WEST OF ORKNEY WINDFARM

Offshore EIA Report, Volume 3, Outline Plan 2: Marine Mammal Mitigation Protocol

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West of Orkney Windfarm

Values Teamwork Empowerment Commitment

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OWPL Revision History

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Revision Record

Revision Number	Revised Section	Description of Changes
2	Throughout	Edits in response to OWPL and SMRUC comments. Redraft of Section 7.6.3 Noise abatement systems.
3	Throughout	Final edits.
4	Throughout	Final edits.

Contents

Summary

HiDef Surveying Ltd ("HiDef") were commissioned to prepare an outline protocol for Marine Mammal Mitigation Protocol (MMMP) required to minimise the risk of injury to marine mammals from pre-construction and construction underwater noise related impacts at the proposed West of Orkney Windfarm (the 'Project').

The underwater noise impact assessment (Offshore EIA Report, Supporting Study (SS) 10: Marine mammal underwater noise impact assessment) has highlighted the risk of auditory impairment (injury) from proposed piling activity and potential Unexploded Ordnance (UXO) clearance activities. The impact assessment found that proposed geophysical surveys presented a negligible risk; however potential mitigation is presented in the event the equipment used differs from that assessed.

The primary aim of an MMMP is to reduce the risk of Permanent Threshold Shift (PTS) onset. Mitigation proposed draws from the Joint Nature Conservation Committee (JNCC) guidelines (JNCC, 2010a; 2010b; 2017), together with consultation responses from NatureScot (Marine Mammal Consultee meeting on 22nd March 2023; SS10: Marine mammal underwater noise impact assessment). This outline MMMP presents indicative mitigation that can be used to secure embedded mitigation measures (HiDef, 2023). Protocols will be refined and agreed in consultation with Marine Directorate – Licensing Operations Team (MD-LOT) and NatureScot post-consent to reflect refined Project parameters. Adherence to a finalised MMMP will be a consent condition of the Section 36 Consent/ Marine Licences.

1 Introduction

1.1 Purpose

The Outline Marine Mammal Mitigation Protocol (MMMP) has been prepared by HiDef Surveying Ltd (HiDef) on behalf of Offshore Wind Power Limited (OWPL), to support the Offshore Environmental Impact Assessment (EIA) Report for the West of Orkney Wind Farm hereafter referred to as 'the offshore Project'. As this is an outline document, further information will be provided post-consent.

The information provided in this document is based on the current understanding of the baseline environment and how the offshore Project will be constructed and operated using the best available technologies, in compliance with current legislation and best practice at the time of writing. Information contained within this document is accurate at the time of submission and will be reviewed as required and updated if necessary.

This outline MMMP has been reviewed by the installation contractor[1] with regards to the proposed mitigation measures.

A Piling Strategy will be prepared and finalised post consent. This MMMP will be updated once the Piling Strategy has been developed and impact assessment presented in the Offshore EIA Report confirmed.

1.2 Objectives

This outline MMMP has been developed to inform potential mitigation options based on the findings presented in following supporting studies within the EIA:

• Marine mammal and megafauna (HiDef, 2023)	Offshore EIA Report – Chapter 12
• Marine mammal and megafauna baseline (HiDef, 2023)	Offshore EIA Report – Supporting Study 9 (SS9)
• Marine mammal underwater noise impact assessment (Sinclair *et al*., 2023)	Offshore EIA Report – Supporting Study 10 (SS10)
• Underwater Noise Assessment (Subacoustech, 2023)	Offshore EIA Report – Supporting Study 11 (SS11)

The key components of the offshore Project that require consideration of marine mammal mitigation are:

- Impact piling (fixed foundations):
  - Up to 125 Wind Turbine Generators (WTGs), with either monopile or jacket foundation;
  - Up to 5 Offshore Substation Platforms (OSPs) with jacket foundations;
- Unexploded Ordnance (UXO) clearance; and
- Site investigation surveys (geophysical).

The following sections outline the worst case scenarios considered in the EIA, together with a summary of impacts and available mitigation methods. The worst case scenario assessments undertaken to inform the EIA will be updated if required, post consent to inform the Piling Strategy and UXO clearance methodology, which will in turn confirm the impact assessment presented in the Offshore EIA Report, inform the mitigation measures required and final MMMP.

The final MMMP will be required as a condition of consent for the Section 36 Consent and Marine Licences and therefore will be submitted to MD-LOT for approval.

[1] Due to the confidential nature of current discussions with a potential installation contractor, it is not possible to identify the specific contractor at this stage.

1.3 Consent compliance

The MMMP fulfils the consent conditions for the preparation of a MMMP as outlined in Table 1-1.

