MMOs will be required to fully observe the 1 km MZ. The number of personnel required will depend on the vessel types used for the clearance activity. Often one MMO is situated on the relatively small boat tasked to deploy the donor charges, located close to the UXO location pre-detonation. The elevation from this platform is unlikely to enable 1 km visibility. The second MMO is usually positioned on a guard vessel, standing off at a distance of ~1 km. Observations from one point on the MZ boundary, means there is an effective 2 km range to monitor. Depending on the elevation of the survey platform this may not be possible. Therefore, a third MMO may be required to observe on the boundary opposite the guard vessel to provide full coverage. The specific requirement will be discussed and agreed for the finalised MMMP.

PAM

3.4.3 All UXO clearance should take place during daylight hours and in good weather conditions. However, there may be occasion (e.g. for health and safety reasons) where clearance needs to occur at night/poor visibility. In these instances, PAM would be used in combination with visual observations. Whilst there are limitations in detectability of certain species using PAM (e.g. harbour porpoise; Paragraph 2.3.7), it is recommended as supplementary mitigation. PAM may also be considered as supplementary during daylight hours, where cryptic species may be present (JNCC, 2025). This will be agreed for the finalised MMMP.

ADD

3.4.4 Whilst it is possible to visually monitor the potential impact ranges for the low order scenario, mitigation supplemented by an ADD is considered best practice. The maximum design auditory injury ranges in the low order scenario were 1,265 m for harbour porpoise (VHF) to less than 200 m for all other species. It is likely that the use of an ADD will deter marine mammals beyond 1,265 m (Annex A).

3.4.5 In the high order scenario, the maximum design injury range was 14,230 m for harbour porpoise (VHF), 4,120 m for minke whale (LF), 1,675 m for seals (PCW) and less than 1,000 m for bottlenose dolphin (HF).

3.4.6 Although a deterrence effect has been shown for harbour porpoise up to 7,500 m (Brandt *et al.,* 2013a) it did not result in complete exclusion. Thompson *et al.* (2020) found a deterrence effect out to 21,700 m, but again not complete exclusion. It is therefore likely that the use of an ADD will significantly reduce the probability of harbour porpoise remaining in the injury zone, but complete exclusion out to 14,230 m cannot be guaranteed.

3.4.7 Whilst ADDs have been shown to have a deterrence effect for minke whales (McGarry *et al.,* 2017) as all individuals were observed to flee ADD noise in this study. However, observations were only made out to 1 km distance, so the full extent of fleeing is currently unknown.

3.4.8 The maximum design high order auditory injury range predicted for seals was 1,675 m. ADDs have only been shown to result in a behavioural response within 1,000 m (Gordon *et al.,* 2019). Therefore for seals, ADD use may not add additional protection beyond 1,000 m. However, in this study, a 'response' was not always a directed movement away from the sound source they found it depended on their activity and direction of travel at the time of the ADD activation. The minimum approach distance to the ADD was 473 m.

3.4.9 Combined MMO/PAM/ADD mitigation will fully mitigate the risk of auditory injury for marine mammals where low order clearance methods are employed, regardless of the charge weight of any identified UXOs.

3.4.10 It is likely that the combined MMO/PAM/ADD mitigation will not fully mitigate the risk of auditory injury for VHF (harbour porpoise), LF (minke whale), and seals where high order clearance methods are employed. It is likely that ADD mitigation will reduce the auditory injury risk for all other species hearing groups to negligible.

3.4.11 Any residual risk will be assessed, and mitigation agreed during the Marine Licence and EPS Licence process once the number and size of UXOs is better understood, together with confirmation of the clearance methodology that will be used. Where ADDs are used, conservative swimming speeds will be assumed for relevant species to determine an appropriate duration of ADD activation to deter animals out of the MZ whilst not causing more disturbance than necessary to mitigate auditory injury.

