Environmental Impact Assessment Report

NISA

North Irish Sea Array

Volume 9: Appendices (Offshore)

Appendix 14.4

Marine Mammal Mitigation Protocol

Statkraft

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Appendix 14.4:
Marine Mammal Mitigation Protocol

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Table of Contents

Appendices

Appendix A – Pile driving mitigation procedure summary

Appendix B – Geophysical survey mitigation procedure summary

Appendix C – UXO mitigation procedure summary

1. Introduction

1.1 Project Background

North Irish Sea Array Windfarm Ltd hereafter referred to as the 'the Developer' is proposing to develop the North Irish Sea Array (NISA) Offshore Windfarm (hereafter referred to as 'the Proposed Development'). The Proposed Development will be located approximately 11.3 km to 23.5 km off the coast of counties Dublin, Meath and Louth in the western Irish Sea (Figure 1.1).

1.2 Purpose of the Marine Mammal Mitigation Protocol (MMMP).

This Marine Mammal Mitigation Protocol (MMMP) has been prepared for the Developer to support the Environmental Impact Assessment Report (EIAR) and the Natura Impact Statement (NIS) for the Proposed Development.

As highlighted in the EIAR chapter (Volume 3, Chapter 14: Marine Mammal Ecology) and the NIS, the proposed development identified potential impacts on marine mammals (e.g. cetaceans and seals). Therefore, the purpose of the MMMP is to present mitigation measures to seek to minimise risk of Permanent Threshold Shift (PTS) arising in marine mammals from underwater noise resulting from activities relating to the Proposed Development. The activities identified as requiring mitigation measures, and as such are presented herein are:

- Impact pile driving;
- Geophysical surveys; and
- UXO clearance.

The primary aim of this MMMP is to detail measures which are committed to by the Developer to reduce the risk of a permanent threshold shift (PTS) in hearing of marine mammals. The MMMP is intended to reduce the risk of injury to a negligible level. This MMMP complies with 'Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters' provided by the Department of Arts, Heritage and the Gaeltacht (DAHG, 2014). The relevant wildlife groups responsible for marine mammal underwater noise of DAHG are now found within the Department of National Parks and Wildlife Service (NPWS). Whilst the primary purpose of the MMMP is to mitigate PTS in marine mammals, the measures outlined herein may also provide secondary mitigation to other marine species.

2. Description of the Project

1.3 Scenarios Considered

1.3.1 Project Design Options and Impact Pile Driving

For the offshore component of the Proposed Development, two discrete Project Options are proposed:

- Project Option 1: 49 wind turbine generators (WTG) with monopile foundations and one offshore substation platform (OSP) installed on either of two monopiles, or jacket on four pin piles; or
- Project Option 2: 35 WTG with jacket foundations, with up to four pin piles per jacket or monopile foundations, and one OSP installed on either of two monopiles, or jacket on four pin piles.

The Proposed Development may install both monopiles and pin-piles and so both foundation types have been assessed in the EIAR (see Chapter 14: Marine Mammal Ecology) and the Natura Impact Statement. Monopiles and/or pin-piles could be installed using either pile-driving or drilling methodologies. For the purposes of the underwater noise which has informed this MMMP, it is assumed that all foundations will be piled for both Project Option 1 and Project Option 2. Additionally, the parameters for the installation of the monopiles are the same across both Project Option 1 and Project Option 2, in so far as they affect the input parameters of the model (pile size, hammer energy, number of piles installed in a 24-hour period; see the Underwater Noise Report for full details). Pin piles would only be used for Project Option 2. No simultaneous pilling or drilling events will occur.

The construction programme comprises the installation of monopiles or jacket (three or four leg) foundation structures over a period of six months. Whereby the greatest number of piling days is expected to be a maximum:

- 51 piling days when using monopiles; and
- 72 piling days when using pin-piles.

A summary of the parameters assessed are presented in Table 1-1 and Table 1-2 for either monopile or pin-pile installation. The greatest impact ranges arise from the assumption of either monopiles or pin piles being fully installed using percussive piling; however, monopiles or pin-piles could be installed via percussive piling, drilling, or a combination of both, or additionally through the use of vibropiling techniques (if ground conditions allow for this). For full details on installation methodology, refer to Chapter 8: Construction Strategy – Offshore, Section 8.4.4.1 Driven Piles of the EIAR. The WTG Project Options (Table 1-1) and OSP (Table 1-2) foundations and are intended to illustrate the maximum piling parameters (e.g. number of WTG and maximum piling time during foundation) that would be required to install a foundation. It is these parameters which inform the underwater noise modelling and associated predicted impact ranges. In practice, seabed conditions may allow for successful pile installation using less than the maximum hammer energies modelled or drilling methodology, which would lessen impact ranges.

Table 1-1 Overview of the proposed scenarios for WTG foundations.

Parameter	Project Option 1	Project Option 2	
Number of WTG	49	35	
Foundation type	Monopiles	Monopiles	Jackets (3 or 4 leg configurations with pin-piles)
OSPs (see Table 1-2)	1 OSP	1 OSP	
Maximum hammer driving energy (kJ)	5,500	5,500	3,000
Maximum pile diameter (m)	12.5	12.5	6
Maximum seabed penetration (m)	45	45	60
Soft-start duration (up to 20% maximum hammer energy)	30 minutes	30 minutes	
Maximum soft-start hammer energy (kJ)	825	825	450
Maximum piling time per foundation	6 hours 5 mins	6 hours 5 mins	3 hours 20 mins
Maximum piling time[a]	276 hours	210 hours	350 hours*
Maximum number of piles per 24 hours	1	1	2
Total number of piling days[b]	49 days	35 days	70 days
Pile installation programme	Q2-4 Year 2	Q2-4 Year 2	Q2-4 Year 1
[a] = number of foundations multiplied by the time per foundation [b] = assuming 1 day per monopile * = assuming four pin-piles			

All three proposed scenarios will also require one OSP which could have either of the three OSP foundation options shown in Table 1-2 (i.e. OSP foundation installation method is not dependant on WTG foundation installation method).

Table 1-2 OSP project design options

Parameter	Foundation Option 1	Foundation Option 2	Foundation Option 3
Number of Jacket Legs	4	0	0
Number of Monopiles	0	2	1
Maximum Seabed Penetration (m)	60	54	54
Maximum hammer driving energy (kJ)	3,000	5,500	5,500
Maximum pile diameter (m)	6	12.5	12.5
Maximum seabed penetration (m)	60	54	54
Soft-start duration	30 minutes	30 minutes	30 minutes
Maximum soft-start hammer energy (kJ)	450	825	825
Total number of pilling daysa	2	2	1
a = assuming 1 day per monopile			

2. Summary of Relevant Marine Mammal Species

Chapter 14: Marine Mammal Ecology characterised the following marine mammals as common in the area: harbour porpoise (Phocoena phocoena), bottlenose dolphin (Tursiops truncatus), common dolphin (Delphinus delphis), minke whale (Balaenoptera acutorostrata), grey seal (Halichoerus grypus) and harbour seal (Phoca vitulina).

Whilst the primary purpose of the MMMP is to mitigate PTS in marine mammals, the measures outlined herein may also provide secondary mitigation to other marine species (for example fish species).

3. Noise and Vibration Impacts

Installation of offshore windfarms (OWFs) involve multiple activities that can have direct and indirect impacts on marine fauna. This MMMP details measures to reduce the risk of permanent threshold shift (PTS) in hearing, where the hearing sensitivity is reduced after noise exposure, with no hearing recovery in the impacted frequencies. PTS can occur instantaneously or cumulatively (i.e. exposed to the sound source over an extended period). The level of injury depends on the duration, frequency and intensity of the sound source and received level. Whilst PTS is considered a permanent effect, the most likely response of an animal exposed to noise levels that could induce PTS is to flee the ensonified area. Therefore, animals exposed to these noise levels are likely to actively avoid hearing damage by moving away from the area.

Noise exposure criteria are typically represented by dual exposure metrics, including the frequency-weighted cumulative sound exposure level (SELcum; expressed in decibels (dB) re. 1 µPa2–s or µPa2s; where both the received level and duration of exposure are accounted for) and the unweighted zero to peak sound pressure level (SPLpeak; expressed in dB re. 1 µPa in water; ISO 18405, 2017; Juretzek et al., 2021). The ranges relating to SPLpeak indicate the distance from the sound source to which an animal can experience instantaneous injury.

As noted above, underwater noise and vibration resulting from the following activities are considered here:

- Impact pile driving;
- Geophysical surveys; and
- UXO clearance.

Sound waves can propagate in various manners depending on the nature of the sound, the position of the sound source in relation to the water column, bathymetry, and seawater properties. As sound travels through water, it experiences sound attenuation (where sound waves lose amplitude and intensity due to energy loss through a medium). This phenomenon affects high frequency sounds to a greater degree than lower frequencies. Therefore, the risk of auditory injury is reduced with increasing distance from the source.