Table 1-1.Consent conditions relating to the MMMP

Consent reference	Condition	Relevant section
[To be added post consent]		

1.4 Relevant other documents and plans

This MMMP will form part of a set of approved documents (other consent plans required under the offshore consents) that provide the framework for the construction and operations and maintenance stages of the offshore Project.

The links of this MMMP with other consent plans specifically listed in the offshore consent conditions are detailed in Table 1-2.

Table 1-2. Links with other consent plans

Other consent plans/documentation	Linkage with MMMP
[To be added post consent]	

1.5 Structure of the plan

The structure of the document is as follows:

- Section 1 – Introduction;
- Section 2 - Project background;
- Section 3 – Piling;
- Section 4 - UXO clearance;
- Section 5 - Site investigation surveys (geophysical);
- Section 6 - Summary of mitigation measures;
- Section 7 – References;
- Section 8 – Abbreviations; and
- Annex I – Efficacy of an acoustic deterrent system.

2 Project background

The Developer is proposing the development of the West of Orkney Windfarm ('the Project'), an Offshore Wind Farm (OWF), located approximately 23 kilometres (km) from the north coast of Scotland and 28 km from the west coast of Hoy, Orkney.

The offshore Project will comprise of WTGs and all infrastructure required to transmit the power generated by the WTGs to shore. The key offshore components of the offshore Project will include:

- Up to 125 WTGs with fixed-bottom foundations (monopile, piled jacket or suction bucket jacket);
- Up to five High Voltage Alternating Current (HVAC) OSPs;
- Up to 500 km of inter-array cables;
- Up to 150 km of interconnector cables; and
- Up to five offshore export cables to landfalls at Greeny Geo and/or Crosskirk at Caithness, with a total length of up to 320 km (average of 64 km per offshore export cable).

The offshore Project boundary includes the array area and the offshore Export Cable Corridor (ECC) (Figure 2-1). The array area reflects the Option Agreement Area (OAA) awarded to OWPL through the ScotWind Leasing Round. Therefore, the offshore Project boundary encompasses:

- OAA – where the WTGs and associated foundations and supporting structures, inter-array cables, interconnector cables and the OSPs (including offshore export cable connections) will be located;
- Offshore ECC –within which the offshore export cables will be located; and
- Landfall (up to Mean High Water Springs (MHWS)) – where the offshore export cables come ashore and interface with the onshore Project.

[Section to be updated post-consent with final details of offshore Project]