Noise Abatement System (NAS)

3.4.12 Noise abatement works by impeding sound propagation from the source. Whilst there are several NAS that are commercially available, evidence of efficacy for use with UXO clearance is lacking. At the time of writing, the only feasible NAS that can be deployed for UXO clearance are bubble curtains (JNCC, 2025). However, bubble curtains are highly constrained by the local oceanographic conditions. The bathymetry for the Proposed Development ranges from 0 m to -113 m within the Export Cable Corridor, and in the Array Area ranges from -54 m to -91 m. To date bubble curtains have only been effective in water depths of -40 m to -45 m.

3.4.13 Furthermore, bubble curtains are less effective in tidal currents greater than 0.75 m/s (Centre for Environment, Fisheries and Aquaculture Science (CEFAS), undated; Verfuss *et al.,* 2019). Tidal conditions within the Array Area are generally of moderate strength (less than ~0.7 m/s), therefore depth considerations are likely to be more important in the Array Area. However, some of the strongest currents are found just north of the Landfall, with peak current speeds reaching ~0.8 m/s (Volume 3, Technical Appendix 7.1: Physical Processes Baseline Environment).

3.4.14 In the event that a high order detonation is unavoidable, a risk assessment will be produced to accompany the Marine Licence and EPS licence for UXO clearance. This will consider the locations of the pUXO in order to determine any Additional Mitigation requirements and feasibility.

4 Site Investigation Surveys (Geophysical)

4.1 Scenarios Considered

4.1.1 A detailed underwater noise modelling assessment was carried out to investigate the potential for the risk of auditory injury resulting from geophysical and geotechnical surveys (see Volume 3, Technical Appendix 10.4: Subsea Noise Technical Report).

4.1.2 Several sonar-like sources will potentially be used for the geophysical surveys, including Multibeam Echo Sounder (MBES), Side Scan Sonar (SSS), Sub-Bottom Profiler (SBP) and Ultra High-Resolution Seismic (UHRS). The equipment likely to be used, can work at a range of signal frequencies depending on the distance to the seabed and the required resolution. For sonar-like sources the signal is highly directional and is emitted in pulses. Sonar-based sources are considered by the NMFS (2018) as continuous (non-impulsive) because they generally comprise a single (or multiple discrete) frequency. Unlike the sonar-like survey sources, the UHRS is likely to utilise a sparker, which produces an impulsive, broadband source signal. The survey parameters, such as source sound levels used in the underwater noise modelling are presented in detail in Volume 3, Technical Appendix 10.4: Subsea Noise Technical Report.

4.2 Summary of Impacts

4.2.1 Table 4.1 details the potential auditory injury range across all geophysical surveys. The maximum predicted was 251 m for the VHF species group (harbour porpoise). The maximum auditory injury range for all other species was predicted up to 86 m. However, sonar-like sources have very strong directivity (Volume 3, Technical Appendix 10.4: Subsea Noise Technical Report), therefore there is only a realistic potential for injury should a marine mammal be directly underneath the noise source. Once the animal moves outside of the main beam, there is no potential for injury.

4.2.2 The auditory injury threshold was not exceeded for all marine mammal species for geotechnical investigation activities (Volume 2, Chapter 10: Marine Mammals).

Table 4.1: Potential Injury (AUD INJ) Impact Ranges (m) for Geophysical Site Investigation Surveys (N/E = Threshold Not Exceeded)

Species/ Group	Survey Type/Potential Auditory Injury Range (m)				
	MBES	SSS (LF)	SSS (HF)	SBP (chirp/pinger)	UHRS (sparker)
LF	N/E	N/E	N/E	25	N/E
HF	8	60	N/E	86	N/E
VHF	165	251	45	170	17
PCW	N/E	5	N/E	86	N/E

4.3 Mitigation Methods

4.3.1 Mitigation for geophysical activities typically relies on MMO/PAM mitigation to ensure the auditory injury onset range is monitored before the geophysical equipment is activated (following JNCC 2017 guidance). Depending on the level of risk it is common practice for this role to be undertaken by a suitably trained crew member (dedicated to the task during the watch period).