If an individual is within the impact ranges of SPLpeak, they risk immediate onset of a PTS in hearing. To limit this risk, the proposed development will follow standard DAHG (2014) guidelines, which incorporates a pre-watch and soft-start procedure. Marine mammals typically flee when exposed to loud noises within their hearing ranges. This means that the received level decreases as they increase the distance from the source.

Noise modelling has been undertaken by Subacoustech Environmental to assess the potential impacts on marine mammals as a result of pile driving within the array area (Underwater Noise Modelling Report which is Volume 9, Appendix 14.1: of the EIAR and Appendix 5 of the NIS). Impact ranges for marine mammals were calculated using the Southall et al. (2019) impulsive criteria.

4. Pilling Mitigation Methodology

4.1 Introduction

Underwater noise modelling has been undertaken for a piling scenario which has been informed by the current understanding of pile drivability within the proposed development, with the results of that noise modelling having been used to inform the EIAR and this version of the MMMP. As the Proposed Development continues to obtain further data on ground conditions within the array area and this feeds in to more detailed ground models, the pile drivability understanding will continue to develop. As such, prior to construction, additional noise modelling will be undertaken based on the further developed understanding of ground conditions at that point and a piling scenario developed on that understanding. This MMMP, being intended as a live document will therefore be updated following the new noise modelling, with the final mitigation measures required for the Proposed Development identified within the final MMMP.

Therefore, at this point in time, the following mitigation measures have been identified as potential options which may be implemented within the final MMMP to seek to minimise the risk of any auditory injury to marine mammals from underwater noise during pile driving:

- Marine mammal observation;
- Passive acoustic monitoring;
- Pre-piling deployment of acoustic deterrent devices (ADD);
- Soft-start procedure; and
- Noise abatement.

Details of each of the mitigation measures listed above, are detailed in their relevant sections below. A summary of these measures is presented in Appendix 1.

4.2 Summary of PTS Risk

4.2.1 Instantaneous and cumulative PTS-onset

Modelling for WTG and OSP foundation impact piling considered effects across four representative locations within the Array Area, ranging from water depths between 34.8–58.6 m. Two monopile diameter scenarios were modelled with estimated maximum hammer energies depending on the engineering estimates relevant to each piling location.

4.2.1.1 Monopiles

The largest instantaneous PTS-onset impact range (SPLpeak; Table 4-1 for unmitigated impact pile driving is estimated at 810 m from the sound source for harbour porpoise, which can be mitigated for with embedded mitigation measures (e.g. MMO/PAM pre-watch over a 1,000 m mitigation zone and soft-start procedure). For all other marine mammal receptors, the maximum range was <100 m and as such they are not expected to be impacted while the proposed development follows embedded mitigation measures (Table 4-1). The greatest impact ranges correlated with the locations with the deepest water depth.

The largest cumulative PTS-onset impact range (SELcum) for unmitigated impact pile driving is estimated to be 26 km for minke whale. For all other marine mammal receptors, the maximum range was 15 km for harbour porpoise and <100 m for seal species and delphinids (Table 4-1). The predicted impact ranges for minke whale and harbour porpoise are greater than the distance which can be mitigated for with embedded measures; therefore, use of ADDs or noise abatement would be required to encourage individuals to leave the impact range or to limit the extent of the impact. The greatest impact ranges correlated with the locations with the deepest water depth.

4.2.1.2 Multi-leg foundation

The largest instantaneous PTS-onset impact range (SPLpeak) for unmitigated pin-pile driving is estimated at 690 m for harbour porpoise, which can be mitigated for with embedded mitigation measures. For all other marine mammal receptors, the maximum range was ≤ 50 m and as such, marine mammals are not expected to be impacted while the proposed development follows embedded mitigation measures (e.g. Pre-watch monitoring and soft-start; Table 4-1). The greatest impact ranges correlated with the locations with the deepest water depth.

The largest cumulative PTS-onset impact range (SELcum) for unmitigated pin-pile driving is estimated to be 15 km for minke whale. For all other marine mammal receptors, the maximum range was 7.3 km for harbour porpoise and < 100 m for seal species and delphinids (Table 4-1). The greatest impact ranges correlated with the locations with the deepest water depth.

Table 4-1 Summary of the modelled PTS onset impact ranges for marine mammals at the northeast (NE) and southeast (SE) locations within two scenarios of unmitigated pile-driving

Functional Hearing Group (FHG) / Species	Threshold	12.5 m monopile (at 5,500 kJ hammer energy) maximum range unmitigated		6 m pin-pile (at 3,000 kJ hammer energy) maximum range unmitigated	
		NE location	SE location	NE location	SE location
very high frequency (VHF) cetacean (i.e. Harbour porpoise)	Unweighted SPL_{peak} 202 dB re 1μPa	800 m	810 m	680 m	690 m
	VHF weighted SEL_{cum} 155 dB re 1 μPa² s	14 km	15 km	7.3 km	7.6 km
high frequency (HF) cetacean (i.e. bottlenose and common dolphin)	Unweighted SPL_{peak} 230 dB re 1μPa	<50 m	<50 m	<50 m	<50 m
	HF weighted SEL_{cum} 185 dB re 1 μPa² s	<100 m	<100 m	<100 m	<100 m
low frequency (LF) cetacean (i.e. minke whale)	Unweighted SPL_{peak} 219 dB re 1μPa	50 m	50 m	<50 m	<50 m
	LF weighted SEL_{cum} 183 dB re 1 μPa² s	26 km	26 km	15 km	15 km

Phocid Carnivore in Water (PCW; i.e. grey and harbour seals))	Unweighted SPL_{peak} 218 dB re 1µPa	60 m	60 m	50 m	140 m
	PCW weighted SEL_{cum} 185 dB re 1 µPa² s	<100 m	<100 m	<100 m	<100 m

4.3 Mitigation Zone

The mitigation zone will be defined as the maximum potential PTS onset impact range. The Developer will update the noise modelling, if required, prior to construction once the final design details are known. The DAHG (2014) guidance recommends a mitigation zone of 1,000 m for piling which is greater than the current largest impact range for instantaneous PTS onset modelled for the proposed development (i.e. 810 m). Whilst the SELcum PTS onset ranges are currently larger than this, ADDs are effective at displacing marine mammals at larger ranges and as such can provide cover for impact ranges greater than the advised 1,000m mitigation zone. Additionally, were noise abatement systems to be implemented for the proposed development, the impact ranges would be expected to be reduced compared to those considered in this version of the MMMP.

4.4 Pre-watch Monitoring

Pre-watch monitoring is a passive mitigation measure which can be conducted visually (refer to section 4.4.1) or acoustically (refer to Section 4.4.2). This measure is referred to as passive as observers monitor the mitigation zone without emitting noise or risk any form of direct disturbance to marine mammals.

4.4.1 Marine Mammal Observers (MMO)

The DAHG (2014) guidance recommends a pre-piling search of a minimum period of 30 minutes (in waters less than 200 m) for monopile installation. This pre-piling search will be conducted by trained, experienced and dedicated Marine Mammal Observers (MMO) who will be stationed on the piling vessel at an appropriate elevation that provides a 360° view of their surroundings. A trained and experienced MMO requires an individual to have passed a JNCC MMO training course, or equivalent, and hold a minimum of six weeks marine mammal survey experience.

To enable 24-7 construction operations, MMOs will work on back-to-back shifts with passive acoustic monitoring (PAM) operators. MMO duties shall only commence in daylight hours, where visibility is moderate (1-5 km) or good (>5 km). PAM can support visual observation in poor weather conditions or visibility (refer to Section 4.4.2).

The MMO will record all periods of marine mammal observations, including the start and end times of their visual effort, details of the operations, environmental conditions (sea state, weather, visibility, etc.) and any sightings of marine mammals around the piling vessel, using standardised data forms (Appendix 6 in DAHG (2014) guidance).

Following DAHG (2014) guidance, if a marine mammal is detected within the mitigation zone during the MMO pre-piling watch, the soft-start procedure will be delayed until the MMO has observed, assessed and confirmed that the individual(s) has vacated the mitigation zone and there have been no sightings for 20 minutes. If a marine mammal is observed within the mitigation zone during the soft-start, hammer power will not increase until the animal has vacated the mitigation zone. If a marine mammal is observed within the mitigation zone during full power, pile-driving may continue and the MMO will continue to note marine mammal presence and observations of animal behaviour, where possible.