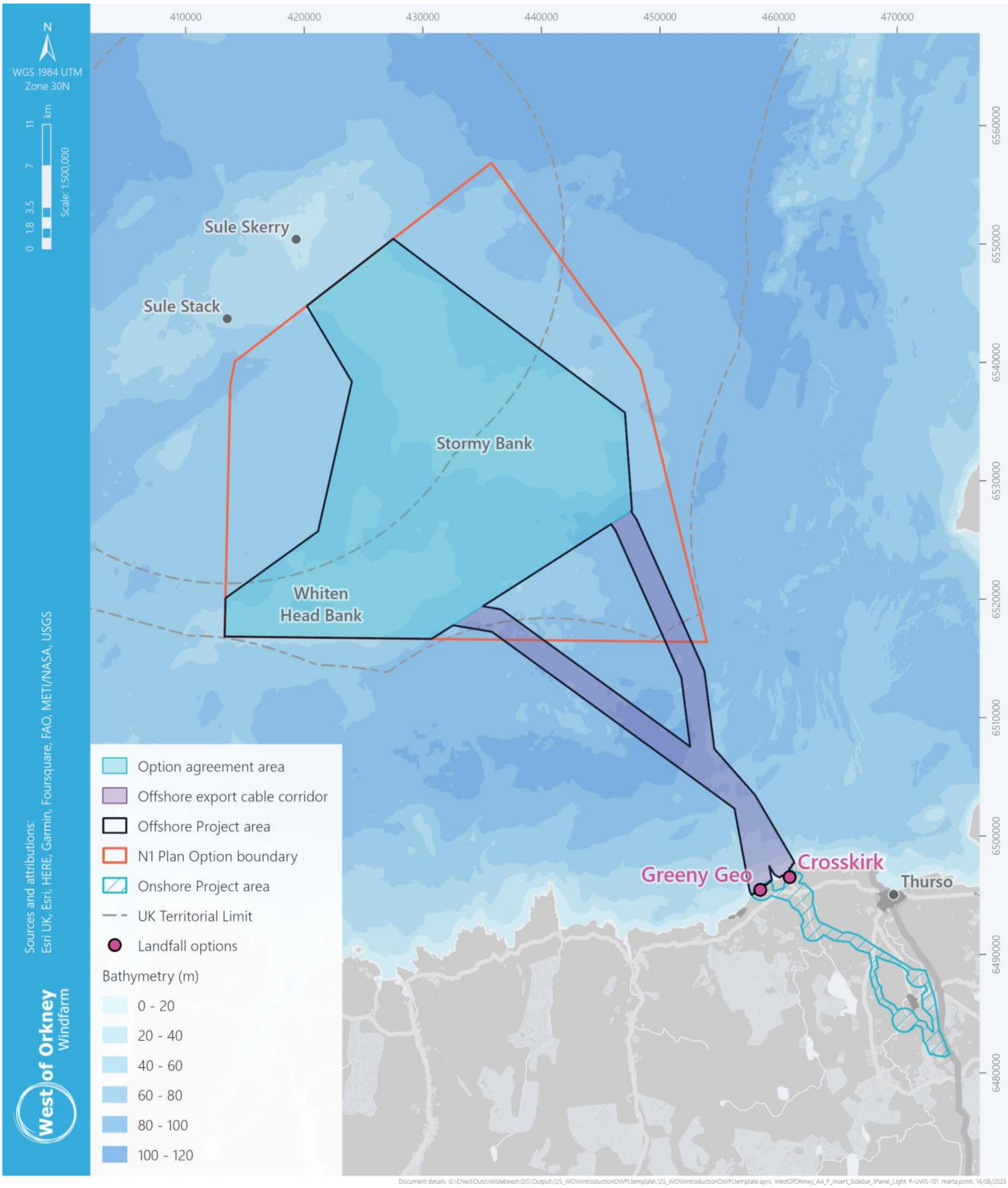

Figure 2-1 Offshore Project boundary

3 Piling

3.1 Scenarios considered

Subacoustech Environmental Ltd undertook modelling and analysis of the effects of piling noise on marine mammals based on the following scenarios (see SS11: Underwater noise modelling report for full details):

- A monopile foundation in hard sediment, installing a 14 m diameter pile with a maximum blow energy of 5,000 kJ, with one monopile installed in a 24-hour period;
- A monopile foundation in soft sediment, installing a 14 m diameter pile with a maximum blow energy of 3,000 kJ, with up to one monopile installed in a 24-hour period;
- A jacket pile foundation in hard sediment, installing 3 m diameter piles with a maximum blow energy of 3,000 kJ, with two piles installed in a 24-hour period; and
- A jacket pile foundation in soft sediment, installing 3 m diameter piles with a maximum blow energy of 3,000 kJ, with four piles installed in a 24-hour period.

Soft start and ramp up parameters[2] were also included in the modelling for the assessment of accumulated PTS-onset (Cumulative Sound Exposure Level (SEL_{cum})) (i.e. blow energies, total duration of piling and strike rate) (Table 3-1,Table 3-2, and Table 3-3).

Table 3-1 Summary of the soft start and ramp up scenario used for the monopile foundation (hard sediment) modelling (SS11: Underwater noise modelling report)

Monopile (Hard)	750 kJ		1,250 kJ	2,500 kJ	3,750 kJ	5,000 kJ
Number of strikes	60	400	400	400	400	21,500
Duration	10 mins	10 mins	10 mins	10 mins	10 mins	430 mins
Strike rate	6 bl/min	40 bl/min				50 bl/min
Single pile: 23,160 strikes, 8 hours duration						

Table 3-2 Summary of the soft start and ramp up scenario used for the monopile foundation (soft sediment) modelling (SS11: Underwater noise modelling report)

Monopile (soft)	450 kJ		750 kJ	1,500 kJ	2,250 kJ	3,000 kJ
Number of strikes	60	400	400	400	400	9,500
Duration	10 mins	10 mins	10 mins	10 mins	10 mins	190 mins
Strike rate	6 bl/min	40 bl/min				50 bl/min
Single pile: 11,160 strikes, 4 hours duration						

[2] 'Soft start' refers to the initial hammer energy used at the beginning of the pile installation. 'Ramp up' refers to the increasing hammer energy from the soft start to full hammer energy.