4.3.2 Based on the maximum predicted injury range the MZ will be the minimum recommend by JNCC (i.e. 500 m). The watch period will be 30 minutes prior to the equipment activation.

4.3.3 If geophysical survey activities are conducted during periods of low visibility or darkness, where visual monitoring is not possible, the trained/qualified PAM operator will monitor the MZ for a pre-shooting search of at least 30 minutes.

4.3.4 If marine mammals are detected in the MZ during the 30 minute pre-shooting search, the geophysical activities must be delayed until the passage of the marine mammal(s), or transit of the vessel, results in the animals being outside of the MZ. There will be a minimum 20 minute delay from the time of last detection and the commencement of the soft start to allow marine mammals to move out of the MZ.

5 Roles and Responsibilities

5.1 Overview

5.1.1 As per the JNCC Guidance (2010a; 2010b; 2017), persons involved in implementing and ensuring compliance with the finalised MMMP include:

- the Developer's Environmental Manager;
- independent Environmental Clerk of Work (ECoW);
- MMO;
- PAM Operator;
- ADD Operator; and
- Explosive Ordnance Disposal (EOD) Supervisor.

5.1.2 All persons will be equipped with the appropriate means of communication between each other in order to ensure that the correct mitigation protocols are undertaken and to allow timely communication if a marine mammal is detected.

5.2 The Developer's Environmental Manager

5.2.1 The Developer's Environmental Manager is responsible for ensuring all compliance documents, such as the MMMP are included in the construction contract documents. They will report marine mammal monitoring and activities related to piling, UXO clearance, and geophysical surveying.

5.3 Independent ECoW

5.3.1 The independent ECoW will be responsible for completing inductions and toolbox talks to onsite construction teams (including piling and UXO detonation) on the requirements of the MMMP and monitoring that all piling and UXO detonation activities are being completed in accordance with the MMMP, other related consent management plans and all relevant regulations and legislation. The independent ECoW is also responsible for stopping operations (e.g. piling) in the event of a non-compliance with the MMMP and/or consent conditions and reporting all non-compliances to MD-LOT.

5.4 MMOs

5.4.1 The lead MMO will report to the ECoW. All MMOs will be appropriately trained to the requirements set out in the relevant JNCC Guidance (JNCC, 2017):

- They will have completed the JNCC registered marine mammal observer course and have sufficient field experience (at least one year of marine mammal observers experience on offshore projects).
- The lead MMO will be experienced (trained observer with three years of field experience observing for marine mammals, and practical experience of implementing the JNCC guidelines).

5.4.2 MMO(s) will be positioned on a suitable platform on a vessel that allows full 360° coverage of the MZ and an observer eye height of at least 5 m. They will

be equipped with appropriate[1] visual aids (such as reticule binoculars) and will be capable of determining the extent of the various MZs depending on the survey. They will be responsible for recording any marine mammal observations using Marine Mammal Recording Forms provided by JNCC[2].

5.5 PAM Operator

5.5.1 There will be one specialist, trained, and dedicated PAM Operator who will be responsible for acoustically tracking vocalising marine mammals using a hydrophone, via appropriate computer software (e.g. PAMGuard). They will report to the ECoW and will also be responsible for deploying and maintaining the hydrophone and any spares. They will be appropriately trained and have sufficient field experience (at least one year of PAM experience on offshore projects).

5.6 ADD Operator

5.6.1 There will be one ADD Operator responsible for deploying, maintaining, and operating the ADDs and any spares, with the requirements outlined in this outline MMMP. They will report to the ECoW and will be required to communicate clearly with MMO, PAM Operator and, in the case of UXO disposal, the EOD Supervisor, to confirm commencement and cessation of ADD usage. They will also be required to communicate with the PAM Operator to check that ADDs are functioning correctly.