MMO limitations include a reduced chance of detecting low profile marine mammals, such as harbour porpoise, in a Beaufort sea state greater than two (Gunnlaugsson et al., 1988, as referenced in Teilmann, 2003). Larger cetaceans (i.e. dolphins and whales) can generally be sighted up to a sea state four (Smith et al., 2020). The height of the vantage point used for observation is a principal factor in determining how far an MMO can see. So long as the MMO has good environmental/weather conditions (i.e. visibility, sea state and swell), an MMO that is, for example, 165 cm tall stationed on a platform 5 m from the water's surface could see up to 1,320 m, a platform height of 10 m would increase this viewing distance up to 2,320 m (as calculated through typical trigonometry methods as used by MMOs e.g. distance (m) = ((observation height (m)) x 1000/no. of mils in the binocular reticle).

4.4.2 Passive Acoustic Monitoring (PAM)

PAM is viewed as a complementary method to aid MMOs in poor weather conditions or visibility (<1 km; e.g. fog or heavy precipitation). This monitoring method has been used routinely since 2002 under jurisdictions following JNCC mitigation guidelines (JNCC, 2023a). PAM will be used as a form of mitigation under hours of darkness when an MMO cannot visually observe. This will be necessary if there is a break greater than 10 minutes during darkness, otherwise the operations would need to wait until daylight to resume. The PAM operator will follow the same data forms and communications procedure as the MMO.

PAM equipment includes a hydrophone array (which is placed over the side of the pile driving vessel), deck cable, data acquisition units (DAQs) and computer/laptop set up with an acoustics software such as PAMGuard (Gillespie et al., 2008). PAMGuard is an open-source software (www.pamguard.org) which has become the industry standard for monitoring and analysing marine mammal vocalisations.

Limitations of PAM include the ability to only detect individuals that are vocalising within range and directionality of the hydrophones during the monitoring period. Detectability of species can be reduced by masking caused by increased background noise levels due to vessel noise, heavy rainfall, or high sea states, for example. Some species will be difficult to detect depending on the background noise and species behaviour, such as low frequency vocalisations of baleen whales (e.g. minke whale Balaenoptera acutorostrata), which can be masked by vessel noise (Cholewiak et al., 2018; Risch et al., 2019), and seals are particularly difficult to detect due to their low vocalisation rates (Hayes et al., 2004; Stone, 2015).

DAHG (2014) guidance supports the use of PAM as a supplementary mitigation and projects in other jurisdictions that follow JNCC guidelines have used PAM as part of their mitigation measures routinely since 2002 (JNCC, 2023a). Use of PAM is also highlighted as appropriate for standard mitigation protocols within the Irish Whale and dolphin Group (IWDG, 2020) policy on offshore windfarm development. PAM is the best available method of monitoring during low visibility and hours of darkness. In addition, the Developer may also deploy an ADD (Refer to section 4.5) prior to commencing operations to encourage marine mammals to move out of the mitigation zone. The use of the ADD as part of the mitigation measures further reduces any risk to marine mammals where PAM may not detect individuals, for example, if they do not vocalise during the pre-watch period.

4.5 Pre-Piling Deployment of ADDs

The Developer may use an ADD, to ensure that there are no marine mammals in the mitigation zone, prior to the commencement of piling. Use of ADDs within this protocol follows the JNCC (2010) guidance in the absence of information within DAHG (2014) guidance, as well as best practice followed on recent OWFs in Scottish and English waters.

The typical ADD used for mitigation is a Lofitech AS Seal Scarer, but other suitable alternatives are available (McGarry et al., 2022); the ADD type to be used will be agreed with MARA and NPWS. The Lofitech AS seal scarer has been used for marine mammal mitigation purposes at a range of European OWF projects during the construction phase, including the C-Power Thornton Bank OWF in Belgium (Haelters et al., 2012), and the Horns Rev II, Nysted and Dan Tysk OWFs in Denmark (Carstensen et al., 2006, Brandt et al., 2009, Brandt et al., 2011, Brandt et al., 2013, Brandt et al., 2016). Within the UK, Lofitech AS seal scarer has been used as mitigation for Dudgeon OWF (Vattenfall, 2017) Beatrice OWF and Race Bank OWF (Seagreen Wind Energy Ltd, 2020).

PAM studies have shown that the Lofitech AS Seal Scarer deter harbour porpoises to a range of 7.5 km (Elmegaard et al., 2023; Graham et al., 2023), with other studies showing displacement effects over distances up to 15km (Brandt et al. 2016). Aerial survey studies have shown that ADDs are effective for harbour and grey seals at a range of approximately 1 km (Götz and Janik, 2010; Götz, 2008) and minke whales have been observed to flee to distances greater than 5 km (maximum tracking range noted within the study; Boisseau et al., 2021; McGarry et al., 2017). In the minke whale study, the deterrence effect continued after the ADD was deactivated with the animals continuing to swim away from the ADD location out to up to 5 km (at which point tracking was halted). This suggests that an ADD would deter minke whales further if activated for longer than the duration used in the study (i.e., 15 minutes; McGarry et al.,2017).

It is proposed that during pile-driving activities, one ADD will be deployed from the deck of the pilling vessel with enough cable length to allow the transducer to be positioned under the hull. The control unit and power supply will be set up in a suitable, safe position on deck where it can be secured to the vessel and located in an area of easy access for the MMO to deploy and operate during pre-watch.

Following the swim speeds used in the underwater noise modelling (Subacoustech Environmental, 2023), the average swim speed of 1.5 ms-1 for harbour porpoises, bottlenose dolphins and seals, and 3.25 ms-1 for minke whale, have been used to calculate ADD duration (Table 4-2).

Table 4-2 sets out the required ADD durations for the current PTS ranges for both instantaneous and cumulative thresholds based on the swim speeds stated above.

Post consent during the pre-construction phase, there will be further noise modelling and calculation of ADD durations undertaken with finalised piling and design parameters to confirm potential impacts on marine mammals, this will be documented within the MMMP.

In the event the ADD durations in the updated MMMP, informed by the final design, exceed the functional deterrent ranges associated with different marine mammal species, NAS will be considered to reduce these and options that may be used are discussed in Section 4.7.

Table 4-2 Modelled PTS onset ranges for SPLpeak and SELcum thresholds based on Southall et al. (2019) and the ADD duration theoretically required to ensure marine mammals would be outside their respective impact ranges.

Species PTS onset threshold	Species	Swim speed (ms^{-1})	Max PTS onset range (m)+	ADD duration (minutes)
Low frequency cetacean (219 dB SPL_{peak})	Minke whale	3.25	50 m	<1
Low frequency cetacean (183 dB SEL_{cum})		3.25	26 km	133.33
High frequency cetacean (230 dB SPL_{peak})	Bottlenose and common dolphin	1.5	<50 m	<1
High frequency cetacean (185 dB SEL_{cum})		1.5	<100 m	1.11
Very high frequency cetacean (202 dB SPL_{peak})	Harbour porpoise	1.5	810 m	9
Very high frequency cetacean (155 dB SEL_{cum})		1.5	15 km	166.67
Pinniped seals (218 dB SPL_{peak})	Grey and harbour seals	1.5	140 m	1.56
Pinniped seals (185 dB SEL_{cum})		1.5	<100 m	1.11

+ based on a starting distance of 0 m from the pile

It should be noted that the calculations of the required duration for the ADD deployment assumes that the animals are present adjacent to the vessel when the ADD is activated. As noted above, recent studies of impacts from construction at offshore wind farms showed that the presence of vessels alone (prior to the start of any piling activity) contributed to deterrence of harbour porpoises from a very close range (Graham et al., 2019) and therefore it is likely that the mammals will be much further away than the minimum distances identified above.

4.6 Soft-Start Procedure

Following the pre-piling procedures (as identified above, ADD activation and MMO/PAM pre-piling watch), a soft-start procedure for monopiling and/or pin-piling will commence. This will be a minimum of 30 minutes and in practice will be much longer as this comprises the period from the first blow through to use of the maximum hammer energy. For the current piling scenario (Table 4-3 and Table 4-4), this comprises 30 minutes of a slow strike rate of 0.1 blows per minute at 825 kJ (for the 5,500 kJ maximum hammer energy scenario) or 450 kJ (for the 3,000 kJ maximum hammer energy scenario) followed by 30 minutes of 10 blows per minute at the same hammer energy. The first 3 blows are often referred to as “stabilisation blows” where single hammer strikes are used to ensure the pile is stable within the soil and corrected positioned for the installation. After this initial phase, the hammer energy will be gradually ramped up to the maximum hammer energy required to reach penetration depth. The specified ramp up is based on the ramp up required for the hardest ground conditions within the array area; as such, it is likely that many piles will require less blows, or a lower maximum hammer energy.

Table 4-3 Summary of the soft start and ramp up scenario used for the monopile foundation modelling. Source: Subacoustech Environmental, 2023

Monopile foundation	825 kJ		1,100 kJ	2,200 kJ	3,300 kJ	4,400 kJ	5,500 kJ
No. of strikes	3	300	600	300	300	300	8,745
Duration	30 mins	30 mins	20 mins	6 mins 40s	6 mins 40s	6 mins 40s	4 hours 25 mins
Strike rate (blows/min)	0.1	10	30	45			33
10,548 strikes over 6 hours 5 mins per pile							

Table 4-4 Summary of the soft start and ramp up scenario used for the multi-leg pile foundation modelling. Source: Subacoustech Environmental, 2023.

