Outer Dowsing Offshore Wind

Outline Marine Mammal Mitigation Protocol

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OUTER DOWSING OFFSHORE WIND

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Abbreviations

Acronym	Expanded name
ADD	Acoustic Deterrent Device
BBC	Big Bubble Curtain
BEIS	Department for Business, Energy & Industrial Strategy (now the Department for Energy Security and Net Zero (DESNZ))
BD	Bottlenose dolphin
DBBC	Double Big Bubble Curtain
DESNZ	Department for Energy Security and Net Zero, formerly Department of Business, Energy and Industrial Strategy (BEIS), which was previously Department of Energy & Climate Change (DECC).
DCO	Development Consent Order
dML	Deemed Marine Licence
EIA	Environmental Impact Assessment
ES	Environmental Statement
GS	Grey seal
HF	High Frequency
HP	Harbour porpoise
HS	Harbour seal
HSD	Hydrosound-Damper
JNCC	Joint Nature Conservation Committee
LF	Low Frequency
MDS	Maximum Design Scenario
MLWS	Mean Low Water Spring
MMMP	Marine Mammal Mitigation Protocol
MMO	Marine Management Organisation
MMOb	Marine Mammal Observer
NAS	Noise Abatement Systems
MW	Minke whale
NMS	Noise Mitigation System
OP	Offshore Platform
OWF	Offshore Wind Farm
PAM	Passive Acoustic Monitoring
PCW	Phocine Carnivore in Water
PEIR	Preliminary Environmental Information Report
PTS	Permanent Threshold Shift
SEL	Sound Exposure Level
SEL_{cum}	Cumulative Sound Exposure Level
SPL	Sound Pressure Level
SPL_{peak}	Peak Sound Pressure Level
SNCB	Statutory Nature Conservation Body
UK	United Kingdom
UXO	Unexploded Ordnance
VHF	Very High Frequency

Acronym	Expanded name
WBD	White Beaked dolphin
WTG	Wind Turbine Generator
µPa	Micropascal

Terminology

Term	Definition
Array area	The area offshore within the PEIR Boundary within which the generating stations (including wind turbine generators (WTG) and inter array cables), offshore accommodation platforms, offshore transformer substations and associated cabling are positioned.
Baseline	The status of the environment at the time of assessment without the development in place.
deemed Marine Licence (dML)	A licence administered under the Marine and Coastal Access Act 2009. The licence set out within a Schedule within the Development Consent Order (DCO).
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for a Nationally Significant Infrastructure Project (NSIP) from the Secretary of State (SoS) for Department for Energy Security and Net Zero (DESNZ).
Effect	Term used to express the consequence of an impact. The significance of an effect is determined by correlating the magnitude of an impact with the sensitivity of a receptor, in accordance with defined significance criteria.
Environmental Impact Assessment (EIA)	A statutory process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information, which fulfils the assessment requirements of the Environmental Impact Assessment (EIA) Regulations, including the publication of an Environmental Statement (ES).
EIA Regulations	Infrastructure Planning (Environmental Impact Assessment) Regulations 2017.
Environmental Statement (ES)	The suite of documents that detail the processes and results of the Environmental Impact Assessment (EIA).
Impact	An impact to the receiving environment is defined as any change to its baseline condition, either adverse or beneficial.
Landfall	The location at the land-sea interface where the offshore export cable will come ashore.
Maximum Design Scenario	The maximum design parameters of the combined project assets that result in the greatest potential for change in relation to each impact assessed
Mitigation	Mitigation measures, or commitments, are commitments made by the Project to reduce and/or eliminate the potential for significant effects to arise as a result of the Project. Mitigation measures can be embedded (part of the project design) or secondarily added to reduce impacts in the case of potentially significant effects.
Peak Sound Pressure Level	Characterised as a transient sound from impulsive noise sources, it is the maximum change in positive pressure as the wave propagates
Preliminary Environmental	The PEIR is written in the style of a draft Environmental Statement (ES) and provides information to support and inform the statutory

