Awel y Môr Offshore Wind Farm

Category 6: Environmental Statement

Volume 4, Annex 7.2: Draft Outline Marine Mammal Mitigation Protocol

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Glossary of terms

TERM	DEFINITION
Permanent Threshold Shift (PTS)	A total or partial permanent loss of hearing at a particular frequency caused by some kind of acoustic trauma. PTS results in irreversible damage to the sensory hair cells of the ear, and thus a permanent reduction of hearing acuity at that frequency.
Temporary Threshold Shift (TTS)	Temporary loss of hearing at a particular frequency as a result of exposure to sound over time. The mechanisms underlying TTS are not well understood, but there may be some temporary damage to the sensory cells. The duration of TTS varies depending on the nature of the stimulus, but there is generally recovery of full hearing over time.
Threshold	The threshold generally represents the lowest signal level an animal will detect in some statistically predetermined percent of presentations of a signal.
Unweighted sound level	Sound levels which are ‘raw’ or have not been adjusted in any way, for example to account for the hearing ability of a species.
Weighted sound level	A sound level which has been adjusted with respect to a ‘weighting envelope’ in the frequency domain, typically to make an unweighted level relevant to a particular species. The overall sound level has been adjusted to account for the hearing ability of marine mammals.

Abbreviations and acronyms

TERM	DEFINITION
ADD	Acoustic Deterrent Device
AfL	Agreement for Lease
AyM	Awel y Môr Offshore Wind Farm
DCO	Development Consent Order
EIA	Environmental Impact Assessment
ES	Environmental Statement
ETG	Expert Topic Group
GyM	Gwynt y Môr Offshore Wind Farm
JNCC	Joint Nature Conservation Committee
HF	High Frequency
LF	Low Frequency
MDS	Maximum Design Scenario
MMMP	Marine Mammal Mitigation Protocol
MMOb	Marine Mammal Observer
MPCP	Marine Pollution Contingency Plan
NGET	National Grid Electricity Transmission
OSP	Offshore Substation Platform
OWF	Offshore Wind Farm
PAM	Passive Acoustic Monitoring
PCW	Phocid carnivores in water
PEIR	Preliminary Environmental Impact Report

TERM	DEFINITION
PEMP	Project Environment Management Plan
PTS	Permanent Threshold Shift
PVM	Permanent Vessel Mooring
SEL_{cum}	Sound Exposure Level (cumulative)
SEL_{ss}	Sound Exposure Level (single strike)
SNCB	Statutory Nature Conservation Body
SPL_{peak}	Sound Pressure Level (peak)
TTS	Temporary Threshold Shift
UXO	Unexploded Ordnance
VHF	Very High Frequency
WTG	Wind Turbine Generator

Units

UNIT	DEFINITION
Hz	Hertz
kHz	Kilohertz
km	Kilometer
km^2	Kilometer squared
m	Meter
m/s	Meters per second

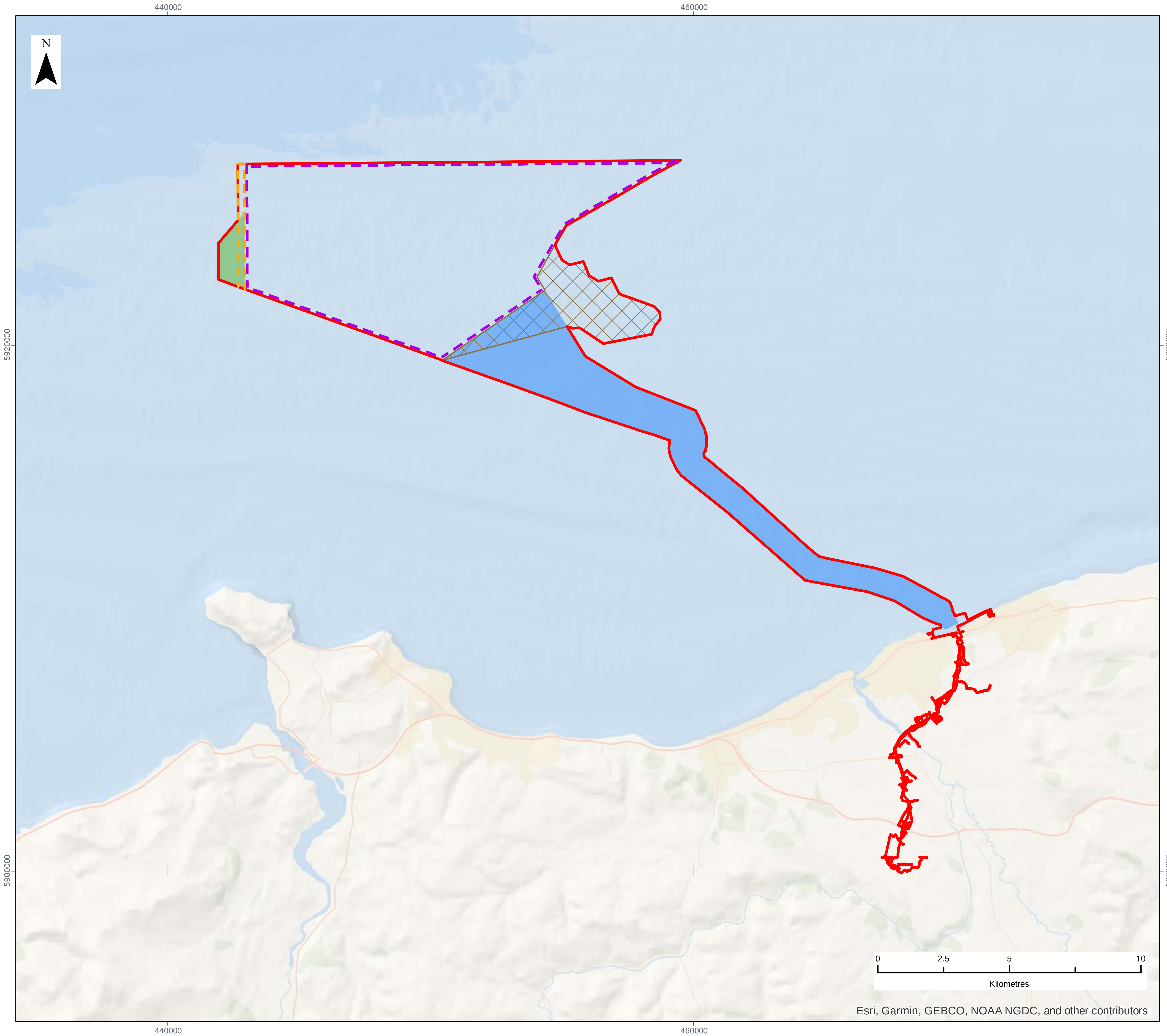
Introduction

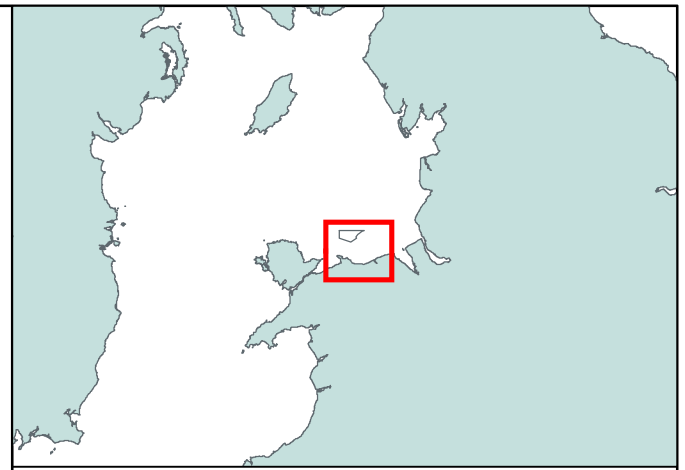
1.1 Project background

1 Awel y Môr Offshore Wind Farm Limited (the 'Applicant') is proposing to develop Awel y Môr Offshore Wind Farm ('AyM'), which is a sister project to the operational Gwynt y Môr offshore wind farm (GyM) off the coast of north Wales (Figure 1). GyM has been operational since 2015.