Table 3-3 Summary of the soft start and ramp up scenario used for the jacket pile foundation (hard and soft sediment) modelling (SS11: Underwater noise modelling report)

Jacket pile (Hard + Soft)	450 kJ		750 kJ	1,500 kJ	2,250 kJ	3,000 kJ
Number of strikes	60	400	400	400	400	9,500
Duration	10 mins	10 mins	10 mins	10 mins	10 mins	190 mins
Strike rate	6 bl/min	40 bl/min				50 bl/min
Single pile: 11,160 strikes, 4 hours duration 2 piles (hard sediment): 22,320 strikes, 8 hours duration 4 piles (soft sediment): 44,640 strikes, 16 hours duration						

3.2 Summary of impacts

3.2.1 Instantaneous PTS-onset

The maximum instantaneous PTS-onset predicted for VHF cetaceans (harbour porpoise) using unweighted Peak Sound Pressure Level (SPL_{peak}) was 720 m, and for all other species groups this was less than 100 m, typically 50-60 m (Table 3-4).

3.2.2 Cumulative PTS-onset

The modelling of SEL_{cum} used a fleeing animal approach. The impact ranges presented therefore represent the distance to a 'safe' starting position.

Maximum PTS-onset ranges were predicted for LF cetaceans (minke whale) using the SEL_{cum} criteria, with ranges of up to 47 km, and for Very High Frequency (VHF) cetaceans (harbour porpoise) PTS ranges are predicted up to 17 km. PTS-onset ranges for the other species groups were significantly smaller with less than 100 m for High Frequency (HF) cetaceans (dolphins) and 350 m for seals (Table 3-4).

Table 3-4 Summary of the worst case pile driving[3] underwater noise modelling results for marine mammals, detailing instantaneous and cumulative PTS-onset impact ranges (SS9: Marine mammal and megafauna baseline)

Species	Instantaneous PTS-onset (SPL_{peak}) (km)	Cumulative PTS-onset (SEL_{cum}) (km)
Harbour porpoise (Very High Frequency; VHF)	0.72	17
Dolphins (High Frequency; HF)	<0.1	<0.1
Minke whale (Low Frequency; LF)	<0.05	47
Seals (Phocid Carnivores in Water; PCW)	<0.05	0.35

3.3 Mitigation methods

As agreed in the Marine Mammal Consultee meeting held 22nd March 2023 the pre-piling mitigation requirements will be based upon the instantaneous risk of PTS-onset. This is consistent with other Scottish offshore wind developments (e.g., Beatrice Piling Strategy, 2017; Moray East Piling Strategy, 2019). Standard mitigation protocols (JNCC, 2010a) are used to reduce the PTS-onset risk to negligible, based on the findings of the underwater noise modelling and assessment (SS10: Marine mammal underwater noise impact assessment; SS11: Underwater noise modelling report). The following sections provide detail on the available mitigation methods typically employed when applying the JNCC standard mitigation protocols.

[3] Worst case scenario – 14 m diameter monopile; 5,000 kJ max hammer energy, hard sediment (SS11: Underwater noise modelling report).

3.3.1 Marine Mammal Observers (MMO)

The MMO team will be led by an experienced MMO, which is defined in the JNCC guidance as someone who is a trained observer with 3 years of field experience observing for marine mammals and practical experience of implementing JNCC guidelines. The role of the MMO(s) is to monitor the agreed Mitigation Zone (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, 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-degree visibility, and/or observer fatigue.

The maximum instantaneous PTS-onset range predicted is 720 m based on the worst case scenario assessed in the EIA. This is beyond the standard MZ of 500 m for piling and so further consideration will be given post consent (if required) as to how this range can be observed/mitigation. Depending on the elevation of the survey platform, the MMO may be able to monitor a MZ out to 720 m. This will be confirmed once the Piling Strategy has been developed (post consent).

3.3.2 Passive Acoustic Monitoring (PAM)

A passive acoustic monitoring system is used by a 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 typically used to monitor for 30 minutes prior to piling commencing. PAM is a useful supplementary monitoring method. It is worth noting the limitations of PAM in relation to detection distances for different species. For harbour porpoise this is typically approximately 300 m, therefore, it is important that a suite of complimentary methods is used.

3.3.3 Acoustic Deterrent Device (ADD)

As no one mitigation method is 100% effective, ADD mitigation can be used to supplement MMO/PAM to cover a 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; NNG Piling Strategy, 2020; Moray West OfTI 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 warning sound results in displacement of marine mammals from the MZ (A1. Annex 1 details the current knowledge regarding the efficacy of ADD mitigation).

3.3.4 Soft Start Procedure

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 is often required by engineers when the pile first enters the sediment (Thompson *et al.,* 2020), but also minimises noise exposure at the beginning of each piling sequence. The use of lower hammer energies at the beginning of the installation allows marine mammals longer to flee before maximum hammer energies are reached. The noise generated by the soft start process is therefore considered to act as a deterrent effect, effectively reducing the modelled maximum MZ (as assessed at highest hammer energy).