Term	Definition
Information Report (PEIR)	consultation process in the pre-application phase. Following that consultation, the PEIR documentation will be updated to produce the Project's ES that will accompany the application for the Development Consent Order (DCO).
Pre-construction	The phases of the Project before construction takes place.
Sound Exposure Level	Measure that considers both the received level of the sound and duration of exposure.
Sound Pressure Level	Measure of the average unweighted level of sound, usually a continuous noise source.
Receptor	A distinct part of the environment on which effects could occur and can be the subject of specific assessments. Examples of receptors include species (or groups) of animals or plants, people (often categorised further such as 'residential' or those using areas for amenity or recreation), watercourses etc.
PEIR Boundary	The PEIR Boundary is outlined in Figure 3.1 of Volume 1, Chapter 3: Project Description and comprises the extent of the land and/or seabed for which the PEIR assessments are based upon.
The Applicant	GT R4 Ltd. The Applicant making the application for a DCO. The Applicant is GT R4 Limited (a joint venture between Corio Generation, TotalEnergies and Gulf Energy Development (GULF)), trading as Outer Dowsing Offshore Wind. The project is being developed by Corio Generation (a wholly owned Green Investment Group portfolio company), TotalEnergies and GULF.
The Project	Outer Dowsing Offshore Wind including proposed onshore and offshore infrastructure.
Wind turbine generator (WTG)	All the components of a wind turbine, including the tower, nacelle, and rotor.

1 Introduction

1.1 Project Background

1.1.1 GT R4 Limited (trading as Outer Dowsing Offshore Wind) hereafter referred to as the 'Applicant' is proposing to develop Outer Dowsing Offshore Windfarm (hereafter referred to as 'the Project'). The Project will be located approximately 54km from the Lincolnshire coastline in the southern North Sea. The Project will include both offshore and onshore infrastructure including an offshore generating station (windfarm), export cables to landfall, onshore cables, and connection to the electricity transmission network, and ancillary and associated development (see Volume 1, Chapter 3: Project Description for full details).

1.2 Purpose of the Outline Marine Mammal Mitigation Protocol

1.2.1 The primary aim of this Outline Marine Mammal Mitigation Protocol (MMMP) is to detail potential contingency measures which may be proposed to reduce the risk of permanent threshold shift (PTS) auditory injury to marine mammal species from pile driving activity at the Project. This Outline MMMP draws on the guidance provided by the Joint Nature Conservation Committee (JNCC, 2010) and Statutory Nature Conservation Bodies (SNCB) recommendations with regards to use of Acoustic Deterrent Devices (ADD) (JNCC, 2020).

1.2.2 The measures outlined in this Outline MMMP should be considered as examples of potential mitigation measures which could be employed by the Project, rather than identification of specific mitigation measures that will be used. Prior to construction, noise modelling will be undertaken based on the final pile driving parameters (following further site investigation works). This will then inform the final MMMP which will be developed for use during construction and will be based on the measures and guidance available at that time.

1.2.3 This Outline MMMP is for pile driving activities for the foundation structures only. A separate Marine Licence application will be made for any required Unexploded Ordnance (UXO) clearance activities, for which a dedicated UXO-specific MMMP would be developed as part of that application.

1.3 Implementation of the Outline MMMP

1.3.1 This document establishes the principles which will be implemented during construction. If a Development Consent Order (DCO) is granted and once the final project design has been confirmed, a final MMMP will be prepared for approval following the principles established in this Outline MMMP.

2 Description of the Project

2.1 Scenarios Considered

2.1.1 For the offshore aspects of the Project, the Maximum Design Scenario (MDS) is the installation of:

- up to 93 monopile wind turbine generator (WTG) foundations; and
- seven Offshore Platform (OP) foundations.

2.1.2 The Project may install both monopiles and pin-piles, so both foundation types have been assessed in the PEIR (see Volume 1, Chapter 11: Marine Mammals).

2.1.3 The foundation installation duration under the MDS (greatest spatial extent on any one day) is expected to be a maximum:

- 50 piling days in total when using monopiles (Table 2.1); and
- 100 piling days when using pin-piles.

2.1.4 A summary of the parameters assessed are presented in the sections below, with the outcome of the marine mammal assessment summarised in Section 3.

2.1.5 In Volume 1, Chapter 11: Marine Mammals of the PEIR, the assessment provides predicted impacts from the MDS.

2.1.6 The MDS based on engineering predictions is presented in Table 2.1 for monopile and Table 2.2 for pin-piles.

2.2 Monopile MDS

2.2.1 Table 2.1 details the piling parameters that represent the MDS for monopiles as relevant to the Outline MMMP. For full details of the piling parameters see Volume 2, Appendix 3.2: Underwater Noise Assessment.