2 AyM will include both offshore and onshore infrastructure including an offshore generating station (wind farm) of up to 50 wind turbine generators (WTGs), export cables to landfall, an onshore substation and connection to the National Grid Electricity Transmission (NGET) substation at Bodelwyddan.

3 The proposed project area has been reduced from EIA scoping in response to a number of constraints, including potential impacts on marine mammals and noise sensitive receptors to the west of the proposed project area. The evolution of the AyM Order Limits is detailed in Volume 1, Chapter 4: Site Selection and Consideration of Alternatives (application ref: 6.1.4).





LEGEND

- Order Limits
- Array Area
- Offshore Export Cable Corridor
- Other Wind Farm Infrastructure Zone
- Subsea Infrastructure and Temporary Works Area
- GyM Interlink Zone

Data Source:

PROJECT TITLE:

AWEL Y MÔR OFFSHORE WINDFARM

FIGURE TITLE:

The AyM Order Limits

VER	DATE	REMARKS	Drawn	Checked
1	15/09/2021	For Issue for PEIR	BPHB	RM
2	03/03/2022	For Issue For ES	BPHB	RM

FIGURE NUMBER:

Figure 1

SCALE:	PLOT SIZE:	DATUM:	PROJECTION:
1:150,000	A3	WGS84	UTM30N

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AWEL Y MÔR
Offshore Wind Farm

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1.2 Purpose of the draft Outline Marine Mammal Mitigation Protocol (MMMP)

4 The primary aim of this draft Outline MMMP is to set out the measures proposed to reduce the risk of Permanent Threshold Shift (PTS) auditory injury to any marine mammal species in close proximity to the pile driving for the installation of AyM foundation structures to negligible (as defined in Section 1.5 in Volume 2, Chapter 5: Marine Mammals). This draft Outline MMMP draws on the guidance provided by the Joint Nature Conservation Committee (JNCC 2010)[i] and Statutory Nature Conservation Bodies (SNCB) recommendations with regards to use of Acoustic Deterrent Devices (ADD).

5 The Applicant has developed a range of mitigation measures though the EIA process to eliminate or reduce impacts as far as possible. All mitigation measures relevant to marine mammals are described in Table 1. If unexploded ordnance (UXO) clearance is required pre-construction, an additional licence will be applied for after detailed pre-construction surveys have been carried out. Included in the additional UXO license will be a UXO specific MMMP. This draft outline MMMP is for pile driving activities for the foundation structures only.

6 All mitigation measures relevant to marine mammals are described in Table 1, as identified in Volume 2, Chapter 7: Marine Mammals (application ref: 6.2.7). These include embedded measures such as design changes and applied mitigation which is subject to further study or approval of details.

Table 1: Mitigation for Marine Mammals.

PARAMETER	MITIGATION MEASURES
GENERAL	
Pollution prevention	A Project Environment Management Plan (PEMP) is proposed to be produced to ensure that the potential for contaminant release is strictly controlled. The PEMP will include a Marine Pollution Contingency Plan (MPCP)

[i] New mitigation guidelines for piling are expected to be published by JNCC in the next few months. While not available to incorporate into this draft Outline MMMP, the new guidelines will be fully considered in the final MMMP.

PARAMETER	MITIGATION MEASURES
	and will also incorporate plans to cover accidental spills, potential contaminant release and include key emergency contact details. Typical measures will include: only using chemicals approved under the Offshore Chemicals Regulations 2002; storage of all chemicals in secure designated areas with impermeable bunding (generally to 110% of the volume); and double skinning of pipes and tanks containing hazardous materials. It will also include key emergency contact details (e.g. NRW, Maritime Coastguard Agency and the project site co-ordinator). The PEMP will be secured as a condition in the Marine Licence.
Vessel codes of conduct	The adoption of best practice vessel-handing protocols (e.g. following the Codes of Conduct provided by the WiSe Scheme, Scottish Marine Wildlife Watching Code or Guide to Best Practice for Watching Marine Wildlife) will minimise the potential for any impact. The final codes of conduct will be discussed and agreed with NRW and JNCC.
CONSTRUCTION	
Project design	Inclusion of soft-start and ramp-up procedures for pile driving. In the case of monopiles, piling will only occur at one location at a time. There is no possibility of simultaneous or concurrent piling. In the case of pin-piled multi-leg jacket foundations, pin-piles may be installed concurrently, but only on adjacent legs of the same jacket foundation. There is no possibility of simultaneous or concurrent piling at two separate foundation locations.
Marine Mammal Mitigation Protocol (Piling specific)	A piling MMMP will be implemented. The MMMP will be secured as a condition within the Marine Licence. This document is a draft outline version of the piling MMMP.

PARAMETER	MITIGATION MEASURES
Reduction in array area	The footprint of the array has been reduced in the west to reduce inter alia underwater noise impacts on marine mammal designated sites (overall reduction in footprint of 26% when compared to scoping boundary) The number of turbines has reduced by 52% when compared to the scoped design, reducing total WTG foundations from 107 to 50.
No concurrent piling	There will be no concurrent piling of monopile foundations at two locations during the construction phase. Though there remains the possibility of concurrent piling of pin piles, this is limited to piling at a single foundation location.
OPERATION	
None	N/A
DECOMMISSIONING	
Decommissioning Plan	A Decommissioning Programme will be developed to cover the decommissioning phase as required under Chapter 3 of the Energy Act 2004. As the decommissioning phase will be a similar process to the construction phase but in reverse (i.e., increased project vessels on-site, partially deconstructed structures) the embedded mitigation measure will be similar to those for the construction phase. The Decommissioning Plan will be secured as a condition in the Marine Licence.

1.3 Implementation of the draft Outline MMMP

7 This draft Outline MMMP establishes the principles which will be implemented during construction. Following the granting of the DCO and marine licence for AyM and once the final project design has been confirmed, a final MMMP will be prepared following the principles established in the draft Outline MMMP. Specific details regarding proposed mitigation can be found in the Schedule of Mitigation (application reference 8.1).

Pile driving scenarios

1.4 Scenarios considered

8 For the offshore aspects of AyM, the Maximum Design Scenario (MDS) is the installation of up to 50 WTG foundations in addition to the following piled infrastructure:

- Up to two Offshore Substation Platforms (OSPs); and
- Up to one met mast.