Jacket pile foundation	450 kJ		600 kJ	1,200 kJ	1,800 kJ	2,400 kJ	3,000 kJ
No. of strikes	3	300	600	300	300	300	3,300
Duration	30 mins	30 mins	20 mins	6 mins 40s	6 mins 40s	6 mins 40s	1 hour

							40 mins
Strike rate (blows/min)	0.1	10	30	45			33
5,103 strikes over 3 hours 20 mins per pile 10,206 strikes over 6 hours 40 mins for 2 piles							

It should be noted that this modelling scenario is based on the upper bounds of the soil conditions and is therefore deemed precautionary. Therefore, whilst piling will adhere to the ramping up process, the hammer energy will not be increased above that which is necessary to complete the piling. For example, if ground conditions are such that a lower hammer energy is sufficient to complete installation, then the hammer energy will not unnecessarily be ramped up to the maximum capacity.

4.7 Noise Abatement

In the event that impact ranges predicted by the underwater noise modelling to be undertaken based on the final design for the proposed development post-consent are larger than distances capable of passive mitigation (MMOs and PAM) and ADDs, Noise Abatement Systems (NAS) may be used to minimise the risk of injury. The term NAS is commonly used to describe systems which are designed to reduce the emission of underwater noise into the wider marine environment and as such the terms encompasses true abatement systems which alter the sound at source i.e. hammer attachments (e.g. PULSE or the Menck Noise Reduction Unit) or alternative types of percussive piling (e.g. BLUE piling) as well as mitigation systems that reduce the noise released into the wider environment such as bubble curtains and hydro-sound dampers.

The DAHG (2014) guidance presents a staged process towards managing risk but does not enforce any process nor state explicit decibel limits to restrict noise impacts. In Section 4 of the guidance, it details various management options for regulatory authorities to consider while approving any marine licences. The following point references use of NAS as a risk minimisation measure:

"A6.4. Incorporate the use of fully enclosing or confined bubble curtains, encircling absorptive barriers (e.g., isolation casings, cofferdams) or other demonstrably effective noise reduction methods at the immediate works site, in order to reduce underwater sound propagation from on-site operations. Studies have shown that such methods can provide a significant reduction in sound input to the wider aquatic environment in the order of 10-30 dB."

Table 6-1 presents a summary of available NAS, with relevant noise reduction values within tested water depths, which are viable for the Proposed Development. Following confirmation of the final design, the MMMP will be updated to include the appropriateness of the best available technology based on that design and commercial viability. Based on the current design, where maximum hammer energies are reached during WTG foundation installation and where cumulative PTS onset ranges are considered for mitigation, NAS will be used to reduce impacts of underwater noise and vibration.

The proposed development has a water depth, relative to the lowest astronomical tide level, ranging from 30 – 63 m (Volume 9, Appendix 10.2 of the EIAR, Marine Physical Processes Numerical Modelling). Chapter 10 of the EIAR which is Marine geology, Oceanography and Physical Processes states that the typical maximum peak flow speed (on spring tides) during the flood phase is around 0.48m/s within the middle of the ECC, in contrast, the equivalent peak ebb flow speed is around 0.41m/s. There are also infrequent atypical peak flood flows which reach up to 0.64m/s which are associated with short periods of imbalance between the opposing tidal waves from the north and south which develops a local gyre. For the array area, the maximum peak flow speed (on spring tides) during the flood phase is around 0.52m/s, in contrast, the equivalent peak ebb flow speed is around 0.46m/s. Peak flows during periods of neap tide show slightly less asymmetry between flood and ebb and typically reach up to 0.3m/s.

Some NAS presented in Table 4-5 will have limitations in the deeper locations of the array area, but the tidal flow is compliant with all NAS displayed below. Current limitations of each technology are included in the development status column.

Table 4-5 Summary of available NAS methods and performance parameters. Where depth is included with a noise reduction value, this is the water depth the device was tested within.

Method / System	Noise reduction principle	Can be used in combination with	Noise reduction	Development status
Big bubble curtains[b]	Reflection, scattering and absorption (frequency dependent)	Single, double, triple application; isolation casing; Hydro Sound Dampers; reduced blow energy; prolonging pulse duration	Single: 11 – 15 dB SEL (depth: 25 m), Double: 14 – 18 dB SEL (depth: 40 m)	State of the art (up to ~ 45 m water depth, ~ 8 m pile diameter).
Isolation Casings[b]	Shielding, reflection	Additional built-in features; double bubble curtain; reduced blow energy; prolonging pulse duration	13 – 17 dB SEL (depth: < 45 m)	State of the art (up to ~ 45 m water depth, ~ 8 m pile diameter)
Hydro Sound Dampers[b]	Encapsulated resonator system. Scattering and absorption by resonators, reflection, dissipation and material damping (frequency tuning possible)	Double Bubble curtain; reduced blow energy; prolonging pulse duration; pile cushioning	up to 12 dB SEL (depth: 40–60 m)	State of the art (in principle unlimited by water depth, ~ 8 – 13 m pile diameter)

Pile cushions[a]	Dampens high-frequency noise and wave amplitudes, prolongation of the pulse duration	All secondary noise mitigation measures	2–6 dB SEL; 9–12 dB SPL	Proven modular add-on (e.g. Pulse or MNRU)) that can be used with hydrohammers.
Dewatered Cofferdams[b]	Decoupling noise from the water column	Double Bubble curtain; Hydro Sound Dampers; reduced blow energy; prolonging pulse duration	13 – 23 dB SEL (depth: < 20 m)	Monopile full scale prototype tested offshore in 2011 and 2012, state of the art in substations
AdBm Noise Mitigation System[a]	Encapsulated resonator system. Broadband frequency attenuation	Completely customisable in design	Up to 3 – 11 dB SPL at targeted frequency (depth: < 47 m)	Full scale model successfully tested by Van Oord in 2019. Van Oord plan to continue to use this technology in future wind farms (in principle not constrained by water depth).
BLUE Piling Technology[a]	Prolongation of the pulse duration	All secondary noise mitigation measures	19–24 dB SEL (depth: 22.4 m)	Full scale prototype successfully tested under offshore conditions, improvements on technology currently being studied and implemented.

Vibratory Hammer[a]	Alternative piling method using low frequency oscillations	All secondary noise mitigation measures	10 – 20 dB SEL, 30 s (depth: < 25 m)	Proven technology in combination with impact piling. Exclusive vibropiling: Offshore pilot wind turbine with monopile successfully installed in Dutch waters.

Key: a: Primary Mitigation Measure; b Secondary Mitigation Measure. SEL is measured in dB re 1 µPa2s and SPL in dB re 1 µPa.

Additional note- performance is non verified by author, based on literature cited only.

Sources: Bubble Curtains: Koschinski 2011, Koschinski and Lüdemann 2020, Merchant and Robinson, 2020, Bohne et al., 2019, Tsouvalas et al., 2016. Isolation Casings: Verfuss et al., 2019, O'Kelly and Arshad, 2016, Koschinski and Lüdemann, 2015. Hydro Sound Dampers: Bellmann et al., 2020, Elmer, 2018, Elmer and Savery, 2014. Pile cushioning: Merchant and Robinson, 2020. Dewatered Cofferdams: Koschinski and Lüdemann, 2020, Kim et al., 2019, O'Kelly and Arshad, 2016. AdBm NMS: Verfuss et al. 2019; Van Oord, 2020; AdBm technologies, 2020.

4.8 Breaks in Piling Procedure

Standard DAHG (2014) guidance for breaks in piling activity (high output pile driving) will be followed should they occur. If there is a break in piling operations for a period of greater than 10 minutes, then a pre-piling search and soft-start procedure as set out above will be repeated prior to piling recommencing, if it is practicable to do so (see below). If a watch of the mitigation zone has been continued, the MMO/PAM operator will confirm the presence or absence of marine mammals and it may be possible to commence the soft-start immediately. If there has been no watch, then a pre-piling search will need to be undertaken prior to soft-start commencing.

Under some circumstances, it may not be practicable to recommence piling with a soft-start procedure due to technicalities such as ground conditions and equipment limitations. In this case the ADD will be deployed prior to re-commencing piling, following pre-piling search. This will align to DAHG guidance which advises where ramp-up is not possible, alternatives will be implemented whereby the underwater output of acoustic energy is introduced in a consistent, sequential and gradual manner over a period of 20-40 minutes prior to commencement of the full necessary output.