Table 2.1: Monopile MDS parameters

Parameter	Monopiles	
	WTG	OP
Maximum hammer energy (kJ)	6,600	
Maximum pile diameter (m)	13	14
Soft start duration (s)	600	
Ramp up duration (s)	5,400	

Pin-pile MDS

2.2.2 Table 2.2 details the piling parameters that represent the MDS for pin-piles as relevant to the Outline MMMP. For full details of the piling parameters see Volume 2, Appendix 3.2: Underwater Noise Assessment.

Table 2.2: Multi-leg pin-piled jacket MDS parameters

Parameter	Pin-piles
Maximum hammer energy (kJ)	3,500
Maximum pile diameter (m)	5
Soft start duration (s)	600
Ramp up duration (s)	4,500

3 Summary of Potential Impacts

3.1 Maximum Design Scenario

3.1.1 For full details of the piling parameters modelled see Volume 2, Appendix 3.2: Underwater Noise Report.

Instantaneous and Cumulative PTS-Onset

3.1.2 The largest instantaneous PTS-onset impact range (unweighted peak Sound Pressure Level (SPL_{peak})) for piling is estimated at 590m for harbour porpoise. For all other marine mammal receptors, the maximum range was <50m (Table 3.1). The largest PTS-onset impact range (weighted cumulative Sound Exposure Level (SEL_{cum})) for piling is estimated to be 5,500m for minke whale. For all other marine mammal receptors, the maximum range was <100m except harbour porpoise which is estimated to be 3,400m (Table 3.1).

Table 3.1: Estimated instantaneous and cumulative PTS-onset ranges (m) at full hammer energy

Species	Threshold	Monopiles (6,600 kJ)	Pin-pile (3,500 kJ)
		Maximum range (m)	Maximum range (m)
Harbour porpoise	Unweighted SPL_{peak} 202 dB re 1µPa	590	510
Very high frequency (VHF) cetacean	VHF weighted SEL_{cum} 155 dB re 1 µPa² s	3,400	2,300
Bottlenose dolphin	Unweighted SPL_{peak} 230 dB re 1µPa	<50	<50
High frequency (HF) cetacean	HF weighted SEL_{cum} 185 dB re 1 µPa² s	<100	<100
White-beaked dolphin	Unweighted SPL_{peak} 230 dB re 1µPa	<50	<50
HF	HF weighted SEL_{cum} 185 dB re 1 µPa² s	<100	<100
Minke whale	Unweighted SPL_{peak} 219 dB re 1µPa	<50	<50
Low frequency (LF) cetacean	HF weighted SEL_{cum} 183 dB re 1 µPa² s	5,500	3,900
Grey seal	Unweighted SPL_{peak} 218 dB re 1µPa	<50	<50
Phocid Carnivore in Water (PCW)	PCW weighted SEL_{cum} 185 dB re 1 µPa² s	<100	<100
Harbour seal	Unweighted SPL_{peak} 218 dB re 1µPa	<50	<50
PCW	PCW weighted SEL_{cum} 185 dB re 1 µPa² s	<100	<100

3.2 Summary of Assessment for Marine Mammals

3.2.1 Volume 1, Chapter 11: 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 use of embedded mitigation methods (outlined within this Outline Marine Mammal Mitigation Protocol), it is expected that the risk of PTS will be negligible under the MDS for both monopiles and pin-piles and is not therefore considered to have a significant effect on any marine mammal species considered in the assessment.

4 Embedded Mitigation Measures

4.1.1 As part of the Project design process, a number of embedded mitigation measures have been adopted to reduce the potential for impacts on marine mammals. These embedded mitigation measures have evolved over the development process as the Environmental Impact Assessment (EIA) has progressed and in response to consultation.

4.1.2 These measures typically include those that have been identified as good or standard practice and include actions that would be undertaken to meet existing legislative requirements. As there is a commitment to implementing these embedded environmental measures, and also to various standard sectoral practices and procedures, they are considered inherently part of the design of the Project and are set out in this Outline MMMP.

4.1.3 All embedded mitigation measures of relevance to marine mammals are detailed within Volume 1, Chapter 11: Marine Mammals. Of primary relevance to this Outline MMMP, is the commitment to develop and implement a piling MMMP, as required under the draft DCO and associated deemed Marine Licences contained within (Document Reference 3.1).