9 Both monopiles and pin piles could be installed at AyM and so both foundation types have been assessed in the ES (see Volume 2, Chapter 7: Marine Mammals (application ref: 6.2.7)). The foundation installation duration under the WCS is expected to be approximately 56 piling days in total for the WTGs and other piled infrastructure when using pin piles (Table 3), and 34 piling days in total when using monopiles (Table 2). A summary of the parameters assessed are presented in the sections below, with the outcome of the marine mammal assessment summarised in Section 3.

10 In Volume 2, Chapter 7: Marine Mammals (application ref: 6.2.7) of the ES, the assessment provides predicted impacts from the MDS. The MDS is intended to cover the maximum piling parameters that would ever be required to install a foundation (in terms of maximum hammer energies and longest piling durations). The MDS, based on engineering predictions, is a maximum 5,000 kJ hammer energy for monopiles and 3,000 kJ for pin piles.

11 Following the pre-application consultation, through the scoping process and the marine ecology and marine mammals Expert Topic Group (ETG) a refinement was made to increase the maximum hammer energy for pin piles (MDS) based on analyses undertaken by foundation installation engineers. Following these analyses, foundation installation engineers also confirmed that the ramp-up profile for the MDS could be modified to incorporate a lower strike rate upon commencement of piling.

1.5 Monopile MDS

12 Table 2 details the piling parameters that represent the MDS for monopiles. For full details of the piling parameters see Volume 4, Annex 6.2: Underwater Noise Technical Report (application ref: 6.4.6.2).

Table 2: Monopile MDS parameters.

<table>
<tr><th>PARAMETER</th><th>WTG FOUNDATIONS (50 MONOPILE FOUNDATIONS)</th><th>OTHER PILED INFRASTRUCTURE</th></tr>
<tr><td>Maximum hammer driving energy</td><td>5,000 kJ</td><td>5,000 kJ</td></tr>
<tr><td>Number of piles</td><td>50</td><td>OSP: 16
Met mast: 1</td></tr>
<tr><td>Maximum pile diameter</td><td>15 m</td><td>15 m</td></tr>
<tr><td rowspan="2">Total number of piling days</td><td>25 (assuming 2 monopiles are installed in 1 day)
50 (assuming 1 monopile is installed in 1 day)
150 (assuming it takes up to 3 days of piling/ drilling to install 1 monopile)</td><td>9 (assuming 2 monopiles are installed in 1 day)
17 (assuming 1 monopile is installed in 1 day)
51 (assuming it takes up to 3 days of piling/drilling to install 1 monopile)</td></tr>
<tr><td colspan="2">34 (assuming 2 monopiles are installed in 1 day)
67 (assuming 1 monopile is installed in 1 day)</td></tr>
</table>

PARAMETER	WTG FOUNDATIONS (50 MONOPILE FOUNDATIONS)	OTHER PILED INFRASTRUCTURE
	201 (assuming it takes up to 3 days of piling/drilling to install 1 monopile)	

1.6 Pin Pile MDS

13 Table 3 details the piling parameters that represent the MDS for pin piles (. The design envelope considers the possibility of two piling vessels piling at the same time, at the same location for multi-leg foundations, which would represent the spatial PTS-onset MDS for AyM. For full details of the piling parameters see Volume 4, Annex 6.2: Underwater Noise Technical Report.

Table 3: Pin pile MDS parameters.

PARAMETER	WTG FOUNDATIONS (50 MULTI-LEG FOUNDATIONS)	OTHER PILED INFRASTRUCTURE
Maximum hammer driving energy	3,000 kJ	3,000 kJ
Number of pin piles	400	OSPs: 24
Maximum pile diameter	3.5 m	3.5 m
Total number of piling days	50 (assuming 1 jacket is installed in 1 day) 100 (assuming 1 jacket is installed in 2 days)	6 (assuming 1 jacket is installed in 1 day) 12 (assuming 1 jacket is installed in 2 days)
	56 (assuming 1 jacket is installed in 1 day) 112 (assuming 1 jacket is installed in 2 days)	

Summary of potential impacts

1.7 Maximum design scenario

14 For full details of the piling parameters see Volume 4, Annex 6.2: Underwater Noise Technical Report (application ref: 6.4.6.2).

1.7.1 Instantaneous PTS-onset

15 The largest instantaneous PTS-onset impact range (unweighted SPL_{peak}) for impact piling is estimated at 640 m for harbour porpoise. For all other marine mammal receptors, the maximum range was <100 m (Table 4).

Table 4: Estimated instantaneous PTS-onset impact ranges (m) at full hammer energy (maximum design scenario).

		MONOPILE (5,000 KJ)		PIN PILE (3,000 KJ)		PIN PILE 2 AT 1 LOC	
MODELLING LOCATION		NW	SE	NW	SE	NW	SE
SPECIES	THRESHOLD						
Harbour porpoise	Unweighted SPL_{peak} 202 dB re 1µPa	640	50	540	42	NA	NA
Minke whale	Unweighted SPL_{peak} 219 dB re 1µPa	50	50	50	50		
Bottlenose, common and Risso's dolphin	Unweighted SPL_{peak} 230 dB re 1µPa	<50	<50	<50	<50		
Grey seal	Unweighted SPL_{peak} 218 dB re 1µPa	70	60	60	60		

1.7.2 Cumulative PTS-onset

16 Volume 2, Chapter 7: Marine Mammals presents the cumulative PTS-onset impact ranges. For all marine mammal species considered, the unmitigated cumulative PTS-onset impact ranges resulted in very few animals predicted to be impacted, and as such, the magnitude of the impact was assessed as negligible.

17 Volume 4, Annex 7.3: Marine Mammal Quantitative Noise Impact Assessment – Assumptions, Limitations and Uncertainties details the multiple avenues of precaution built into the calculation of cumulative PTS impact, and how the resulting impact ranges are considered to be highly over-precautionary and unrealistic. This is primarily driven by the two key assumptions:

- The amount of sound energy an animal is exposed to within 24 hours will have the same effect on its auditory system, regardless of whether it is received all at once (i.e. with a single bout of sound) or in several smaller doses spread over a longer period (called the equal-energy hypothesis); and,
- The sound keeps its impulsive character, regardless of the distance to the sound source.

18 In practice:

- There is a recovery of a threshold shift caused by the sound energy if the dose is applied in several smaller doses (e.g. between pulses during pile driving or in piling breaks) leading to an onset of PTS at a higher received energy level than assumed with the given SELcum threshold; and,
- Pulsed sound loses its impulsive characteristics while propagating away from the sound source.

19 Both assumptions therefore lead to a conservative determination of the impact ranges (please see Volume 4, Annex 7.3 for full details). Volume 4, Annex 7.3 provides an illustration of potential cumulative PTS-onset impact ranges if the threshold is adjusted to account for recovery in hearing between pulses. This highlights that impact ranges can decrease significantly if the threshold is increased by 2 or 3 dB.

