Rampion 2 Wind Farm

Category 7: Other Documents

Draft Piling Marine Mammal Mitigation Protocol (clean)

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A	04/08/2023	Final for DCO Application	GoBe	RED	RED
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C	01/08/2024	Updates for Deadline 6	GoBe	RED	RED

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Executive Summary

The primary aim of this **Draft Piling Marine Mammal Mitigation Protocol** (the Draft Piling MMMP) (Document Reference:7.14) **[REP4-051]** (updated at Deadline 6)) is to detail the contingency measures proposed to reduce the risk of permanent threshold shift (PTS) auditory injury to any marine mammal species in the close proximity to the pile driving for the installation of Rampion 2 monopile and pin-pile foundations.

A summary of the potential impacts is provided in **Section 3** including the maximum design scenario which has been assumed, and a summary of the impact assessment for marine mammals in relation to permanent threshold shift for piling noise. The proposed embedded environmental measures to reduce the impacts are provided in **Section 4**, and **Section 5** outlines the suite of mitigation measures that the Applicant could implement for Rampion 2 piling and the reporting and communication proposals.

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1. Introduction

1.1 Purpose of the Draft Piling Marine Mammal Mitigation Protocol (MMMP)

1.1.1 The primary aim of this Draft Piling Marine Mammal Mitigation Protocol (the Draft Piling MMMP) is to detail the contingency measures proposed to reduce the risk of permanent threshold shift (PTS) auditory injury to any marine mammal species in the close proximity to the pile driving for the installation of Rampion 2 monopile and pin-pile foundations to negligible (as defined in **Table 11.7** in **Chapter 11: Marine mammals, Volume 2** of the ES (updated at Deadline 6) (Document Reference: 6.2.11) **[REP5-031]**. This Draft Piling MMMP draws on the guidance provided by the Joint Nature Conservation Committee (JNCC, 2010) and Statutory Nature Conservation Bodies (SNCBs) recommendations with regards to use of Acoustic Deterrent Devices (ADD) (JNCC, 2022).

1.1.2 During pre-construction separate MMMPs for piling and unexploded ordnance (UXO) clearance will be developed for Rampion 2. The Final MMMPs will be updated to take account of the most suitable mitigation measures available at the time of construction. These measures will be consulted upon with Natural England and other stakeholders as appropriate, including The Wildlife Trust (TWT).

1.2 Implementation of the Draft Piling MMMP

1.2.1 This document is a draft protocol of the measures which will be implemented during construction. Following the granting of the Development Consent Order (DCO) and once the final project design has been confirmed, a Final Piling Marine Mammal Mitigation Protocol (the Final Piling MMMP) will be prepared following the principles established in this Draft Piling MMMP (as required under DCO Condition 11 of the Schedules 11 and 12 of the deemed marine licences). Details regarding proposed mitigation can be found in the embedded mitigation (**Table 4-1**).

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2. Description of the Proposed Development

2.1 Key Relevant Project Characteristics and Maximum Design Scenario (MDS)

2.1.1 Rampion Extension Development Limited (hereafter referred to as 'RED') (the Applicant) is developing the Rampion 2 Offshore Wind Farm Project (Rampion 2) located adjacent to the existing Rampion Offshore Wind Farm Project ('Rampion 1') in the English Channel.

2.1.2 Rampion 2 will be located between 13km and 26km from the Sussex Coast in the English Channel and the offshore array area will occupy an area of approximately 160km^2.

2.1.3 The key offshore elements of the Proposed Development will be as follows:

- up to 90 offshore wind turbine generators (WTGs) and associated foundations;
- blade tip of the WTGs will be up to 325m above Lowest Astronomical Tide (LAT) and will have a 22m minimum air gap above Mean High Water Springs (MHWS);
- inter-array cables connecting the WTGs to up to three offshore substations;
- up to two offshore interconnector export cables between the offshore substations;
- up to four offshore export cables each in its own trench, will be buried under the seabed within the final cable corridor; and
- the export cable circuits will be High Voltage Alternating Current (HVAC), with a voltage of up to 275kV

2.1.4 The key onshore elements of the Proposed Development will be as follows:

- a single landfall site near Climping, Arun District, connecting offshore and onshore cables using Horizontal Directional Drilling (HDD) installation techniques;
- buried onshore cables in a single corridor for the maximum route length of up to 38.8km using:
  - trenching and backfilling installation techniques; and
  - trenchless and open cut crossings.
- a new onshore substation, proposed near Cowfold, Horsham District, which will connect to an extension to the existing National Grid Bolney substation, Mid Sussex, via buried onshore cables; and

- extension to and additional infrastructure at the existing National Grid Bolney substation, Mid Sussex District to connect Rampion 2 to the national grid electrical network.