4.1.4 Table 4.1 sets out the embedded mitigation measures relevant to piling and how these affect the marine mammal assessment.

Table 4.1: Relevant marine mammal environmental measures relevant to piling

Environmental measure proposed	Project phase measure introduced	How the environmental measures will be secured	Relevance to marine mammal assessment
A piling MMMP will be implemented during construction and will be developed in accordance with JNCC (2010) guidance and up to date, current best practices. The piling MMMP will include details of soft start to be used during piling operations	Scoping	dML conditions	The piling MMMP will reduce the impact of underwater noise from piling activities, lowering the risk of injury, including PTS

5 Mitigation Methodology

5.1 Introduction

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

- Pre-piling deployment of ADDs;
- Marine Mammal Observation (MMOb);
- Passive Acoustic Monitoring (PAM); and
- Piling soft-start procedure.

5.1.2 In addition to the above measures that, in various combinations of use, are considered to be "standard" measures for use in United Kingdom (UK) waters, offshore windfarms in European waters are required to use noise abatement systems (NAS) to reduce the noise emitted into the marine environment. As part of the UK Government Energy Security Strategy, a number of "Nature-based Design Standards" (BEIS, 2023) are being developed, which may include reductions in noise levels from piling activity. If these standards are introduced prior to the construction of the Project, the requirement to use NAS would also be considered in developing the piling MMMP, in addition to the above measures.

5.1.3 The specific mitigation measure (or suite of measures) that will be implemented during the construction of the Project will be determined, in consultation with relevant SNCBs, and be subject to approval by the MMO prior to the commencement of the piling works, 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).

5.1.4 The following sections provide a high-level methodology for each of these measures.

5.2 Mitigation Zone

5.2.1 The mitigation zone is defined as the maximum potential PTS-onset impact range. The Applicant will update the noise modelling prior to construction once the final project details are known. The JNCC (2010) guidance recommends a mitigation zone of 500m during piling. The actual mitigation zone for the Project piling will be confirmed in the final MMMP and will be determined based on the final noise modelling. If the final noise modelling estimates a PTS-onset impact range larger than the 500m suggested in the JNCC piling guidance, the mitigation zone will be increased to cover the PTS-onset impact.

5.3 Pre-piling deployment of Acoustic Deterrent Devices

ADD Choice and Specification

5.3.1 If an ADD is chosen as part of the suite of mitigation measures set out in the final piling MMMP, the ADD that is the current preferred option to be used is the Lofitech AS seal scarer, although this will be confirmed within the final document. This ADD has been shown to have the most consistent effective deterrent ranges for harbour seals, grey seals and harbour porpoise (Sparling *et al.,* 2015; McGarry *et al.,* 2017). The Lofitech AS seal scarer has been successfully used for marine mammal mitigation purposes at a number of OWF construction projects in Europe, including the C-Power Thornton Bank OWF in Belgium (Haelters *et al.,* 2012), 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). Additionally, Lofitech AS seal scarer has been used as mitigation for recent UK projects, including Hornsea Project One, Hornsea Project Two and for the Sofia Offshore Wind Farm UXO campaign.

5.3.2 It is important to note that there may be additional ADD models identified in the pre-construction phase for the Project that are available and suitable for use. As such, if the requirement for an ADD is identified as part of the suite of mitigation measures set out in the final MMMP, the final choice of a specific ADD model and its specification would be confirmed within the document submitted for approval.

Duration of Deployment

5.3.3 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.

5.3.4 A swim speed of 1.5m/s (Lepper *et al.,* 2012) is assumed for all marine mammals with the exception of minke whales. A swim speed of 3.25m/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 4.2m/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 1.97m/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 2m/s.

5.3.5 Marine mammals are expected to continue moving away from the noise source during the soft start period and throughout the ramp up. In addition, the presence of additional construction 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; Benhemma-Le Gall *et al*., 2021).

Instantaneous PTS

5.3.6 Under the monopile MDS, the maximum duration to flee the relevant PTS-onset range under the monopile MDS is recorded for harbour porpoise (Table 5.1). The maximum instantaneous PTS-onset range is 590m and, given a swim speed of 1.5m/s, animals starting at the piling location would take approximately 6.6 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 monopiles (Table 5.1).