Where practicable (i.e. if vessel remains on site and hammer crew think they can recommence within one hour of halt), the MMO/PAM operator will maintain watch throughout any break in piling activities to ensure that no marine mammals are present within the 1,000 m radius.

4.9 Delays in the Commencement of Pilling

There is a risk of animals moving into the mitigation zone when there is no piling activity nor ADD activation. If ADDs are activated for their permitted duration and piling is not ready to commence, the ADD will be switched off. This is to avoid unnecessary noise entering the marine environment. The ADD will not be switched on until the ADD operator is notified that piling is ready to commence and the Developer will follow the procedure as set out in this MMMP (i.e. MMO/PAM pre-watch, ADD activation and soft-start).

4.10 Data Collection and Reporting

A record of piling operations, MMO/PAM survey effort and sightings will be maintained during piling. These reports include:

- An outline of the marine mammal monitoring methodology and procedures employed;
- A record of all piling operations detailing dates, soft-start duration, piling duration, hammer energy during soft-start and full-power, and any operational issues;
- A record of survey effort including the duration of the MMO/PAM watch, environmental conditions, a description of any marine mammal sightings and any actions taken, and a record of any incidental sightings made during the pre-piling watch or operations;
- Details of any problems encountered during the piling process including instances of non-compliance with the marine licence; and
- Any recommendations for amendment of the protocol.

Reports will be collated and provided to MARA for information once the works are complete, alongside a summary report of the numbers of marine mammals seen and any mitigation required during construction. The report will also discuss the protocols followed and put forward any recommendations based on project experience that could benefit future OWF construction projects.

4.11 Communications

A communications protocol will be developed between the MMO/ADD operator, the PAM operator and ADD operator (a trained crew member on night shift) and the construction manager and/or appropriate crew members (e.g. hammer operators and Operations Manager). The below details the personnel, organisations, and responsibilities for the MMMP:

- The Developer’s Environment Manager
  - Overall responsibility for compliance with all environmental monitoring, mitigation and reporting requirements on the Proposed Development. Will ensure that the MMO, PAM operator, ADD operator, nominated Client Representative for construction activities and installation personnel have received all relevant information, and will consult with them before making decisions affecting the MMMP.
- MMO and PAM operator(s) (to be confirmed)
  - Responsible for advising on, monitoring and recording compliance with this MMMP. Liaises with the nominated Client Representative for construction activities, and Offshore Construction Contractor as appropriate. PAM and MMO responsibilities cannot be shared by one person. The PAM operator is responsible for the PAM equipment (verification and calibration prior to use) in accordance with the MMMP, co-ordination of deployment, maintenance, operation, and recording/reporting.
- ADD operator(s) (to be confirmed)
  - Responsible for the provision of equipment (verification and calibration prior to use) in accordance with the MMMP, co-ordination of deployment, maintenance, operation and recording/reporting. The ADD operator can work a dual role as the MMO; however, the ADD and PAM operator cannot be the same person. If ADD operation is required during darkness, a crew member on night shift will be trained by the MMO/ADD operator during mobilisation.
- Nominated Client Representative for construction activities
  - Takes offshore responsibility that the requirements of this protocol are met, responsible for ensuring adequate communication and liaison between MMO/PAM operator and installation personnel as required. Has the responsibility to delay piling activities when notified by the MMO/PAM operator.
- Offshore Construction Contractor (to be confirmed)

 – Responsible for informing MMO about scheduled piling activity and communication as per protocol. Responsible for providing pile driving records to MMO/PAM operator and Client Representative.

A pre-survey kick-off meeting is recommended to confirm the marine mammal mitigation requirements and further meetings on board the vessel, between the vessel surveyors and engineers, and the MMOs to agree on mitigation procedures as set out in the MMMP and consent.

- The communications protocol and flow charts will include but not be limited to procedures:
- To notify the MMO/PAM operator to begin 30-minute pre-watch prior to soft-start commencing;
- For the MMO/PAM operator to give the nominated Offshore Construction Contractor the green light for construction activities; and that deployment of ADD and activation for the required time has been successful;
- The nominated Client Representative or Offshore Construction Contractor to notify the MMO/PAM operator that there has been a delay in the onset of the soft-start; and that the MMO should turn off the ADD; and
- For the MMO/PAM operator to notify nominated Offshore Construction Contractor or Client Representative for construction activities that a marine mammal has been detected within the mitigation zone and that the soft-start will need to be delayed to notify nominated Client Representative for construction activities that a marine mammal has been detected within the mitigation zone and that the soft-start will need to be delayed.
- The client to notify MARA that the piling operations have been successfully completed.

5. Geophysical Survey Mitigation Methodology

5.1 Introduction

Geophysical survey techniques may be used as part of the installation process, including pre-construction surveys, monitoring of the installation activities, and 'as built' surveys. The purpose of geophysical surveys is to characterise the seabed conditions and morphology, determine soil design parameters and identify any potential obstructions or hazards to the construction works as well as furthering understanding of baseline metocean conditions. Geophysical surveys are non-intrusive and will utilise towed equipment such as side scan sonar (SSS), sub bottom profiler (SBP), multibeam echosounder (MBES) and magnetometer to gather detailed information on the bathymetry, seabed sediments, geology, and anthropogenic features (e.g., existing seabed infrastructure, unexploded ordnance (UXO)) that exist across the offshore development area.

The MMMP is focused on outlining a project-specific mitigation protocol during the geophysical surveys to minimise the risk of PTS, as presented herein, adhering to international best practice, including DAHG (2014) guidance. A summary of these mitigation measures is presented in Appendix 2.

5.2 Summary of Risk of PTS

Only the SBP is predicted to overlap with the estimated hearing range of relevant marine mammal species included in this assessment. As such, the other noise sources are not considered to pose a risk of causing PTS in marine mammals as it won't be audible to them.

For dolphins, the source levels of SBP equipment are below the PTS-onset thresholds. As such, there is no risk of PTS onset to any dolphin species from the use of this equipment.

For harbour porpoise, the predicted SBP source levels exceed the PTS-onset threshold and as such, the use of this equipment has the potential to cause PTS. However, results for SBPs have indicated that PTS onset is likely to occur within a small area directly around the source, with one study estimating that PTS could arise between 17–23 m from the use of this equipment at source levels of 267 dB re 1 µPa (SPLpeak) (BEIS, 2020).

For seals and minke whales, only the upper limits of potential sources levels are expected to exceed the PTS-onset thresholds. Whilst it is possible that the use of this equipment could operate at source levels below the PTS-onset thresholds for these species, at this stage of the proposed development it is difficult to determine whether that will be the case. Noise modelling for pipeline surveys have previously indicated PTS-onset in minke whales within 5 m of the source when SBP pingers operate with a sound source of 220 dB re 1 µPa (SPLpeak; Shell 2017), and ~10 m for seals (Department for Business Energy & Industrial Strategy 2019).

5.3 Mitigation Zone

The mitigation zone is dependent on the specification/type of equipment and impact range of injury for the most sensitive marine mammal. Based on the assessment, the maximum range for instantaneous injury (PTS onset) is < 25 m. This indicates that instantaneous injury could occur within more restricted impact ranges than the advised 1,000 m mitigation zone stated within DAHG (2014) guidance. Consequently, the proposed development will use a mitigation zone of 500 m from the SBP sound source.

5.4 Pre-watch Monitoring

5.4.1 Marine Mammal Observers (MMO)

A general introduction to MMO duties is found in Section 4.4.1. This procedure follows DAHG (2014) guidance.

Two trained and dedicated (personnel with no other role onboard the vessel) MMOs will be present on board the vessel throughout the survey. The MMOs carry out dedicated watches for marine animals during survey operations during daylight hours. Continuous watches are conducted when the survey equipment is not operational, and all effort data recorded accordingly. Two MMOs enable continuous watch while avoiding observer fatigue.

The MMOs will monitor the area for 30 minutes prior to commencement of activities with the naked eye and 10 x 50, 7 x 50 or 7 x 30 reticule binoculars checking for visual cues such as feeding seabirds, splashes, blows and sea surface disturbance. When marine mammals are observed, the distance and bearing to the sighting will be recorded along with the species identification, time of sighting, vessel position and other data required for the completion of the sighting form. Species identification can be aided, by photographic records of sightings, taken using digital cameras or reference to a field guide (e.g. Shirihai and Jarrett, 2006).

Observations are carried out from the same vessels as the operations. Observation points should provide unobstructed 360-degree views of the mitigation zone, preferably from the bridge wings.

Distances to sightings are estimated using reticule binoculars or range finder sticks and by reference to the known distances of, for example, acoustic gear.

Information on operations (e.g. survey type, start/end of sound output, vessel location, time of day and any mitigation actions), survey effort (including the vessel's location and weather conditions) and sightings will be recorded using standardised data forms (DAHG, 2014). Communication with survey and the MMOs are maintained by handheld VHF radio with the surveyors in the instrument room informing the MMO of all planned activities and any change in source activity.