20 Given these levels of uncertainty and over-precaution, and given that this is an evolving field of research, the Project does not consider it necessary to commit to mitigating cumulative PTS-onset at this stage. The Project acknowledges that this is a draft outline MMMP, and that research and understanding of this topic will continue to evolve prior to the drafting of the final MMMP for AyM. As such, at this stage, the Project commits to aligning the mitigation requirements of the final MMMP to the knowledge and evidence available on this topic at the time of drafting the final MMMP, to ensure that appropriate mitigation measures are implemented which reflect the best-available knowledge at the time.

1.8 Summary of impact assessment for marine mammals in relation to PTS for piling noise

21 Volume 2, Chapter 7: Marine Mammals presents the full assessment of the impacts of PTS-onset for piling noise of marine mammals. In summary, the assessment concluded that with the impact of PTS-onset from piling noise under the MDS is not considered to have a significant effect on any marine mammal species considered in the assessment (Table 5).

Table 5: Summary of the assessment for PTS-onset from pile driving for each marine mammal species.

SPECIES	MAGNITUDE	SENSITIVITY	SIGNIFICANCE
Harbour porpoise	Negligible adverse	Low	Negligible adverse significance
Bottlenose dolphin	Negligible adverse	Medium	Negligible adverse significance
Common dolphin	Negligible adverse	Medium	Negligible adverse significance
Risso's dolphin	Negligible adverse	Medium	Negligible adverse significance
Minke whale	Negligible adverse	Low	Negligible adverse significance
Grey seal	Negligible adverse	Low	Negligible adverse significance

Mitigation methodology

1.9 Introduction

22 In order to minimise the risk of any auditory injury to marine mammals from underwater noise during pile driving, there is a suite of mitigation measures that the Applicant could implement for AyM piling. These mitigation measures may include (but are not limited to) the following:

- Pre-piling deployment of ADDs;
- Marine mammal observation;
- Passive acoustic monitoring system (PAMS); and
- Piling soft-start procedure.

23 The specific mitigation measure (or suite of measures) that will be implemented during the construction of AyM will be determined, in consultation with NRW and JNCC, following the appointment of the installation contractors (and therefore, confirmation of final hammer energies and foundation types), collection of additional survey data (noise or geophysical data) and/ or acquisition of noise monitoring data, and/ or information on maturation of emerging technologies. This additional data and information will allow the noise modelling to be updated to feed into the final MMMP and discussions on the appropriate mitigation measure(s).

24 The following sections provide a high-level methodology for each of these elements. A final MMMP will be produced for approval by NRW prior to the relevant works commencing for approval by NRW (see Section 1.3).

1.10 Mitigation zone

25 The mitigation zone is defined as the maximum potential instantaneous PTS-onset impact range. The maximum instantaneous PTS-onset zone, and thus the mitigation zone is 640 m for monopiles and 540 m for pin piles (harbour porpoise - Table 4).

26 The Applicant will update the noise modelling prior to construction once the final project details are known. The JNCC (2010) recommends a mitigation zone of 500 m during piling. The actual mitigation zone for AyM piling will be confirmed in the final MMMP and will be determined based on the final confirmed foundation options and hammer energies etc. If the final noise modelling estimates a PTS-onset impact range larger than the 500 m suggested in the JNCC piling guidance, the mitigation zone will be increased to cover the PTS-onset impact.

1.11 Marine mammal observers

27 JNCC recommends a pre-piling search of a minimum period of 30 minutes (JNCC 2010) for both the monopiles and pinpiles. The marine mammal observer (MMOb) would undertake visual monitoring for marine mammals within the defined mitigation zone around the piling location from a suitable elevated platform. The MMOb would record all periods of marine mammal monitoring, including start and end times. Details of environmental conditions (sea state, weather, visibility, etc.) and any sightings of marine mammals around the piling vessel would also be recorded as per JNCC marine mammal recording forms and guidelines. In addition, any obvious responses of animals to the ADD activation would be recorded (e.g. a change in behaviour from milling or bottling to directed travel away from the ADD at the onset of ADD activation).

28 If, during the MMOb pre-piling search, a marine mammal is detected within the mitigation zone, the soft-start will be delayed until it is assessed by the MMOb that the marine mammal has vacated the mitigation zone and a further 20 minutes have elapsed since the last detection within the mitigation zone. At the same time, the ADD will be checked to ensure correct operation. The MMOb would continue to note detections and observations on animal behaviour during the soft-start period.

29 Full details on the role and responsibilities of the MMOb with respect to piling are described in JNCC guidelines for minimising the risk of injury to marine mammals from piling noise (JNCC 2010).

30 The specific details regarding MMObs and methods employed will be updated in the final MMMP with respect to any updated and available guidance at the time.

1.12 Passive acoustic monitoring

31 A PAMS may be used to allow a trained PAMS operative to conduct acoustic monitoring. This would be utilised in conjunction with visual monitoring during daylight operations and/ or as an alternative method of monitoring the mitigation zone during periods of reduced visibility (e.g. night, fog, high sea state i.e. above sea state 4 as per JNCC 2010). If a PAMS is not available for monitoring, then piling would be unable to commence during such periods of restricted visibility that are not conducive to visual monitoring as there is a greater risk of failing to detect the presence of marine mammals.

1.13 Pre-piling deployment of ADDs

1.13.1 ADD choice and specification

32 If an ADD is chosen as part of the suite of mitigation measures set out in the final MMMP, the ADD that is likely to be used is the Lofitech AS seal scarer, although this will be confirmed within the final MMMP. This ADD has been shown to have the most consistent effective deterrent ranges for grey seals, harbour porpoise and minke whales in environments similar to the offshore wind farm (OWF) construction site (Sparling et al. 2015, McGarry et al. 2017) (see Appendix 1 for details).

33 The other species of primary importance to consider for AyM is bottlenose dolphins, and while little research has been conducted on the response of bottlenose dolphins to ADDs, it has been demonstrated that they are capable of hearing the sound ADDs produce (Todd et al. 2019). It is considered that deterrents only have to be effective over a small range for dolphin species in order to ensure these species are not at risk of auditory injury, and if the ADD is effective for low frequency (LF) and very high frequency (VHF) species then it is also likely to be effective on VHF species such as bottlenose dolphins.

34 It is important to note that there may be additional ADD models identified in the pre-construction phase for AyM that are available and suitable for use. As such, if an ADD is identified as part of the suite of mitigation measures set out in the final MMMP, the final ADD choice and specification would be confirmed within the final MMMP.

1.13.2 Duration of deployment

35 The duration of ADD deployment would be calculated using swimming speed assumptions to ensure that marine mammals are beyond the mitigation zone when piling commences.

36 A swim speed of 1.5 m/s (Lepper et al. 2012) is assumed for all marine mammals with the exception of minke whales. A swim speed of 3.2 m/s is assumed for minke whales (Blix and Folkow 1995). There is evidence to suggest that these selected swim speeds are precautionary and that animals are likely to flee at much higher speeds, at least initially. For example, Minke whales have been shown to flee from ADDs at a mean swimming speed of 4.2 m/s (McGarry et al. 2017). A recent study by Kastelein et al. (2018) showed that a captive harbour porpoise responded to playbacks of pile driving sounds by swimming at speeds significantly higher than baseline mean swimming speeds, with greatest speeds of up to 1.97 m/s which were sustained for the 30-minute test period. In another study, van Beest et al. (2018) showed that a harbour porpoise responded to an airgun noise exposure with a fleeing speed of 2 m/s.