5.3.7 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 5.1). The maximum instantaneous PTS-onset range for pin-piles is 510m and, given a swim speed of 1.5m/s, animals starting at the pile location would take approximately 5.7 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 5.1).

5.3.8 Therefore, in order to ensure that the instantaneous PTS-onset range is free of animals, ADD activation would be required for approximately 6.6 minutes for monopiles and 6.5 minutes for pin-piles.

Table 5.1: Estimated time for marine mammals to flee maximum PTS-onset impact range (SPL_{peak})

Species	Monopiles (6,600 kJ)						Pin-piles (3,500 kJ)					
	HP	BD	WBD	MW	GS	HS	HP	BD	WBD	MW	GS	HS
Maximum PTS-onset range (m)	590	<50	<50	<50	<50	<50	510	<50	<50	<50	<50	<50
Swim speed (m/s)	1.5	1.5	1.5	3.25	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Time to flee (mins)	6.6	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

Cumulative PTS

5.3.9 The maximum cumulative PTS-onset range for harbour porpoise for monopile is predicted to be 3,400m and, given a swim speed of 1.5m/s, animals starting at the piling location would take approximately 38 minutes to exit the impact range. The maximum instantaneous PTS-onset range for harbour porpoise for pin-piles is predicted to be 2,300m and, given a swim speed of 1.5m/s, animals starting at the piling location would take approximately 26 minutes to exit the impact range. It would take less time for each of the other species to exit their maximum cumulative PTS-onset ranges for monopiles (Table 5.2).

5.3.10 Therefore, in order to ensure cumulative PTS-onset range is free of individuals, ADD activation will be required for 38 minutes for monopiles and 26 minutes for pin-piles.

Table 5.2: Estimated time for marine mammals to flee SEL_{cum} PTS impact zone

Species	Monopiles (6,600 kJ)						Pin-piles (3,500 kJ)					
	HP	BD	WBD	MW	GS	HS	HP	BD	WBD	MW	GS	HS
Maximum PTS-onset range (m)	3400	<100	<100	5500	<100	<100	2300	<100	<100	3900	<100	<100
Swim speed (m/s)	1.5	1.5	1.5	3.25	1.5	1.5	1.5	1.5	1.5	3.25	1.5	1.5
Time to flee (mins)	38	<2	<2	34	<2	<2	26	<2	<2	20	<2	<2

ADD deployment procedure

5.3.11 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".

5.3.12 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. Recent best-practice for offshore windfarms has involved the required ADD duration to be observed to ensure an animal is outside any PTS-onset range being run concurrently to the MMObs watch, but not for the full MMObs watch period. This ensures that the risk of PTS is negligible, whilst avoiding excessive disturbance to marine mammals through extended ADD durations. The final ADD activation period will be discussed and agreed with SNCBs and JNCC, prior to MMO approval, to ensure that the mitigation ensures sufficient clearance of the mitigation zone without resulting in unnecessary disturbance impacts.

5.3.13 It is expected that during monopile or pin-pile installation, one ADD will 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 will 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.

ADD Operator Training and Responsibilities

5.3.14 A trained and dedicated ADD operator will be responsible for ADD maintenance, operation and reporting. The ADD duties would include deployment of the ADD from the installation platform or vessel, verifying the operation of the ADD before deployment, operation of the ADD throughout the pre-piling period (and to be available in the case of piling breaks to reactivate), ensuring batteries are fully charged and that spare equipment is available in case of any problems, and recording and reporting on all ADD and piling activity. Prior to the start of the marine mammal observer pre-piling watch period, the ADD operator will test the equipment to ensure the ADD is working and ensure they are deployed appropriately

from the vessel or jacket to the 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 ADD operator will activate the ADD and the marine mammal observer will commence the pre-piling watch. When the soft start commences the ADD operator will deactivate the ADD.

5.4 Marine Mammal Observers

5.4.1 JNCC (2010) recommends a pre-piling search by a qualified MMOb of a minimum period of 30 minutes (JNCC, 2010) for both the monopiles and pin-piles for the visual mitigation zone (the area visually observable from a raised location, often on the installation vessel). 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 ADD activation (if chosen as a mitigation measure in the final MMMP) 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).