3.4 Reporting

Reporting will follow standard JNCC procedures (JNCC, 2010a) and will include:

- A report of MMO, PAM effort, and ADD activation, detailing durations of watch, any observations, and any non-compliances, or variation from agreed procedure;
- A log of piling activities:
    - date, location, and duration of piling – including soft start, ramp up and full power durations,
    - details of any delays, or stoppages of piling activity, and
    - a description of any technical issues, and what if any actions taken.

3.5 Additional content for the finalised MMMP

The finalised and agreed MMMP (as informed by the Piling Strategy) will detail a clear communications protocol between the mitigation personnel and the construction team. Roles and responsibilities will be defined, and a piling procedure will be detailed in terms of timing of mitigation steps and process to follow during piling mitigation including in the event of a planned, or unplanned break in piling.

4 Unexploded Ordnance (UXO) clearance

4.1 Scenarios considered

An assessment of the potential occurrence of unexploded ordnance was undertaken. Initial investigation, based on analysis (by an UXO specialist) of the extensive Project specific geophysical survey data available for the OAA and ECC, estimated that there could be 222 potential UXO (pUXO) targets (6Alpha, 2022). These may not all be UXOs, or they may not all need clearance. It is suggested that between 3-10% of these targets (6Alpha, 2022) may require clearance, which would mean that between 6 and 22 UXOs may require clearance. Regardless, the mitigation employed will be the same should there be one confirmed UXO or any number up to the maximum pUXO. The intended hierarchy of mitigation is:

- UXO avoided;
- UXO removed to a safe location;
- UXO detonated in-situ:
  - Low order methods; and
  - High order methods.

In accordance with the joint interim position statement (DEFRA, 2022) the use of low noise alternatives to high order detonations will be prioritised. However, robust evidence of reduced levels of noise from low noise alternatives in relation to high order clearance is not yet available. Therefore, the recommendation is that mitigation should be in place to cover the worst case scenario, *i.e.*, high order detonation. It is likely that forthcoming evidence (Offshore-energy.biz, 2023[4]; Lepper *et al.,* 2022) will be available post consent. This will then be considered in more detail for the Marine Licence and European Protected Species (EPS) Licence applications.

The potential for PTS-onset was assessed in SS11: Underwater noise modelling report:

- Low order clearance – the noise levels emitted due to deflagration is related to the donor shape charge (Robinson *et al,* 2020). Low order impact has therefore been assessed based on the shape charge weight of 0.05 kg; and
- High order detonation – the noise level assessed was estimated on the maximum charge weight of 247 kg + 5 kg donor.

4.2 Summary of impacts

A UXO clearance event is defined as a single pulse (SS11: Underwater noise modelling report) therefore, an assessment using an accumulated dose is not appropriate (i.e. SEL_{cum}). Consequently, the impacts have been assessed using SPL_{peak} and Sound Exposure Level (single strike) (SEL_{ss}).

4.2.1 Instantaneous PTS-onset

Impacted ranges based on SPL_{peak} were greater than those predicted using SEL_{ss} and therefore have been used here to inform mitigation requirements (Table 4-1).

Table 4-1 A summary of predicted PTS-onset ranges (km) based on SPL_{peak} for low order (0.05 kg donor only) and high-order (247 charge weight +5 kg donor)

Species	Low order (0.05 kg donor charge)	High order (247 +5 kg)
Harbour porpoise (VHF)	0.58 km	9.9 km
Dolphins (HF)	0.03 km	0.57 km

[4] Offshore-energy.biz (2023) EODEX to remove unexploded ordnance from Moray West site - Offshore Energy (offshore-energy.biz) (Accessed 02/05/2023)

Species	Low order (0.05 kg donor charge)	High order (247 +5 kg)
Minke whale (LF)	0.10 km	1.7 km
Seals (PCW)	0.11 km	1.9 km

4.3 Mitigation methods

Standard JNCC guidance is available for UXO mitigation (JNCC, 2010b). This follows a similar logic to the standard mitigation guidance for piling (MMO/PAM/ADD) but tailored for the injury risk from explosives.

4.3.1 Marine Mammal Observers (MMO)

MMO team will be led by an experienced MMO (as defined in Section 4.3.1). JNCC (2010b) guidance sets out the minimum requirement of a 1 km MZ for explosives mitigation. It is probable that three MMOs will be required to fully observe the 1 km MZ. The number of personnel, however, 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 shape charges[5], initially located close to the UXO location. The elevation from this platform is unlikely to enable 1 km visibility. The second MMO is usually 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 available 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. This requirement will be discussed and agreed for the Marine Licence and EPS Licence applications.