37 Marine mammals are expected to continue moving away during the soft-start and throughout the ramp-up. In addition, the presence of novel vessel activity on-site is also predicted to result in animals moving away from the piling location and out of the mitigation zone prior to the commencement of piling (Brandt et al. 2018, Graham et al. 2019).

38 As stated previously, this draft Outline MMMP focuses on mitigating only the “instantaneous” PTS-onset impact ranges. The species with the maximum duration to flee the relevant PTS-onset range under the monopile maximum design scenario, is harbour porpoise (Table 6). The maximum instantaneous PTS-onset range is 640 m and given a swim speed of 1.5 m/s, animals starting at the pile location would take 7.1 minutes to exit the impact range. It would take less time for each of the other species to exit their maximum instantaneous PTS-onset ranges for monopiles (Table 6).

39 As with monopiles, it is harbour porpoise that have the largest instantaneous PTS-onset impact range for pin piles, and thus the longest duration to flee the impact range (Table 6). The maximum instantaneous PTS-onset for pin piles is range is 540 m and given a swim speed of 1.5 m/s, animals starting at the pile location would take 6 minutes to exit the impact range. It would take less time for each of the other species to exit their maximum instantaneous PTS-onset ranges for pin piles (Table 6).

40 Therefore, in order to ensure that the instantaneous PTS-onset range is free of animals, ADD activation would be required for 7.1 minutes for monopiles and 6 minutes for pin piles.

41 The JNCC (2010) guidance states that "ADDs should be switched on throughout the pre-piling search and turned off immediately after the piling activity has started". Given that the pre-piling search is recommended to be a minimum of 30 minutes, this means that the ADD should be activated for a minimum of 30 minutes. The final ADD activation period will be discussed and agreed with NRW and JNCC to ensure that the mitigation ensures clearance of the mitigation zone without resulting in unnecessary disturbance impacts.

Table 6: Estimated time for marine mammals to flee the instantaneous PTS-onset impact zone.

	MONOPILE MDS (5,000 KJ)				PIN PILE MDS (3,000 KJ)			
SPECIES	HP	MW	BND, CD & RD	GS	HP	MW	BND, CD & RD	GS
Maximum PTS-onset range (m)	640	60	50	70	540	50	50	60
Swim speed (m/s)	1.5	3.25	1.5	1.5	1.5	3.25	1.5	1.5
Time to flee (mins)	7.1	<1	<1	<1	6	<1	<1	<1

1.13.3 ADD deployment procedure

42 It is expected that during monopile or pin pile installation, one ADD would be deployed from the deck of the piling platform/ vessel, with the control unit and power supply on board the platform/ vessel in suitable, safe positions on deck. The ADD would need to be verified for operation prior to pre-piling activation. The exact deployment procedure will be agreed once the piling contractor is in place and will follow safe, standard working practices using experienced/ trained staff to ensure the ADD equipment is used and deployed correctly within the confines of different vessel layouts.

1.13.4 ADD operator training and responsibilities

43 A trained and dedicated ADD operator would be responsible for ADD maintenance, operation, and reporting. The ADD duties involved would be to deploy the ADD from the installation platform or vessel, to verify the operation of the ADD before deployment, to operate the ADD throughout the pre-piling period (and be available in the case of piling breaks to reactivate), ensure batteries are fully charged and that spare equipment is available in case of any problems, and record and report on all ADD and piling activity. Prior to the start of the MMO pre-piling search period, the ADD operator would test the equipment to ensure the ADD is working and ensure they are deployed appropriately from the vessel or jacket to an agreed depth. Following the deployment and testing of the ADD equipment, before the commencement of the soft-start procedure (for monopiles/ pin piles respectively), the MMOb and or PAMS operative will commence the pre-piling search and the ADD operator would activate the ADD. When the soft start commences the ADD operator would then deactivate the ADD. The ADD must always be used in conjunction with visual and/ or acoustic monitoring and is not considered a suitable substitute for monitoring.

1.14 Soft-start procedure

44 Following the pre-piling deployment of the ADDs and the completion of the pre-piling search, the installation of each foundation will commence with a soft-start of a maximum of 15% of the maximum hammer energy for a duration of 10 minutes. The hammer energy then ramps-up in steps until the levels required to install the pile are reached or up to the maximum hammer energy. The gradually increase in hammer energy means that if any marine mammals are still present in the vicinity of the piling location, they are encouraged to leave by the initial low levels of underwater noise prior to the noise reaching levels which could cause PTS-onset.

45 It is important to note that to avoid unnecessary structural stress on the piles, they will be installed using the lowest required hammer energy required to complete each installation – i.e. if ground conditions are such that a lower than maximum hammer energy is sufficient to complete installation, then hammer energy will not be unnecessarily ramped-up to full hammer energy.

46 If a marine mammal enters the mitigation zone during the soft-start then the piling operation should either stop (if technically feasible), or the hammer energy would not be further increased until the marine mammal exits the MZ, and there is no further detection for 20 minutes. Once the soft-start has been completed, there is no requirement to stop piling or reduce the hammer energy if a marine mammal is detected in the MZ.

47 The soft-start procedure outlined in Volume 2, Chapter 7; Marine Mammals is based on the MDS when using a maximum hammer energy of 5,000 kJ.

1.15 Noise abatement

48 There are several different noise abatement systems that have been commercially deployed at offshore wind farm projects, including: Big Bubble Curtains, the IHC Noise Mitigation System, the Hydrosound damper and vibro-hammers. In addition to these, other methods have undergone, or are currently undergoing testing, such as: the AdBm-Noise Abatement System, BLUE Piling Technology (an alternative hammer type) and HydroNAS (Verfuss et al. 2019). The purpose of these noise abatement systems is to reduce the noise propagated through the water column during pile driving, and thus reduce the impact of piling noise on marine life.

49 The amount of noise reduction that can be achieved by these different methods, alone and in combination, is outlined in Table 7 and Figure 2:. A review of noise abatement methods and their limitations is provided in Verfuss et al. (2019).

Table 7: Minimum and maximum noise reduction efficacy. Data obtained from Bellmann et al. (2018) and Verfuss et al. (2019).