5.7 EOD Supervisor

5.7.1 An EOD Supervisor will be required during UXO clearance activities to ensure that the requirements of the outline MMMP are met. They will report to the ECoW and will be responsible for decisions involving initiating, delaying or pausing detonation and ensuring that no UXO detonation occurs without their explicit consent. They must ensure clear lines of communication between the ECoW, MMO, PAM Operator, ADD Operator and EOD contractors.

[1] Night vision binoculars will be adopted if considered effective for location and likely species
[2] Reporting forms accessible from the JNCC website https://jncc.gov.uk/our-work/marine-mammals-and-noise-mitigation/.

6 Reporting

6.1 Overview

6.1.1 The ECoW will collate a detailed record of operations, mitigation procedures and any marine mammal sightings. These records will be prepared and submitted in compliance with consent and/or licence conditions to MD-LOT and will include completing and submitting Marine Mammal Recording Forms provided by the JNCC.

6.1.2 All reporting will include the following;

- presence, location, and activity of vessels during mitigation activities;
- the mitigation procedures followed, including details of marine mammal observer activities, PAM operation, and ADD duration;
- details of PAM equipment and ADDs used and any relevant observations on their efficacy;
- all marine mammal sightings;
- detailed descriptions of any technical problems encountered and what, if any, actions were taken;
- any instances of non-compliances with the MMMP, and variations from agreed procedures; and
- put forward any recommendations based on the project and any marine mammal sightings/behaviour encountered during the mitigation operations which could benefit future projects.

6.2 Impact Piling

6.2.1 In addition, impact piling reporting will include the following:

- date and location of piling operations;
- a record of all piling activity, including details of the duration of the pre-piling search and soft start/ramp up procedures; and
- any occasions when piling activity was stopped or delayed due to the presence of marine mammals.

6.3 UXO Clearance

6.3.1 In addition, UXO reporting will include the following:

- operator details (including licence reference number issued by the regulator);
- type of explosive used, including charge weight and trinitrotoluene (TNT) equivalent;
- location(s) of clearance event; and
- summary of MMO/PAM monitoring, including the number of personnel, and their experience, where each MMO/PAM personnel were located (including

if location had to move away for safety reasons), confirmation of MMO elevation and the 360° field of view.

6.4 Site Investigation Surveys (Geophysical)

6.4.1 In addition, geophysical reporting will include the following:

- approach taken for each geophysical survey, including dates, times, survey type, equipment used, and coordinates and transects of surveys.

7 Summary of Mitigation Measures

Table 7.1: Summary of Mitigation Measures Based on Maximum Design Impacts for Impact Piling, UXO Clearance and Geophysical Surveys

Activity	Maximum Impact Range	Mitigation Options/Comments
Impact piling	2.02 km	• Soft start/ramp up procedure; • MMO/PAM/ADD standard mitigation protocols; and • Specific details agreed for the finalised MMMP post consent.
UXO Clearance (Low Order)	1.27 km	• MMO/PAM/ADD standard mitigation protocols; and • Specific details agreed for the finalised MMMP post consent.
UXO Clearance (High Order – if unavoidable)	14.23 km	• MMO/PAM/ADD standard mitigation protocols; • Residual injury risk for VHF and LF cetaceans, with a smaller residual risk for seals (PCW); • The residual risk to be assessed and mitigation agreed for the finalised MMMP post consent once the need for high order clearance is established; • Additional mitigation (such as NAS (e.g. bubble curtains) considered) highly dependent on location of UXO; and • An EPS Licence for injury may be required.
Site investigation surveys (geophysical)	0.25 km	• MMO standard mitigation protocols.

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ANNEX A. EFFICACY OF AN ACOUSTIC DETERRENT SYSTEM

A1. Introduction

A1.1.1 ADDs have been used as standard for all piling activity in Europe (Herschel *et al.,* 2013). In the UK ADDs have not to date been considered as a standard requirement, however; in Scotland ADDs have been used as sole mitigation in the Moray Firth (see Beatrice offshore wind farm and Moray East piling strategies).

A1.1.2 The recommendation remains that ADDs are used in combination with MMO/PAM (JNCC, 2010).