4.3.2 Passive Acoustic Monitoring (PAM)

Visual observation is ineffective during periods of darkness or poor visibility. Whilst it is likely clearance activities will only be conducted in the daytime / good conditions, there may be occasion (*e.g.,* for health and safety reasons) where clearance needs to occur at night / poor conditions. In these instances, PAM would be used in combination with visual observations. Whilst there are limitations in detectability of certain species (*e.g.*, harbour porpoise), PAM is recommended as supplementary mitigation.

4.3.3 Acoustic Deterrent Device (ADD)

The worst case high order impact range predicted (Table 4-1) for HF cetaceans (delphinids) is within the 1 km MZ and therefore will be covered by MMO/PAM. The ranges for all other species extend beyond the standard MZ, therefore, ADD mitigation would supplement MMO/PAM (Annex 1 details the current knowledge regarding the efficacy of ADD mitigation). It is likely that the use of ADDs will reduce the risk for minke whales, as evidence shows minke whale individuals were observed fleeing from a Lofitech ADD at 1 km range from the ADD when activated (McGarry *et al.,*2017). The extent of fleeing was not fully assessed, but continuation of fleeing for a further 700 m is not unrealistic.

The worst case high order PTS-onset range predicted for seals is 1.9 km. ADDs have only been shown to result in a behavioural response within 1 km, therefore for seals, ADD use may not add additional protection beyond 1 km. However, at this range without ADD mitigation, Table 7.1 in SS10: Marine mammal underwater noise impact assessment, predicts that < 1 harbour seal and 6 grey seals are at risk of PTS-onset at high order.

The worst case high order PTS-onset impact range for harbour porpoise is 9.9 km. The impact range for harbour porpoise for a high order detonation is not fully mitigable with the suite of available mitigation methods. Therefore, low order clearance will be prioritised. If high order clearance methodology is unavoidable, there will be a residual risk of injury to harbour porpoise. Table 7.1 (in SS10: Marine mammal underwater noise impact assessment) illustrates that in the high order scenario 46 individuals are at risk of PTS-onset without ADD mitigation.

Fewer individuals than predicted will be affected if ADD mitigation is employed. 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 while not causing more disturbance than necessary to mitigate PTS-onset.

[5] As outlined in SS11: Underwater noise modelling report, low order clearance involves the use of an initial shaped explosive donor charge.

4.4 Reporting

The reporting of marine mammal mitigation activities will follow JNCC (2010b) reporting guidance and will include:

- Where relevant, the reference number for the activity provided by the regulatory authority;
- Date and location of the activity;
- Details of the proposed operation, including information on the size of charges used, the start times of explosive detonations, the start and end times of watches by MMOs, the start and end times of any PAM, and details of all explosive activity during the relevant watches;
- Any marine mammal sightings summarised in completed "Marine Mammal Recording Forms". Although these have been developed for the seismic industry JNCC state they can be used for other applications, such as explosive use. All the forms and guidance for their completion are available on the JNCC website at http://www.jncc.gov.uk/page-1534; and
- Details of any Acoustic Deterrent Devices used, and any relevant observations on their efficacy. Details of any problems encountered during the activity, including instances of non-compliance with the JNCC guidelines and any variations from the agreed procedure.

5 Site investigation surveys (geophysical)

5.1 Scenarios considered

Site investigation surveys during the pre-construction phase can result in injury or disturbance to marine mammal species depending on the acoustic characteristics of the equipment used. Pre-construction geophysical surveys for the Project may be performed using Multibeam Echosounder (MBES), Side Scan Sonar (SSS) (with piggybacked magnetometer) and Ultra-Short Baseline (USBL). Surveys using sub-bottom profilers are not planned.

There is likely to be overlap between the functional hearing of marine mammals (Table 5-1) and the sound frequency emitted from the intended geophysical survey equipment. The expected sound pressure level and frequencies for the different equipment types are presented in Table 5-2.

Table 5-1 Summary of generalised and best ranges of marine mammal functional hearing groups (NMFS, 2018, Southall *et al.*, 2019)

Hearing group	Example species	Generalised Hearing range	Range of best hearing
LF (Low-Frequency cetacean)	Minke whale	7 Hz – 35 kHz	0.2 kHz – 19 kHz
HF (High-Frequency cetacean)	Delphinids	150 Hz – 160 kHz	8.8 kHz – 110 kHz
VHF (Very High-Frequency cetacean)	Porpoise	275 Hz – 160 kHz	12 kHz – 140 kHz
PCW (Phocid Carnivores in Water)	Seals	50 Hz – 86 kHz	1.9 kHz – 30 kHz

Table 5-2 Expected geophysical survey operating characteristics and overlap with marine mammal hearing capabilities (SS10: Marine mammal underwater noise impact assessment)