2.1.5 A full description of the Proposed Development is provided in **Chapter 4: The Proposed Development, Volume 2** of the ES **[APP-045]** (updated at Deadline 6) (Document Reference 6.2.4) **[APP-045]**.

2.1.6 Both monopiles and pin-piles can be installed at Rampion 2. The worst-case scenario (WCS) assessed in the **ES** (Document Reference: 6.2) for marine mammals is the installation of monopiles as they require 4,400 kJ hammer energy (see **Chapter 11: Marine mammals, Volume 2** of the ES (updated at Deadline 6) (Document Reference: 6.2.11) **[REP5-031]**. The foundation installation duration under the WCS is expected to be approximately 93 piling days in total for the WTGs and other piled infrastructure when using monopiles (**Table 2-1**), and 99 piling days in total when using pin-piles (**Table 2-3**). A summary of the assessment assumptions is presented in the sections below, with the outcome of the marine mammal assessment summarised in **Section 3**.

2.1.7 The assessment in **Chapter 11: Marine mammals, Volume 2** of the ES (updated at Deadline 6) (Document Reference: 6.2.11) **[REP5-031]** provides predicted impacts from the WCS. The WCS is intended to cover the maximum piling parameters and assumptions that would ever be required to install each foundation (in terms of maximum hammer energies and longest piling durations). The WCS, based on engineering predictions, is a maximum 4,400kJ hammer energy for each monopile and 2,500kJ for each pin-pile.

Monopile MDS

2.1.8 **Table 2-1** and **Table 2-2** detail the assumptions that represent the WCS for monopiles. For full details of the piling parameters see **Appendix 11.2: Marine mammal quantitative underwater noise impact assessment, Volume 4**, of the ES (Document Reference: 6.4.11.2) [**[APP-148]** and **Appendix 11.3: Underwater noise assessment technical report, Volume 4** of the ES (Document Reference: 6.4.11.3) **[REP5-046]**.

2.1.9 The Commitment to not exceed the worst-case soft-start/ramp up profile will be achieved through compliance with the final MMMP.th

Table 2-1 Monopile assumptions

Assumption (parameters in bold)	Monopile foundations
Maximum hammer driving energy (kJ)	4,400
Number WTG monopiles	Up to 90
Number OSS monopiles	3
Soft start and ramp up duration (minutes)	30
Total number of piling days	93 (assuming 1 monopile installed in one day)

Table 2-2 Summary of the worst-case ramp up scenario for monopile foundations

Worst-case monopile foundations	880 kJ	1,760 kJ	2,640 kJ	3,520 kJ	4,400 kJ
Number of strikes	75	75	113	113	8,400
Duration (minutes)	7.5	7.5	7.5	7.5	240
Strike rate	10 strikes per minute (1 strike every 6 seconds)		15 strikes per minute (1 strike every 4 seconds)		35 strikes per minute

Pin-pile MDS

2.1.10 **Table 2-3** and **Table 2-4** detail the piling assumptions that represent the WCS for pin-piles. For full details of the piling see **Appendix 11.2: Marine mammal quantitative underwater noise impact assessment, Volume 4** of the ES (Document Reference: 6.4.11.2) **[APP-148]**.

Table 2-3 Pin-pile assumptions

Assumption	WTG foundation
Maximum hammer driving energy (kJ)	2,500
Number of WTG pin-piles	360
Number OSS pin-piles	36
Soft start and ramp up duration (minutes)	30
Total number of piling days	99 (assuming 1 multileg foundation installed in one day)

Table 2-4 Summary of the worst-case ramp up scenario for pin-pile foundations

Worst-case pin-pile foundations	500 kJ	1,000 kJ	1,500 kJ	2,000 kJ	2,500 kJ
Number of strikes	75	75	113	113	8,400
Duration (minutes)	7.5	7.5	7.5	7.5	240
Strike rate	10 strikes per minute (1 strike every 6 seconds)		15 strikes per minute (1 strike every 4 seconds)		35 strikes per minute

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3. Summary of potential impacts

3.1 Maximum design scenario

3.1.1 For both the monopile and pin-pile WCS, the maximum instantaneous (peak Sound Pressure Level - SPL_{peak}) and cumulative (cumulative Sound Exposure Level - SEL_{cum}, the potential for PTS-onset as a result of exposure to piling noise over a 24-hour period) PTS-onset impact ranges predicted at full hammer energy are shown in **Table 3-1**. Unweighted reflects sound levels that have not been adjusted to account for hearing ability of any species, whereas weight sound levels are those that have been adjusted with respect to a 'weighting envelope' in a frequency domain to make an unweighted level relevant to a particular species (see **Appendix 11.3: Underwater noise assessment technical report, Volume 4** of the ES (see Document Reference: 6.4.11.3 **[REP5-046]** for more details).