A1.1.3 Evidence of efficacy exists in relation to pre-piling/UXO clearance mitigation for (VHF) harbour porpoise, harbour seals and (LF) minke whale, but is lacking for grey seals and (HF) delphinid species.

A2. Harbour porpoise

A1.1.4 Brandt *et al*., (2013a) investigated the effects of a seal scarer (Lofitech) on harbour porpoise and found that there was a significant deterrence effect up to 7.5 km. Although porpoise detections were significantly reduced, this study did not show complete exclusion up to 7.5 km. However, within 750 m of the ADD, detections decreased between 52% and 95%. In a further study (Brandt *et al.,* 2013b), they observed harbour porpoise total avoidance of the seal scarer (Lofitech) within 1.9 km, and 50% avoidance up to 2.4 km. There was no avoidance evident beyond 2.6 km. The differences in avoidance between these two studies may be due to differences in the environmental characteristics (e.g. seabed composition, depth of water column). The conclusion by the authors was that ADDs would deter animals out of potential danger zones.

A1.1.5 Voβ *et al.,* (2023) investigated the efficacy of an acoustic porpoise deterrent (e.g. FaunaGuard Porpoise module) and found that porpoise detection rates decreased by 30% to 100% at 750 m, and by 25% to 60% at 1,500 m. They highlight that although this was a small sample size (as detection rates were low before the deterrent was activated), detection rates were reduced up to distances of 2.5 km. They conclude that the acoustic porpoise deterrent was at least as effective as a seal scarer (e.g. Lofitech) but without the large-scale disturbance effect.

A1.1.6 Thompson *et al.,* (2020) monitored harbour porpoise during the construction of offshore wind farms in the Moray Firth, Scotland. Within the marine mammal monitoring programme, the authors conducted an experimental playback, using a Lofitech device. The ADD was active for 15 minutes, and the CPOD (a PAM device) detections evidenced avoidance responses. They found that there was ≥ 50 % chance of a response in the three hours following playback up to 21.7 km. This range reduced over six hours and twelve hours indicating porpoise return to the area). The minimum return time after exposure was 133 minutes (~ 2 hours). The authors concluded that the observed changes in detections confirmed that harbour porpoise exhibited a strong behavioural response to

ADD playbacks, and that the use of an ADD with the acoustic characteristics of the Lofitech (frequency content and sound level; ~ 14kHz and ~ 198 dB re 1 µPa (rms) was potentially more effective than was needed for near field deterrence.

A3. Minke whale

A1.1.7 In 2017 ORJIP commissioned a study to investigate the responses of minke to an ADD (McGarry *et al.,* 2017). The Lofitech ADD was used as the potential mitigation ADD. Visual tracking of minke whales was undertaken in Faxaflói Bay, Iceland in August to September 2016. A total of 46 minke whales were tracked and in all cases the animal moved away when the Lofitech ADD was active, increasing their swim speed to an average of 15 kmh^{-1} (~4.2 ms^{-1}). These results suggest that the Lofitech ADD is effective in evoking a deterrence response in minke whales. The study showed a flight response to the ADD at distances of 500 m and 1 km; the study did not track the distance where the animal resumed normal activity. The study offered a recommendation that the duration of ADD activation should be twice the length of the injury zone.

A4. Harbour seal

A1.1.8 Gordon *et al.,* (2019) tested the Lofitech ADD on tagged harbour seals in Scotland (Kyle Rhea and Moray Firth) at ranges of ~500 m to 1,500 m. They found that animals typically responded to the Lofitech ADD out to a distance of 1,000 m. The percentage response decreased with increasing distance from the ADD source with 100% response out to 1,000 m and thereafter a steady decline was seen with the most distant group recorded at 4.1 km showing a 20% response (Gordon *et al.,* 2019). In this study, a "*response*" was not always a directed movement away from the sound source they found it depended on their activity and direction of travel at the time of the ADD activation. The minimum approach distance to the ADD was 473 m.