Equipment	Estimated source pressure level	Expected Sound Frequency	Overlap with functional hearing group			
			LF	HF	VHF	PCW
MBES	218 (peak), 213 dB rms	200 - 400 kHz	No - above all hearing ranges			
SSS	210 (peak), 242 dB rms	300 kHz & 900 kHz	No - above all hearing ranges			

Equipment	Estimated source pressure level	Expected Sound Frequency	Overlap with functional hearing group			
			LF	HF	VHF	PCW
USBL	194 (peak), 188 (rms)	20 – 35 kHz	No[1]	Yes[2]	Yes[2]	Yes[2]

[1] 'No' conclusion is based on the range of best hearing for LF cetaceans (Table 5-1).

[2] 'Yes' – the acoustic characteristics are within the functional hearing group range

5.2 Summary of impacts

Disturbance risk is negligible where there is no overlap between expected sound frequency range and the functional hearing of marine mammals. There may still be potential for injury (PTS-onset) if sound pressure levels are of a high enough magnitude; however, for equipment with frequencies above 200 kHz, this is likely only to be realised in close proximity to the survey vessel.

5.2.1 Instantaneous PTS-onset

Expected sound frequency content for MBES and SSS exceed all hearing ranges for the assessed functional hearing groups. Although estimated source pressure levels are above PTS-onset thresholds for VHF cetaceans, at these high frequencies, sound pressure levels rapidly attenuate below PTS-onset thresholds close to the noise source. Therefore, there is negligible risk to any marine mammal of PTS-onset.

The operating frequency of USBL overlaps with the range of best hearing frequency range of some of the assessed marine mammal groups but the estimated source pressure levels are below PTS-onset thresholds for all marine mammal species considered (Table 5-3). Therefore, there is no risk of injury to any assessed marine mammal species.

Table 5-3 PTS-onset thresholds from marine mammals exposed to impulsive noise. Peak SPL thresholds in dB re 1μPa (Southall *et al*., 2019)

Marine Mammal Hearing Group	PTS-onset: Peak SPL (unweighted) dB re1μPa
LF (Minke whale)	219
HF (delphinid)	230
VHF (porpoise)	202
PCW (seals-in water)	218

5.3 Mitigation methods

Mitigation for geophysical activities typically relies on MMO observations to ensure the PTS-onset zone is monitored before the geophysical equipment is activated (following JNCC, 2017 guidance). Depending on the level of risk, it is common for this role to be filled by a suitably trained crew member (dedicated to the task during the watch period). However, where the equipment in use operates at high frequencies (~>200 kHz) as is predicted here for the MBES and SSS, JNCC recommend that mitigation is not needed (JNCC *et al.,* 2010; DECC, 2011; JNCC, 2017). Further, there is no predicted risk of PTS-onset from the USBL equipment proposed.

Therefore, based on the equipment suggested for use during pre-construction geophysical surveys, it is not expected that any mitigation measures will be required. Depending on final equipment choices e.g. should USBL noise source levels be higher than have been accounted for, or alternative equipment is used, then mitigation measures may be necessary. This will be discussed and agreed through the EPS Licence application process.

6 Summary of mitigation measures

This outline MMMP presents indicative mitigation. Protocols will be refined and agreed in consultation with MD-LOT and NatureScot post-consent, to reflect refined Project parameters and to incorporate any new research outputs. The Piling Strategy will inform the final piling mitigation requirements, and once final details of pre-construction geophysical surveys and UXO clearance activities are known final mitigation requirements for these activities can be developed. Adherence to a finalised MMMP will be a consent condition of the Section 36 Consent/Marine Licences/EPS Licences.

A summary of mitigation options based on the worst case auditory injury is presented in Table 6-1 below.

Table 6-1 Summary of worst case impacts for impact piling, UXO clearance and geophysical surveys, including EPS licence considerations

Activity	Mitigation need[6]	Mitigation options / comments
Piling (PTS-onset; SPL_{peak})	720 m	MMO/PAM/ADD
Piling (disturbance)	--	None
Piling (PTS-onset; SEL_{cum})	17 - 47 km	Alternatives considered (e.g., suction buckets; vibro-piling) Update of modelling post consent if required following development of Piling Strategy to include: • New Risk Assessment using output of project Range Dependent Nature of Impulsive Noise (RaDIN)[7]; • Extension of soft start / ramp up; and • Include displacement from ADD mitigation. EPS Licence for the residual risk of injury may be needed
UXO (PTS-onset; SPL_{peak}) High Order	9.9 km	Low order methods MMO/PAM/ADD
UXO (PTS-onset; SPL_{peak}) Low Order	580 m	MMO/PAM/ADD
UXO (disturbance)	--	None
Pre-construction Geophysical surveys (PTS-onset)	0 m	Not required (based on equipment assessed)