Table 3-1 Estimated instantaneous and cumulative PTS-onset impact ranges (m) at full hammer energy

Species	Threshold	Monopile (4,400 kJ)		Pin-pile (2,500 kJ)	
Modelling location		**NW**	**S**	**NW**	**S**
Harbour porpoise	Unweighted SPL_{peak} 202 dB re 1µPa	430 m	680 m	360 m	560 m
	Weighted SEL_{cum} 155 dB re 1µPa²s	2,200 m	7,400 m	1,500 m	5,900 m
Minke whale	Unweighted SPL_{peak} 219 dB re 1µPa	<50 m	<50 m	<50 m	<50 m
	Weighted SEL_{cum} 183 dB re 1µPa²s	3,200 m	15,000 m	1,700 m	13,000 m
Bottlenose dolphin and Common dolphin	Unweighted SPL_{peak} 230 dB re 1µPa	<50 m	<50 m	<50 m	<50 m
	Weighted SEL_{cum} 185 dB re 1µPa²s	<100 m	<100 m	<100 m	<100 m
Grey seal and Harbour seal	Unweighted SPL_{peak} 218 dB re 1µPa	<50 m	60 m	<50 m	<50 m
	Weighted SEL_{cum} 185 dB re 1µPa²s	<100 m	100 m	<100 m	<100 m

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

3.2.1 **Chapter 11: Marine mammals, Volume 2** of the ES (updated at Deadline 6) (Document Reference: 6.2.11) **[REP5-031]** presents the full assessment of the impacts of PTS onset for piling noise of marine mammals. The assessment concluded that, with the use of embedded environmental measures including the marine licence condition to develop and implement a Final Piling MMMP (Commitment **C-52** in the embedded mitigation (**Table 4-1**) and outlined within this Draft Piling MMMP,), it is expected that the risk of PTS will be negligible under the MDS for both monopiles and pin-piles. Therefore, it is not considered to have a significant effect on any marine mammal species in the assessment.

4. Rampion 2 embedded environmental measures

4.1 Embedded environmental measures

4.1.1 As part of the Rampion 2 design process, a number of embedded environmental measures have been adopted to reduce the potential for impacts on marine mammals. These embedded environmental measures have evolved over the development process as the 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 legislation 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 Rampion 2 and are set out in this Draft Piling MMMP.

4.1.3 All embedded mitigation measures are detailed within the **Commitments Register** (updated at Deadline 6) (Document Reference: 7.22) **[REP5-086]**.

4.1.4 **Table 4-1** sets out the relevant embedded environmental measures within the design and how these affect the marine mammals assessment. Of relevance to this Draft Piling MMMP, the Commitments Register includes Commitment **C-52** to develop and implement a piling MMMP. The Final Piling MMMP must be in accordance with this draft document.

Table 4-1 Relevant marine mammal environmental measures

ID	Environmental measure proposed	Project phase measure introduced	How the environmental measures will be secured	Relevance to marine mammals assessment
C-38	The selection of the foundation type will primarily be based upon the site conditions combined with the wind turbine generator (WTG) that is selected. The following foundation types are being considered: Monopile and Multi-leg.	Construction and Operation	DCO requirements or deemed Marine Licence (dML) conditions.	
C-40	There will be up to three offshore substations installed to serve the Proposed Development. The exact locations, design and visual appearance will be subject to a structural study and electrical design, which is expected to be completed post consent. The offshore substations will be installed on multi-leg or monopile foundations, similar to those described for the wind turbine generators (WTGs) themselves.	Operation	DCO requirements or deemed Marine Licence (dML) conditions.	
C-51	A Vessel Management Plan will be developed pre-construction which will determine vessel routeing to and from construction areas and ports to minimise, as far as reasonably	Scoping	DCO requirements or DML conditions	The VMP will reduce the risk of vessel disturbance and collision risk. The assessment of vessel disturbance and collision