5.4.2 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 determined by the MMOb that the marine mammal has vacated the mitigation zone and sufficient time has elapsed since the last detection for the animal to have reached a safe distance (defined as the PTS-onset range for the Project). At the same time, the ADD (if chosen as a mitigation measure in the final MMMP) will be checked to ensure correct operation. The MMOb would continue to note any detections and observations on animal behaviour during the soft start period.

5.4.3 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).

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

5.5 Passive Acoustic Monitoring

5.5.1 A Passive Acoustic Monitoring (PAM) system may be used to allow a trained PAM 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 four as per JNCC, 2010)). If a PAM is not available for monitoring, then it is unlikely 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.

5.6 Soft Start Procedure

5.6.1 Following the pre-piling deployment of the ADDs (if chosen as a mitigation measure in final MMMP) and the marine mammal observer pre-piling watch, the installation of each foundation will commence with a maximum of 10% of the maximum hammer energy for a duration of 10 minutes. The hammer energy will then ramp up in steps until the levels required to install the pile are reached or up to the maximum hammer energy. The "soft-start" comprises the piling procedure from the first blow until the maximum hammer energy is reached.

5.6.2 The hammer energy will not be increased above the 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.

5.7 Noise Abatement

5.7.1 Whilst the above measures are designed to avoid animals being within the PTS-onset area, the purpose of a NAS is to reduce the sound emitted by the piling operation into the wider marine environment and subsequently reduce the received sound at any given range from the piling operation. There are several different NAS that have been commercially deployed at offshore windfarm projects, including: Big Bubble Curtains (BBC), Double Big Bubble Curtains (DBBC), 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, for example: the AdBm-Noise Abatement System, BLUE Piling Technology (an alternative hammer type) and HydroNAS (Verfuss *et al.,* 2019; Bellmann *et al*., 2020).

5.7.2 The approximate level of noise reduction that can be achieved by these different methods, alone and in combination, is outlined in Table 5.3 and Figure 5.1, based on the review of noise abatement methods and their limitations provided in Verfuss *et al.,* (2019) and Koschinski and Lüdemann (2020) .

Table 5.3: Minimum and maximum noise reduction efficacy. Data obtained from Verfuss *et al.,* (2019) and Koschinski and Lüdemann (2020)

Noise abatement system	Water depth (m)	Noise reduction SELss (dB) range
BBC (> 0.3m³/min*m)	~40	7-11
DBBC (> 0.3m³/min*m)	~40	8-13
DBBC (> 0.4m³/min*m)	~40	12-18
DBBC (> 0.5m³/min*m)	>40	~15-16 (based on one pile)
NMS	Up to 40	13-16
HSD	Up to 40	10-12
NMS + optimised BBC (>0.4m³/(min*m)	~40	17-18
NMS + optimised BBC (>0.5m³/(min*m)	~40	18-20
HSD + optimised BBC (>0.4m³/(min*m)	~30	15-20
HSD + optimised DBBC (0.48m³/(min*m)	20-40	15-28
HSD + optimised DBBC (>0.5m³/(min*m)	<45	18-19
BLUE Hammer	30	19-24

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

Bubble curtain air volume flow given in m³/(min*m)