NOISE ABATEMENT SYSTEM	WATER DEPTH	NOISE REDUCTION SEL_{SS} (DB)
BBC (>0.3m^3/(min*m)	~40 m	7 – 11
DBBC (>0.3m^3/(min*m)	~40 m	8 – 13
DBBC (>0.4m^3/(min*m)	~40 m	12 – 18
DBBC (>0.5m^3/(min*m)	>40 m	~15 – 16
NMS	Up to 40 m	13 – 16
HSD	Up to 40 m	10 – 12
NMS + optimised BBC (>0.4m^3/(min*m)	~40 m	17 – 18
NMS + optimised BBC (>0.5m^3/(min*m)	~40 m	18 – 20
HSD + optimised BBC (>0.4m^3/(min*m)	~30 m	15 – 20
HSD + optimised DBBC (0.48m^3/(min*m)	20-40 m	15 – 28
HSD + optimised DBBC (> 0.5m^3/(min*m)	<45 m	18 - 19
BLUE Hammer	30 m	19 - 24

BBC = Big Bubble Curtain, DBBC = Double Big Bubble Curtain, NMS = IHC Noise Mitigation Screen, HSD = Hydro Sound Damper

Bubble curtain air volume flow given in m^3/(min*m)

Water depth = the depth of the OWF project where noise reduction was used and where noise measurements were obtained

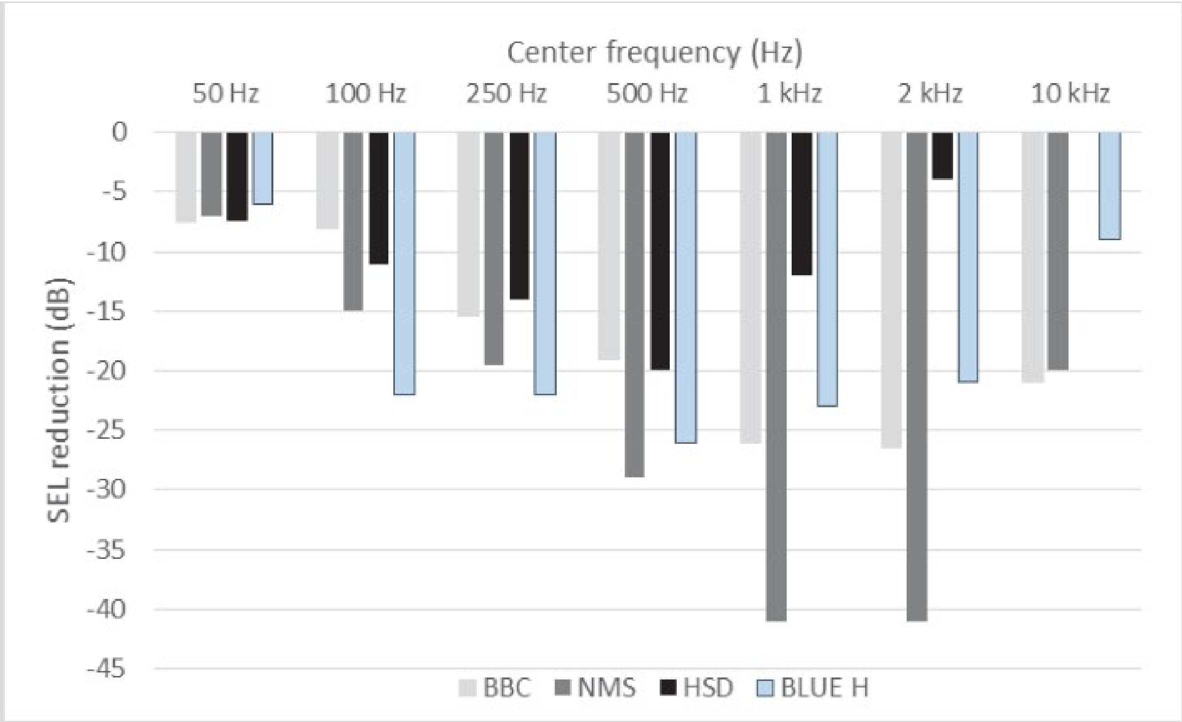

Figure 2: Reduction in SEL at the frequencies 100 Hz, 250 Hz, 500 Hz, 1 kHz and 2 kHz in the 1/3rd octave band frequency spectrum of a pile strike when comparing mitigated versus unmitigated piling (Verfuss et al. 2019).

50 The use of noise abatement methods at AyM has been considered. However, given the small instantaneous PTS-onset impact ranges, it is considered that a combination of MMOb, PAM and short duration ADD use will be sufficient to ensure animals are out of the impact zone prior to piling commencing. In addition to this, it is considered that the use of a bubble curtain has the potential to cause more of a negative disturbance effect (due to increased vessel time, deployment and recovery of equipment) than it would provide in noise reduction benefits. Therefore, it is not considered necessary to make a commitment to the use of such technology at this stage (when it appears it may not be required to achieve the necessary levels of protection).

1.16 Breaks in piling procedure

51 Breaks in the piling process could provide the potential for marine mammals to re-enter the mitigation zone. The guidance provided in JNCC (2010) states that "If there is a pause in the piling operations for a period of greater than 10 minutes, then the pre-piling search and soft-start procedure should be repeated before piling recommences". However, the ability to restart with a soft start may depend on the stage of piling and the pile/soil behaviour. If it is not possible to re-start with a soft start, the pre-piling ADD deployment and pre-piling search would be conducted before recommencing piling. The final procedure for breaks in piling will be agreed with input from the piling contractor (once contracted) and NRW and set out within the final MMMP.

1.17 Delays in the commencement of piling

52 Should there be a delay in the commencement of piling, there is a risk of animals moving back into the mitigation zone when ADDs are switched off. However, there is also a risk of habituation as a result of no aversive piling noise commencing after ADD activation. ADDs would therefore be turned off as soon as the delay in the commencement is realised. The ADD is not switched on again until there is confirmation that piling is ready to commence. The ADD is then reactivated, as above, for the minimum duration required for animals to move out of the mitigation zone, alongside the continuance of visual and/or acoustic monitoring. The MMOb should continue to undertake visual searches during this period.

1.18 Communications

53 The final MMMP will detail a communications protocol to ensure that all marine mammal mitigation measures, including any delays in commencing piling due to marine mammals being present in the area, are undertaken for all piling activities.

54 The final MMMP will also detail all key personnel and their responsibilities to ensure that all marine mammal mitigation measures are successfully undertaken for all piling activities. This will be developed based on the contractual agreement with the mitigation measures and personnel required with the titles and responsibilities being refined depending on the contractual agreement.

1.19 Reporting

55 Reports detailing the piling activity and mitigation measures would be prepared. Where appropriate these include, but are not necessarily limited to:

- Outline of the marine mammal monitoring methodology and procedures employed;
- Record of piling operations detailing date, soft-start duration, piling duration, hammer energy during soft-start and piling and any operational issues for each pile;
- Record of ADD deployment, including start and end times of all periods of ADD activation, any problems with ADD deployment;
- Record of marine mammal observations and PAM detections including duration of marine mammal observer pre-piling search;
- Environmental conditions during the pre-piling search, description of any marine mammal sightings/PAM directions and any actions taken, and a record of any incidental sightings made during out with the pre-piling search;
- Details of any problems encountered during the piling process including instances of noncompliance with the agreed piling protocol; and
- Any recommendations for amendment of the protocol.

56 Reports would be collated and provided to NRW on a weekly basis during the period in which piling operations are being conducted. In addition, a final report is provided following the completion of the construction activity which would be submitted to NRW. The final report will include any data collected during piling operations, details of ADD deployment, details of pre-piling search periods and observations, a detailed description of any technical problems encountered and what, if any, actions were taken. The report will also discuss the protocols followed and put forward recommendations based on project experience and the use of ADDs as mitigation during the construction period that could benefit future construction projects.