6 Mitigation requirements indicated here are based on the worse case assessments presented in the EIA. Assessments will be updated as required post consent to inform final mitigation requirements.
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8 Abbreviations

Acronym/ abbreviation	Full Term
ADD	Acoustic Deterrent Device
ECC	Export Cable Corridor
EIA	Environmental Impact Assessment
EPS	European Protected Species
HF	High Frequency
HiDef	HiDef Surveying Ltd
HVAC	High Voltage Alternative Current
JNCC	Joint Nature Conservation Committee
km	kilometre
LF	Low Frequency
MBES	Multi-beam Echosounder
MMMP	Marine Mammal Mitigation Protocol
MMO	Marine Mammal Observer
MD-LOT	Marine Directorate - Licencing Operations Team
MHWS	Mean High Water Springs
MZ	Mitigation Zone
OAA	Option Agreement Area
OSP	Offshore Substation Platform
PAM	Passive Acoustic Monitoring
PCW	Phocid carnivores in Water
PTS	Permanent Threshold Shift
pUXO	Possible Unexploded Ordnance
RaDIN	Range Dependent Nature of Impulsive Noise
SEL_{cum}	Cumulative Sound Exposure Level
SEL_{ss}	Sound Exposure Level (single strike)
SPL_{peak}	Peak Sound Pressure Level
SSS	Side Scan Sonar

Acronym/ abbreviation	Full Term
USBL	Ultra-Short Baseline
UXO	Unexploded Ordnance
VHF	Very High Frequency
WTG	Wind Turbine Generator

9 Glossary of terms

Term	Definition
[to be included post-consent]	

A1. Annex 1 – Efficacy of an acoustic deterrent system as pre-piling mitigation

Acoustic deterrents (ADDs) have been used as standard for all piling activity in Europe (Herschel *et al*, 2013) whereas in the UK in general, ADDs are not a standard requirement. More recently, in Scotland ADDs have been used as sole mitigation in in the Moray Firth (see Beatrice offshore wind farm and Moray East piling strategies), however the recommendation remains that ADDs are used in combination with MMO/PAM (JNCC, 2010).

Evidence of efficacy exists for (VHF) harbour porpoise, harbour seals and (LF) minke whale, but is lacking for grey seals and (HF) delphinid species.

The evidence currently is in relation to one brand of ADD, Lofitech and as such has been used so far as a multispecies deterrent. There are other brands available where evidence of efficacy is limited in the public domain but may be a suitable alternative.

Harbour porpoise

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.

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 30-100% at 750 m, and by 25-60% 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.

Thompson *et al* (2020) monitored harbour porpoise during the construction of offshore windfarms 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 (Figure A1-1). 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.

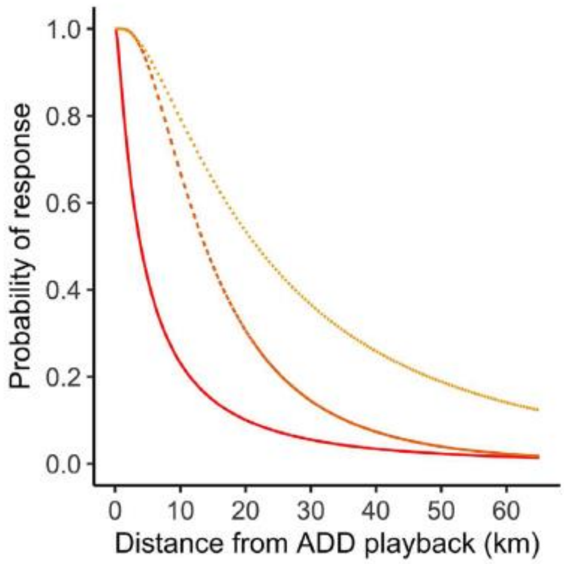

Figure A1-1. Reproduced from Thompson *et al*, (2020) The probability of a harbour porpoise response in relation to distance from ADD playback, over a period of 12 h (solid red line), 6 h (long dash orange line) and 3 h (short dash yellow line). Harbour porpoise occurrence was considered to have responded to ADD exposure when the proportional decrease in occurrence (DPH) exceeded a threshold of 0.5.

Minke whale

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 – 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.

Harbour seal

Gordon *et al.* (2019) tested the Lofitech ADD on tagged harbour seals in Scotland (Kyle Rhea and Moray Firth) at ranges of ~500 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.

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