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

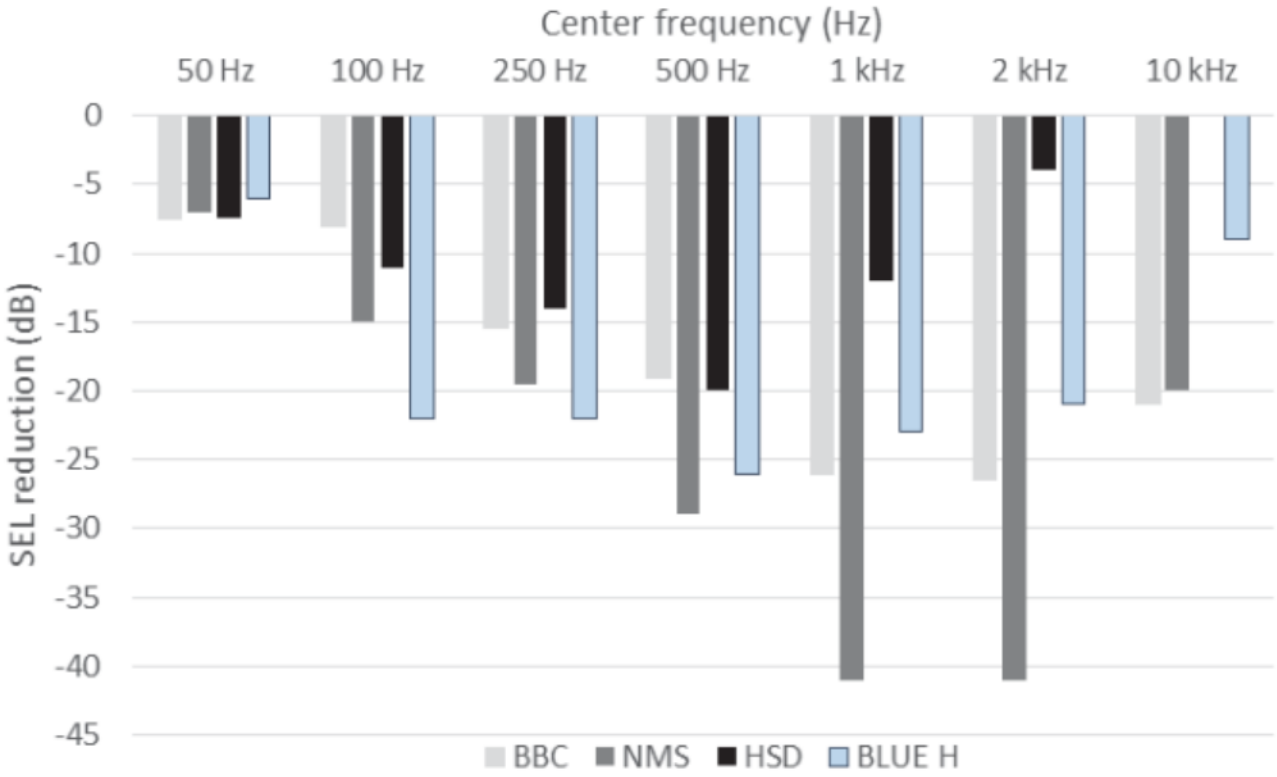

Figure 5.1: Reduction in SEL at frequencies 10 Hz, 250 Hz, 500 Hz, 1 kHz and 2 kHz in the 1/3rd octave and frequency spectrum of a pile strike when comparing mitigated and unmitigated piling. From Verfuss *et al.,* (2019)

5.7.3 As outlined in Bellmann *et al*. (2020), in addition to the above NAS which cover both near-field in-water abatement and alternative piling technologies, the main hydraulic hammer providers have developed NAS which are attachments to the standard hydraulic hammers and which can be included as part of the standard piling set up. Current examples are the Menck Noise Reduction Unit and the IHC Pulse systems. These systems act as "spring-dampers" which minimise power peaks and maximise the impulse duration, resulting in comparable transmission of force from the hammer to the pile whilst reducing the pile-driving noise (due to the reduced peak power) (Bellmann *et al*., 2020). No real-world data is currently available for the reduction in sound from these systems.

5.7.4 To date, NAS has not been utilised for piling activity on a UK offshore windfarm, with the "standard" mitigation measures deemed sufficient to reduce the PTS-onset risk to negligible, based on final pile driving parameters.

5.7.5 If NAS is deemed to be required through the final pile driving scenario for the Project or as a result of changes in policy or guidance from Government or relevant stakeholders, one of the above types may be used or alternatives available at the point of construction.

5.8 Breaks in Piling

5.8.1 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:

"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".

5.8.2 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 SNCBs and set out within the final piling MMMP.

5.9 Delay in Commencement of Piling

5.9.1 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 will therefore be turned off as soon as the delay in the commencement is realised. The ADD will not be switched on again until there is confirmation that piling is ready to commence. The ADD will then be reactivated, as above, for the minimum duration required for animals to move out of the mitigation zone.

5.10 Communications

5.10.1 The final piling MMMP will detail a communications protocol to ensure that all required 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.

5.10.2 The final piling 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 mitigation measures and personnel required with the titles and responsibilities being refined depending on the contractual agreement.

5.11 Reporting

5.11.1 Reports detailing the piling activity and mitigation measures will be prepared as required. Where appropriate these may include, but may not necessarily be 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 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.

5.11.2 Reports would be collated and provided to the MMO on a weekly basis during the period in which piling operations are being conducted. In addition, a final report will be provided following the completion of piling activity which will be submitted to the MMO. 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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