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Appendix 1: Lofitech ADD evidence base

57 The Lofitech AS seal scarer has been successfully used for marine mammal mitigation purposes at a number of offshore wind farm construction projects in Europe, including the C-Power Thornton Bank offshore wind farm in Belgium (Haelters et al. 2012), the Horns Rev II, Nysted and Dan Tysk offshore wind farms in Denmark (Carstensen et al. 2006, Brandt et al. 2009, Brandt et al. 2011, Brandt et al. 2013a, Brandt et al. 2013b) and on various German sites (Georg Nehls, pers comm). In UK waters the Lofitech device has recently been successfully used for marine mammal mitigation purposes for harbour porpoise, harbour and grey seal during piling construction activities at several offshore wind farms.

58 Based on the evidence below, the Lofitech ADD is capable of mitigating the small instantaneous PTS-onset ranges for AyM pile driving activities.

1.20 Harbour porpoise

59 In the German North Sea, an array of CPODs was used to test the effectiveness of Lofitech devices for deterring harbour porpoise (Brandt et al. 2013b). The extent of deterrence was measured by recording porpoise vocalisations up to 7.5 km from the Lofitech deployment site. Ten trials were conducted, where each trial collected four hours of acoustic detections, in conjunction with an active ADD. During the 40 hours of collected data, there was a significant decline in porpoise detections. Within 750 m, detections of porpoise declined by 86% when the ADD was active. Furthermore, declines in porpoise detections were significant up to 7.5 km from the ADD source (Figure 3).

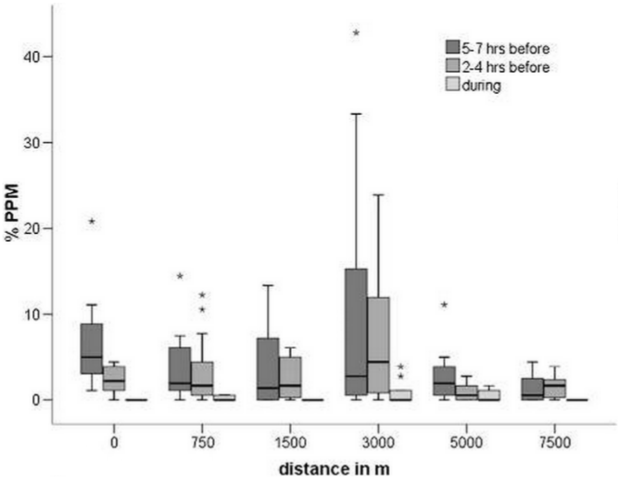

Figure 3: Percentage of porpoise positive minutes recorded before and during Lofitech trials at various distances (Brandt et al. 2013b).

60 In addition to acoustic monitoring, visual aerial surveys were conducted to identify changes in harbour porpoise presence during ADD activation. The average density fell to 0.3 porpoise/km^2 when the Lofitech device was activated, where baseline density estimates were 2.4 porpoise/km^2, over the 990 km^2 study area (Figure 4). To determine the duration of deterrence caused by ADDs, Brandt et al. (2013b) compared harbour porpoise detections before Lofitech activation, and after the device was switched off. Porpoise detection rates were significantly lower up to six hours after devices were switched off, and after 7-9 hours, no significant difference was detected.

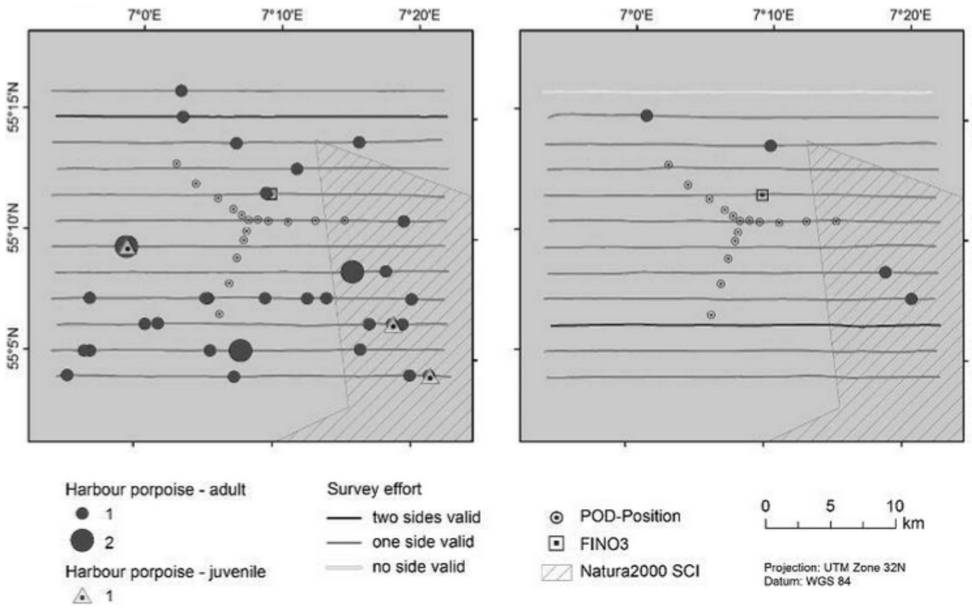

Figure 4: Harbour porpoise aerial sightings before (left) and during (right) Lofitech activation (Brandt et al. 2013b).

61 Brandt et al. (2013a) conducted visual surveys to determine the responses of harbour porpoises to Lofitech ADDs (Figure 5 and Figure 6). In Danish waters, devices were active for four continuous hours, with seven trials in total, leading to 28 hours of collected data. Sighting rates of harbour porpoise significantly declined up to 1 km from the active Lofitech device, which was associated with a minimum sound level of 129 db re 1 µPa RMS. Upon activation of the ADD, the mean number of porpoises detected during a scan decreased from 0.86 to 0.01. While Lofitech trials in German waters observed avoidance up to 7.5 km from the device, in Danish waters avoidance was detected at a maximum of 2.4 km from the ADD. However, due to differences in water depth, the sound level at the offshore German site (119 dB re 1 µPa) and the more coastal Danish site were comparable. Porpoise avoidance behaviour occurred immediately upon device activation, with average swim speeds recorded at 1.6 m/s. Visual observations confirmed porpoises within a 1 km radius of the device, on average 51 minutes after the device was de-activated.

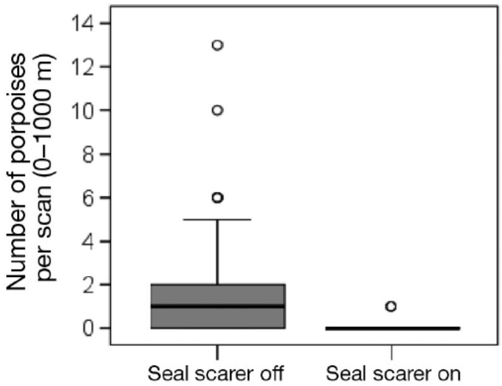

Figure 5: Number of harbour porpoises seen during scans when the Lofitech device was active and inactive (Brandt et al. 2013a).

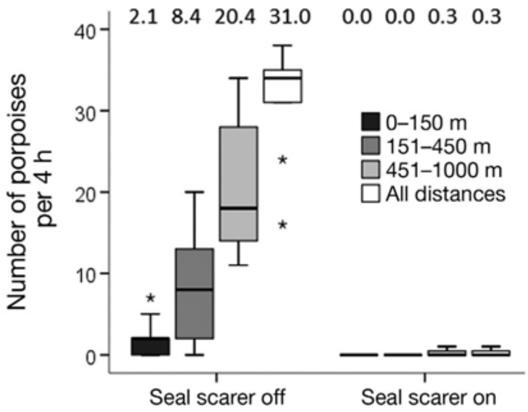

Figure 6: Harbour porpoises sightings rates when the Lofitech device was active and inactive over a range of distances (Brandt et al. 2013a).