5.4.2 **Passive Acoustic Monitoring (PAM)**

A general introduction to PAM is found in Section 4.4.2. The PAM operator will follow the same operational procedure as the MMO but will work back-to-back shifts with the MMO to cover nighttime operations.

The hydrophone array is to be deployed so that the hydrophones are located at a reasonable distance from the vessel and survey equipment to limit interference and masking of sound. This will be determined by the PAM operator once onboard and can assess and agree with the vessel captain where they can position and deploy the PAM cable from. The vessel crew should aid the PAM operator in determining where sound sources are located in relation to the vessel.

5.5 Soft-Start Procedure

Survey equipment with a source SPL above 170 dB re 1µPa shall commence from a lower energy start-up (e.g. a single electric discharge, starting from the lowest sound energy level possible and incrementally adding more until the full complement is achieved) and increase gradually over a period of 40 minutes. After the 40 minutes of ramp-up is concluded, there is no requirement to halt activities even if visibility worsens or if marine mammals enter the mitigation zone.

Where SBP equipment are used, where the operational parameters of the equipment allow, start-up energy will commence from the lowest possible energy and thereafter increase incrementally to operational power over a period of 20 minutes. If the equipment is unable to change the energy levels, the survey team will switch the equipment on and off over the period of 20 minutes, where the portion of time that the equipment is switch on increases gradually. After the 20 minutes of ramp-up is concluded, there is no requirement to halt activities even if visibility worsens or if marine mammals enter the mitigation zone.

5.6 Delay of Operations

The start of the acoustic equipment will be delayed if marine mammals are detected within the mitigation zone during the pre-watch, allowing the animals time to move away from the acoustic source. The start of the source will be delayed for at least 30 minutes following the last sighting within the mitigation zone.

5.7 Breaks in Operations

For any breaks in operation of the equipment of 10 minutes the MMO/PAM operator will undertake dedicated monitoring to check no marine mammals are present within the mitigation zone prior to the source restarting.

If a marine mammal is sighted within the mitigation zone during a break in operation, the equipment will recommence firing with a full soft start once the mitigation zone has been clear for 30 minutes from the last sighting.

For any breaks in operations of more than 10 minutes the equipment will only recommence following a full 30 minutes of dedicated pre-start monitoring and a soft start. If the MMO/PAM operator has been monitoring prior to and throughout the break, this time contributes to the pre-start monitoring time. The source is only started once the mitigation zone is clear of marine mammals for 30 minutes.

For any breaks in operation of more than 30 minutes the equipment will recommence operation following 30 minutes of dedicated pre-start monitoring and a soft start. If the MMO/PAM operator has been monitoring during the break this time contributes to the pre-start monitoring time.

Should marine mammals be sighted within the mitigation zone during this period the start of the equipment will be delayed for at least 30 minutes from the last sighting within the mitigation zone.

5.8 Line Changes

For line changes taking longer than 40 minutes, the source will be stopped, then a pre-watch of 30 minutes followed by a soft-start will be required to resume operations.

5.9 Data Collection and Reporting

The MMO/PAM operator will compile data throughout the survey into three main data sheets: 1) Effort, 2) Operations, and 3) Sightings, in line with Appendix 6 of the 'Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters' (DAHG, 2014).

5.10 Communications

A pre-survey kick-off meeting is recommended to confirm the marine mammal mitigation requirements and further meetings on board the vessel, between the vessel surveyors and engineers, and the MMO/PAM operator to agree on mitigation procedures as set out in the MMMP and consent.

All communication to follow the agreed protocol. Notice for commencement of the pre-line search is to be given to the MMO/PAM operator by VHF radio, at least one hour before any source operation. All soft starts and tests to be cleared with the MMO/PAM operator prior to source activation. In the case of a mitigation action, the MMO/PAM operator would communicate with the surveyors directly, who would then advise all parties.

6. UXO Mitigation Methodology

6.1 Introduction

This section of the MMMP has been developed for the purpose of mitigating the risk of physical trauma and auditory injury (PTS) to marine mammals by the proposed UXO clearance activities. The MMMP presented here can be considered a proposed list of measures and procedures, which can be modified in accordance with advice received from the regulator and their specialist UXO advisors as appropriate prior to UXO clearance activities commencing. Specifically, once UXO identification surveys are complete, further details of the anticipated number, location and type of UXO that may require clearance will be known. The Department of Art, Heritage and the Gaeltacht guidance to manage the risk to marine mammals from man-made sound sources in Irish waters (DAHG, 2014) does not specifically cover UXO; however, it does provide guidance on blasting. Reference is also made to the JNCC guidelines for minimising the risk of disturbance and injury to marine mammals whilst using explosives (JNCC, 2010; 2021; 2023b) as well as best practice from other wind farms in other jurisdictions.

Where appropriate, mitigation may take the form of avoiding the need for the use of explosives, either by leaving the confirmed UXO in situ and micro-siting construction work and infrastructure around it, relocating the UXO to a safe place and leaving in situ, removal of the UXO and taken away for disposal, or the explosive is made safe via low order techniques. However, avoidance, relocation or low order methodologies may not be possible for some UXO and, therefore, a high order detonation may be required.

High-order disposal of UXO, where an attempt is made to fully detonate the contents of the UXO, presents the greatest risk of causing PTS in marine mammals. Alternative methods of detonation such as low-yield and deflagration where practicable can be used as embedded mitigation. Due to the technique involving the disruption (low yield) or burning (deflagration) of the explosive rather than the instigation of an explosion, low-order disposal represents the lowest potential impact and is the preferred method for in situ disposal. The potential for physical trauma, PTS or behavioural disturbance is much reduced for low-yield disposal, corresponding only to the size of the donor charges to be used (as no secondary explosion of the main charge is caused).

A summary of mitigation measures included in this section is presented in Appendix 3.

6.2 Summary of PTS Risk

Table 6-1 summarises the impact ranges for the various FHGs against various charge weights. The Developer has committed to this MMMP to reduce the risk of physical trauma or PTS-onset as far as reasonably practicable. Any charge with PTS-onset impact ranges greater than 1,000 m would be required to implement noise abatement to reduce risk of injury to mitigatable ranges.

To deter marine mammals from potential injury zones, ADDs will be deployed during pre-watch periods. Details of ADD use and soft-start charges will need to be tailored to the anticipated UXO sizes requiring clearance at the site and the different methods of UXO disposal which may be applied.

Table 6-1 shows the potential impact radius of up to 12 km for unmitigated detonations up to a maximum of 525 kg + donor. It has been assumed that avoidance and alternatives, such as low order detonation (e.g. deflagration) will be considered for the UXO inventory for the proposed development where appropriate.

Table 6-1 Summary of the auditory injury (PTS-onset) impact ranges for UXO detonation using the impulsive, weighted SELss and unweighted SPLpeak noise criteria from Southall et al., (2019) for marine mammals.

Southall et al. (2019)	PTS (weighted SEL_{ss})				PTS (unweighted SPL_{peak})			
	LF 183dB	HF 185dB	VHF 155dB	PCW 185dB	LF 219dB	HF 230dB	VHF 202dB	PCW 218dB
Low order (0.25kg)	230m	<50m	80m	40m	170m	60m	990m	190m
25kg + donor	2.2km	<50m	570m	390m	820m	260m	4.6km	910m
55kg + donor	3.2km	<50m	740m	570m	1.0km	340m	6.0km	1.1km
120kg + donor	4.7km	<50m	950m	830m	1.3km	450m	7.8km	1.5km
240kg + donor	6.5km	<50m	1.1km	1.1km	1.7km	560m	9.8km	1.9km
525kg + donor	9.5km	50m	1.4km	1.6km	2.2km	730m	12km	2.5km

6.3 Mitigation Zone and Pre-watch Monitoring

If detonation is deemed required, a mitigation zone of 1,000 m from the detonation location will be established, within which it will be ensured, through visual observations (trained and experienced MMOs), ADD (refer to Section 6.4) and PAM where required, that no marine mammals are present prior to the detonation event. Visual monitoring will be conducted in accordance with DAHG (2014) guidance and PAM will be conducted following JNCC (2010; 2023) guidance. The pre-detonation monitoring should be conducted for a minimum of 30 minutes. Should a marine mammal be detected within the mitigation zone during this time, the monitoring period should be extended by a further 30 minutes. Once 30 minutes has elapsed since the last marine mammal detection, detonation operations may proceed. This pre-detonation procedure is appropriate to the conditions at this site which is applicable in locations of up to 200 m water depth.

In accordance with DAHG guidance (2014), detonations will only occur during daylight and with a strong preference for calm sea conditions. It is advised that, where practicable, detonations be scheduled for early in the day to allow a buffer should marine mammal detections warrant delays. This will reduce the risk of operations having to cease due to nightfall. Ensuring that no marine mammals are present in the mitigation zone prior to detonation will reduce the risk of physical trauma to any species of marine mammal to negligible.