1.21 Minke whales

62 During a study commissioned by ORJIP, the playback of Lofitech ADDs resulted in behavioural modifications of minke whales (McGarry et al. 2017, Boisseau et al. 2021). A significant increase in swim speed and direct movement away from the ADD source implied avoidance of the Lofitech device (Figure 7). It was therefore suggested that Lofitech seal scarers may be used as a deterrent of minke whales from mitigation zones in the future. One limitation of this study was the ability to follow the focal whale after it had been exposed to the ADD. The ADD was activated 1 km from the focal animal, and remained active for 15 minutes; all animals responded, which demonstrates an effective deterrence zone of at least 1 km. No measurements were made with ADDs activated at initial distances > 1 km from the focal animal, and the visual limit of observations limited how far animals could be observed responding to, so it is not known what the maximum effective deterrence range is. However, several animals continuing to swim further away to a distance of between c. 3 km and 4.5 km following exposure.

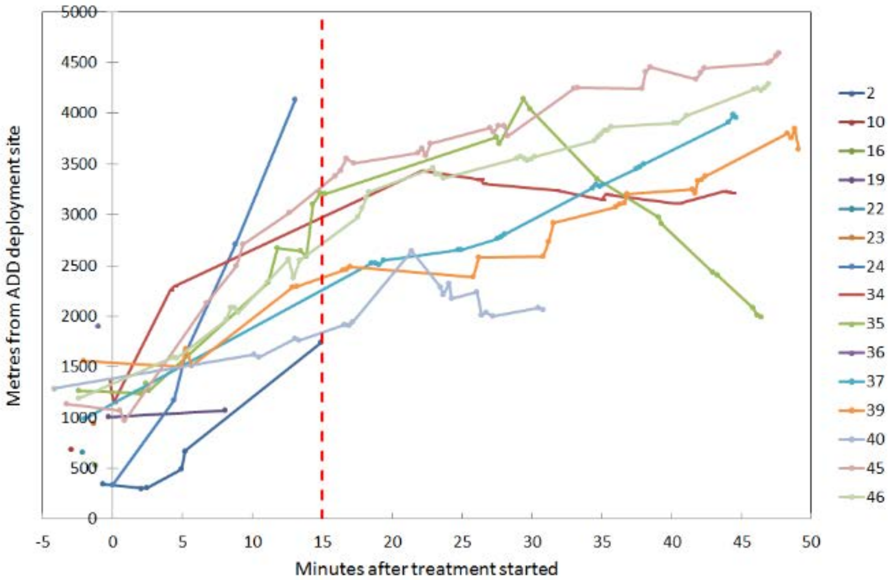

Figure 7: Distance of focal whales from the ADD deployment site during treatment and post treatment phases of the experiment. The red dashed line indicates the end of the treatment phase.

1.22 Seals

63 In 2015, Marine Scotland funded a project to assess the effectiveness of Lofitech devices as harbour seal deterrents (Gordon et al. 2015). In Kyle Rhea in 2013, 10 seals were tagged, and in the Moray Firth in 2014, 13 tags were deployed. In total, 73 controlled exposure experiments were conducted, and responses monitored using a novel telemetry tracking system. All animals within ~1 km of the source exhibited a behavioural response during CEEs (n=38) (Figure 8 and Figure 9). A lack of response to the CEE was first observed 998 m from the device, with a predicted received sound level of 132 dB re 1 1 µPa RMS (Figure 8). Conversely, responses were detected up to 3.112 km from the ADD, where the predicted received level was 120 dB re 1 µPa RMS. However, distances further than 1 km device were characterised by lower response rates, for example, at 4.1 km from the source, only 20% of seals responded to the CEE (Figure 9). Overall, it was concluded that the use the Lofitech device would deter seals up to ~1 km from the source.

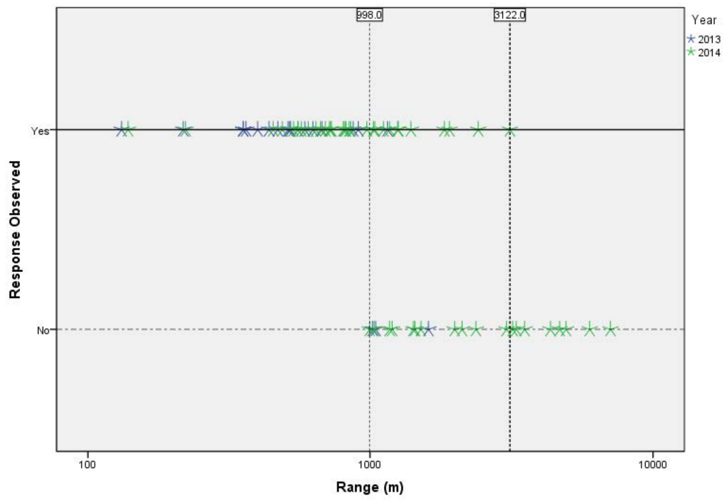

Figure 8: Controlled exposure experiments with harbour seals and the Lofitech device which did and did not elicit responses plotted against range (reproduced from Gordon et al., 2015). The Range of the first closest non-responsive CEE and the most distant responsive CEEs are indicated by the dotted vertical lines.

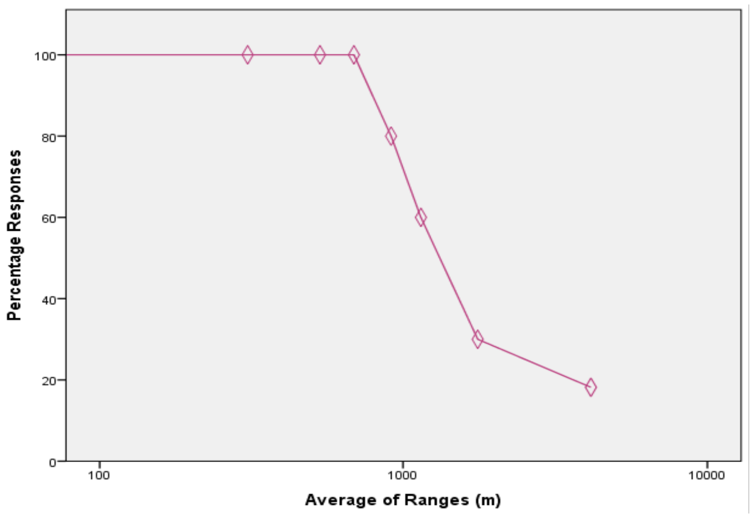

Figure 9: Percentage of controlled exposure experiments with harbour seals and the Lofitech device eliciting a response ranked by range (reproduced from Gordon et al., 2015).

1.23 Dolphin species

64 For dolphin species, there has been little/ no research on deterrence using Lofitech device. However, given that the instantaneous PTS-onset ranges are <50 m, it is considered that this can be fully mitigated using MMObs and PAM.

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