Two MMOs are required to monitor the mitigation zone. Typically, one or two vessels survey around the 1,000 m mitigation zone border on vessels with an observation platform that covers the mitigation zone. One MMO is typically deployed on a smaller vessel that can vacate the area quickly. This vessel, normally a rigid inflatable boat (RIB), will be stationed near the detonation location during the pre-watch and then vacates prior to detonation for safety. In such circumstances, the MMO will monitor the area and note timings of vessel vacation in relation to detonation in the final report.

6.4 Acoustic Deterrent Device (ADD)

Where a UXO disposal method has a risk of PTS impact range that may exceed the 1,000m mitigation zone there is a residual risk of auditory injury to marine mammals at a greater range than can be mitigated by monitoring of the 1,000 m mitigation zone alone. Therefore, an ADD will be operated for a pre-determined length of time, concurrent to the pre-detonation search, to deter marine mammals to a greater distance prior to any detonation. For the site specific UXO clearance activities, it will be necessary to operate the ADD for different durations according to the UXO disposal method used, UXO/charge size, and associated predicted impact ranges. It will also be important to consider the reduction in ADD duration associated with the use of NAS in the final MMMP.

Activation of the ADD should overlap with the latter period of the pre-watch which will be extended to allow a 30 minute search prior to the ADD being switched on. If a delay in detonation is required due to an animal being present within the mitigation zone and the ADD is being used, the ADD should remain active for the duration of the delay; however, if the delay is thought to be greater than one hour, the MMO should consider switching the ADD off to reduce unnecessary noise being emitted into the marine environment. If the ADD is switched off, it must be re-activated for the full duration required prior to the rescheduled detonation.

6.5 Noise Abatement

Where auditory injury impact ranges from the use of high order detonations are greater than what can be mitigated using MMO/PAM watch and ADD (e.g. > 7.5 km; e.g. 120kg + donor impact ranges shown in Table 6-1), noise abatement will be used. MMO/PAM pre-watch and ADD use will still be required if noise abatement is used.

Noise abatement methods include those that act as a barrier, such as big bubble curtains (refer to Table 4-5), to attenuate the emitted sound of a detonation. If bubble curtains are used, they will not be switched on if a marine mammal is within the mitigation zone to ensure they are not trapped within the curtain. Instead, the curtain will be switched on once the pre-watch is concluded and the MMO/PAM operator gives the clear for detonation to occur. Bubble curtains can be less effective in water depths greater than 45 m or water currents greater than 0.75 ms-1 (BSH, 2024). The position of the UXO on the seabed is considered to produce a slight “muffling effect” on the explosion compared to mid-water explosions (Robinson et al., 2022), and tidal flow is typically lower at the seabed compared to mid-water column which would be helpful if tidal flows are at or just above the upper range for bubble curtain efficiencies.

6.6 Technical Delays in operation

If the planned detonation is delayed due to technical reasons during the pre-watch, the Operations Manager and vessel crew need to discuss with the MMO/PAM operator on whether they should continue observing (if the delay is thought to be < 1 hour) or whether they need to postpone the search. If the search is postponed, then a full pre-watch is required prior to the rescheduled detonation.

6.7 Post-detonation Search

It is recommended for the MMO to continue monitoring the mitigation zone during the detonation procedure and undertake a post-detonation search for at least 15 minutes after the final detonation. The MMO is to look for evidence of injury to marine life, including any fish kills. Any other unusual observations will be noted in the post-activity report.

6.8 Data Collection and Reporting

A detailed record of UXO clearance operations, mitigation procedures and marine mammal sightings will be prepared and submitted in compliance with consent conditions and will include completion and submission of standardised forms in line with the ‘Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters’ (DAHG, 2014).

Reporting will include a record of:

All confirmed UXO identified, including estimated size, type, location and water depth;

- The approach taken for each confirmed UXO, including the dates, times, disposal method attempted, size, type and number of donor charge(s) used;
- Vessel presence, location and activity during UXO clearance operations;
- The outcome of each UXO disposal, including evidence of high-order detonation, any clearing charges required and method of debris and residue recovery;
- The mitigation procedures followed for each UXO disposal, including details of visual observations, ADD duration and size and timing of soft-start charges where required;
- All marine mammal sightings and completed marine mammal recording forms; and

- Any problems encountered and instances of non-compliance with the JNCC (2010; 2023)/DAHG (2014) guidelines, MMMP and variations from agreed procedures.

Reports will be collated and provided to MARA for information once the works are complete, alongside a summary report of the numbers of marine mammals recorded (visually or acoustically) and any mitigation required during UXO clearance. The report will also discuss the protocols followed, and put forward any recommendations based on project experience, that could benefit future OWF construction projects.

6.9 Communications

The MMO, PAM and ADD operator will be appointed either directly or indirectly by the Developer. A communications protocol will be developed between the MMO/ADD operator, the PAM operator and ADD operator (a trained crew member on night shift) and the construction manager and/or appropriate crew members (e.g. detonation crew, vessel crew and Operations Manager).

General responsibilities of personnel is included in Section 4.11.

The communications protocol and flow charts will include but not be limited to procedures:

- To notify the MMO/PAM operator to begin 30-minute pre-watch prior to UXO clearance procedure commencing;
- For the MMO/PAM operator to give the nominated Offshore Construction Contractor the green light for clearance activities; and that deployment of ADD and activation for the required time has been successful;
- The nominated Client Representative or Offshore Construction Contractor to notify the MMO/PAM operator that there has been a delay in the onset of the UXO clearance; and that the MMO should turn off the ADD; and
- For the MMO/PAM operator to notify nominated Offshore Construction Contractor or Client Representative for construction activities that a marine mammal has been detected within the mitigation zone and that the soft-start will need to be delayed to notify nominated Client Representative for construction activities that a marine mammal has been detected within the mitigation zone and that the soft-start will need to be delayed.

7. References

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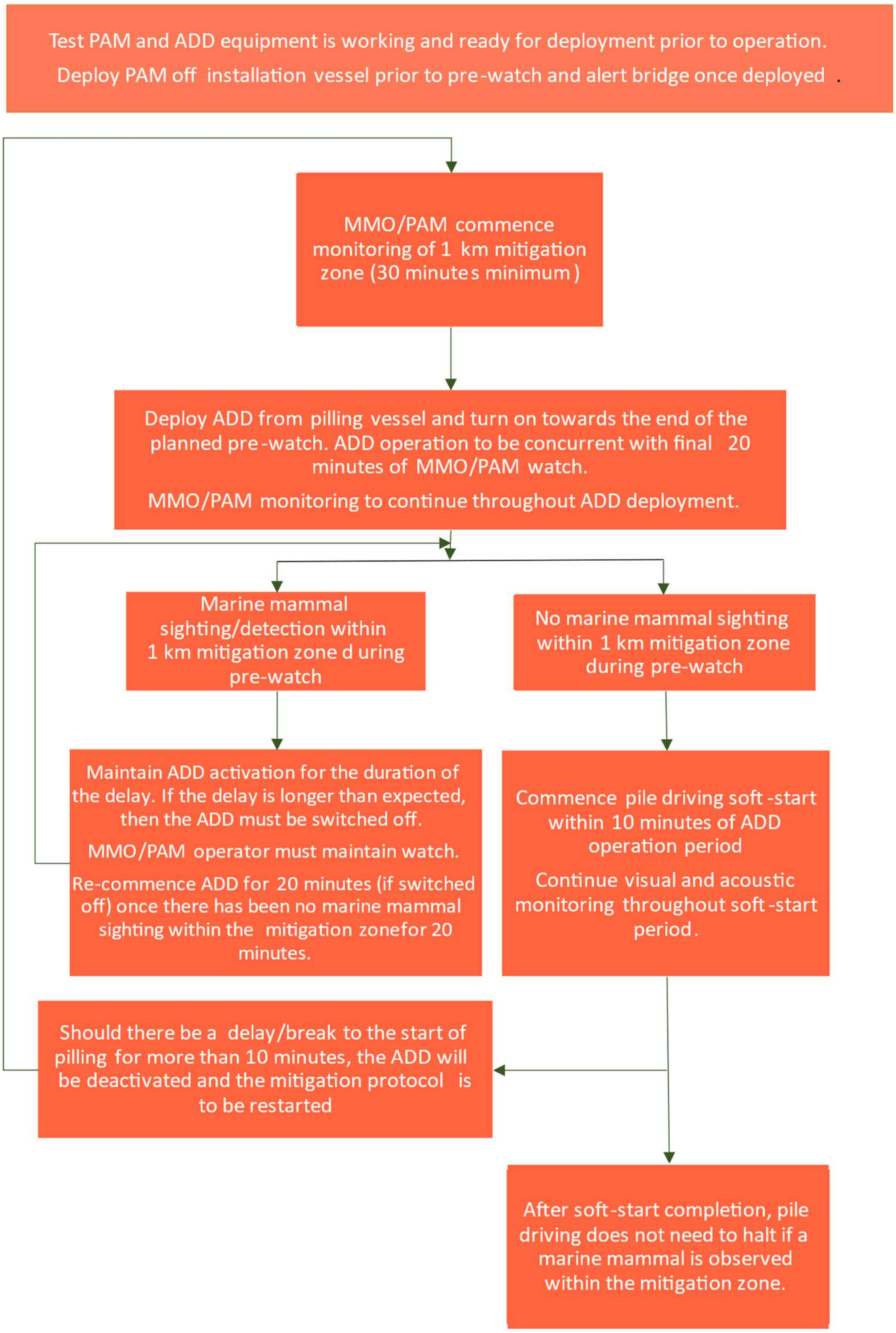
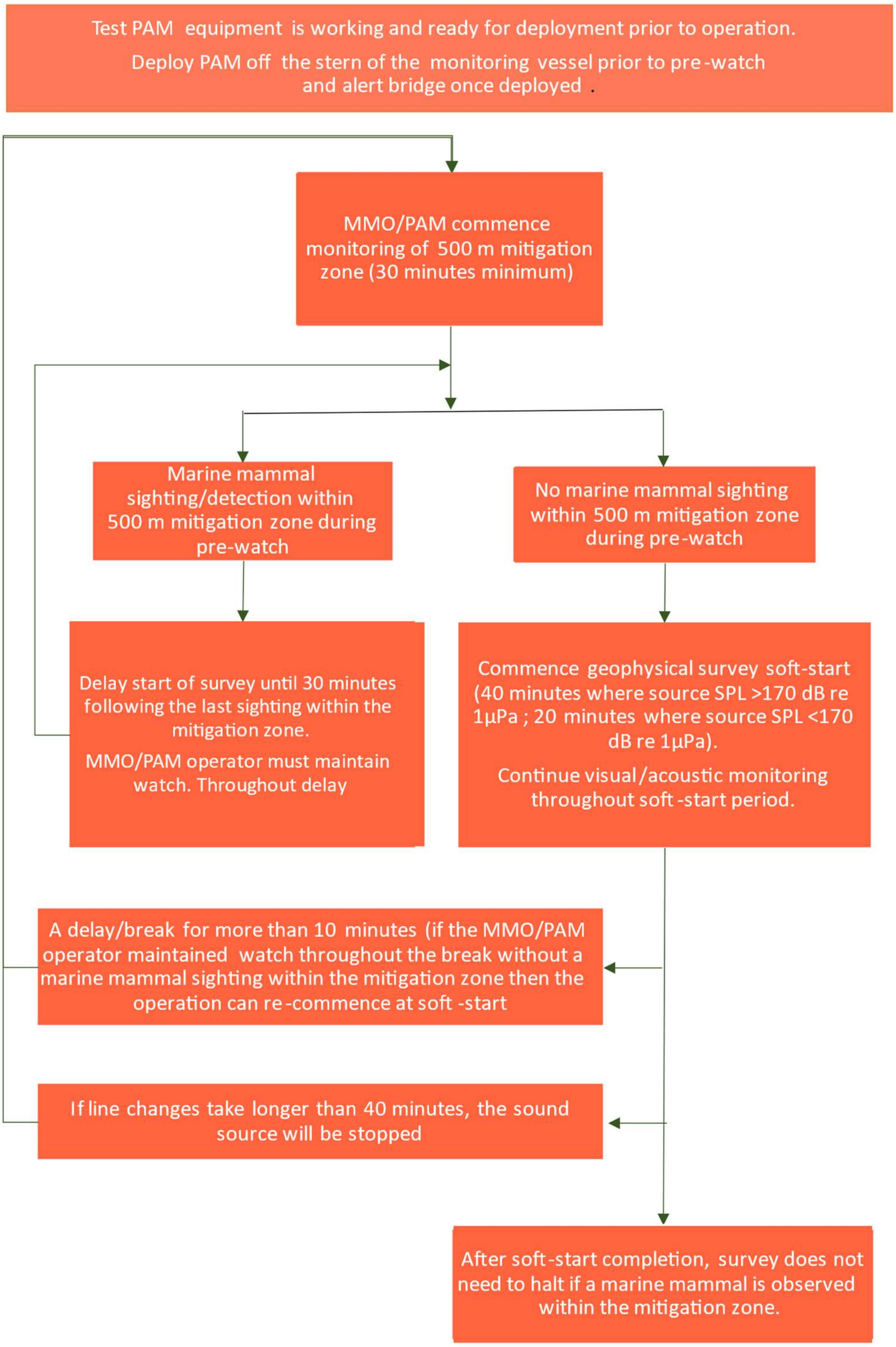
Appendix A: Pile driving mitigation procedure summary

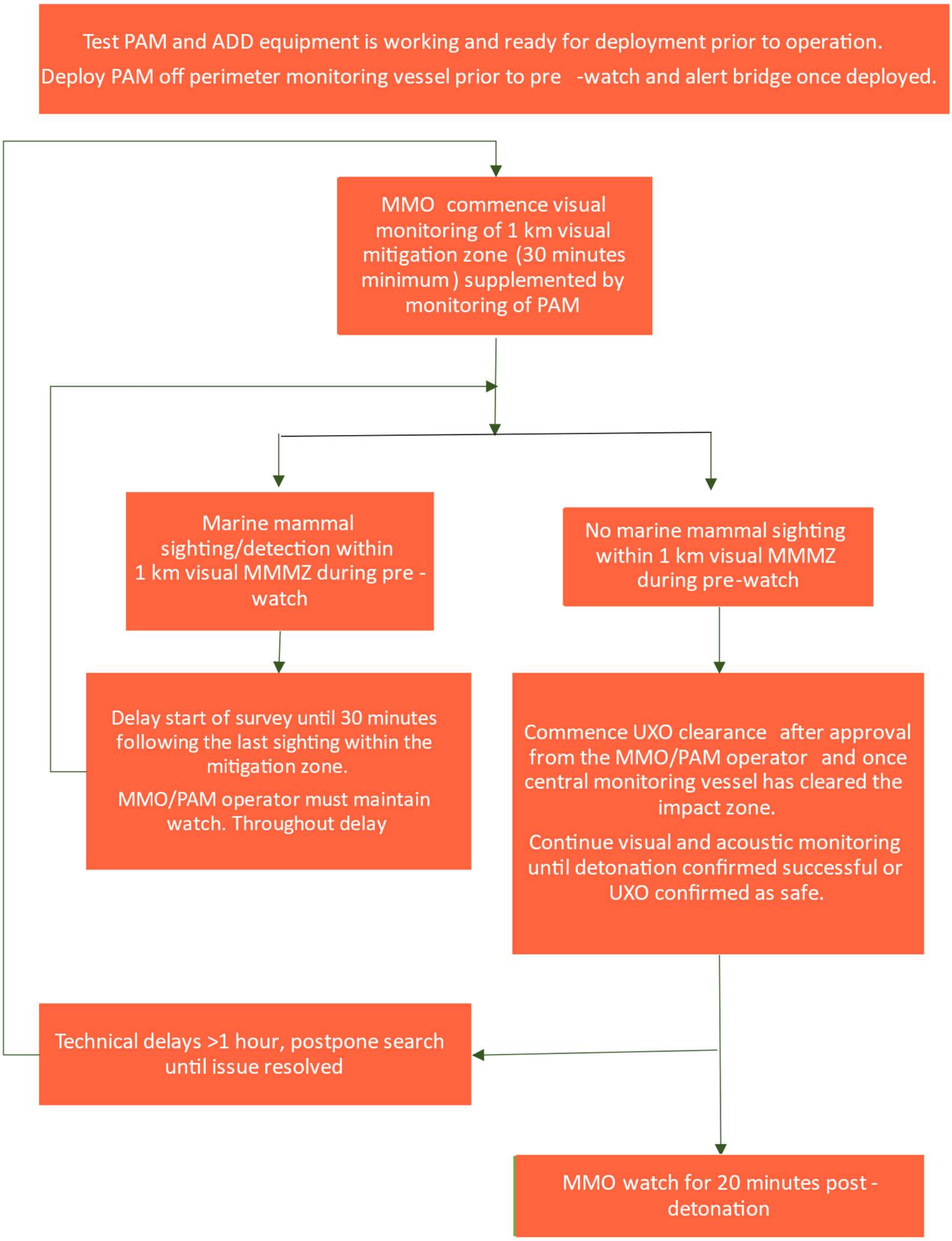


Appendix B: Geophysical survey mitigation procedure summary



Appendix C: UXO mitigation procedure summary

Low order clearance



High order clearance