ID	Environmental measure proposed	Project phase measure introduced	How the environmental measures will be secured	Relevance to marine mammals assessment
	practicable, encounters with marine mammals. It will also consider vessel codes of conduct provided by WiSe Scheme, Scottish Marine Wildlife Watching Code (MWWC) and the Nature Scott "Guide to best practice for watching marine wildlife".			risk are assessed in **Section 11.9 – 11.11** in **Chapter 11: Marine mammals, Volume 2** of the ES (Document reference 6.2.11) **[REP5-031]** (updated at Deadline 6).
C-52	A piling Marine Mammal Mitigation Protocol (MMMP) will be implemented during construction and will be developed in accordance with Joint Nature Conservation Committee (JNCC, 2010) guidance and with the latest relevant guidance and information and in consultation with stakeholders. The piling MMMP will include details of soft starts to be used during piling operations with lower hammer energies used at the beginning of the piling sequence before increasing energies to higher levels. A **Draft Piling Marine Mammal Mitigation Protocol** (Document Reference 7.14 (this document) has been submitted with this application.	Scoping – updated at PEIR and ES	DCO requirements or DML conditions	The implementation of the measures set out in the Piling MMMP will reduce the impact of underwater noise generated from piling activities, lowering the risk of injury, including PTS.

ID	Environmental measure proposed	Project phase measure introduced	How the environmental measures will be secured	Relevance to marine mammals assessment
C-54	A Decommissioning Marine Mammal Mitigation Protocol (MMMP) will be implemented during decommissioning. The Decommissioning MMMP will be in line with the latest relevant available guidance.	Scoping	DCO requirements or DML conditions	The decommissioning MMMP will reduce the impact of underwater noise generated from decommissioning activities, lowering the risk of injury, including PTS. Methods for decommissioning involve cutting and removal of turbines which are activities anticipated to have less of an impact than piling in construction.
C-265	Double big bubble curtains will be deployed as the minimum single offshore piling noise mitigation technology to deliver underwater noise attenuation for all foundation installations throughout the construction of the Proposed Development where percussive hammers are used in order to reduce predicted impacts to: • sensitive receptors at relevant Marine Conservation Zone (MCZ) sites and reduce the risk of	ES	DML conditions	Although the commitment is specific to MCZ, which are not designated for marine mammal features, C-265 is relevant to marine mammals as the use of mitigation technologies will reduce the impact of underwater noise generated from piling during construction phase, this will lower the risk of injury, including PTS.

ID	Environmental measure proposed	Project phase measure introduced	How the environmental measures will be secured	Relevance to marine mammals assessment
	significant residual effects on the designated features of these sites; • spawning herring; and • marine mammals.			

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5. Draft Protocols for Piling

5.1 Possible mitigation measures for piling activities

5.1.1 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 Rampion 2 piling. These mitigation measures may include (but are not limited to) the following:

- pre-piling deployment of ADDs;
- marine mammal observation;
- passive acoustic monitoring systems;
- piling soft-start procedure; and
- at-source noise abatement methods.

5.1.2 The specific mitigation measure (or suite of measures) that will be implemented during the construction of Rampion 2 will be determined in consultation with Natural England, following 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 discussions on the appropriate mitigation measure(s) and the Final Piling MMMP.

5.1.3 The following sections provide a high-level methodology for each of these measures. A Final Piling MMMP will be produced prior to the relevant stage of construction for approval by the Marine Management Organisation (MMO).

Mitigation Zone

5.1.4 The mitigation zone is defined as the maximum potential PTS-onset impact range:

- the maximum instantaneous PTS-onset zone is 680m for monopiles and 560m for pin-piles (harbour porpoise - **Table 3-1**); and
- the maximum cumulative PTS-onset zone is 15km for monopiles and 13km for pin-piles (minke whale - **Table 3-1**).

5.1.5 RED will update the noise modelling prior to construction, once the final project details are known. The JNCC (2010) recommends a mitigation zone of 500m during piling. The actual mitigation zone for Rampion 2 piling will be confirmed in the Final Piling 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 500m suggested in the JNCC piling guidance, the mitigation zone will be increased to cover the PTS-onset impact.

5.1.6 The maximum cumulative PTS ranges of 15km for monopiles and 13km for pin-piles for minke whales are highly precautionary and unlikely to be realised. The key limitations of SEL_{cum} include:

- growing empirical evidence that the equal energy hypothesis assumption behind the SEL_{cum} threshold is not valid (Kastelein et al. 2013; Henderson et al. 1991);
- impulsive noise thresholds overestimate the risk of PTS-onset as impulsiveness reduces over distance;
- fleeing swim speed modelled is precautionary; and
- SEL_{ss} levels are lower at surface -model can overpredict exposure at the surface.

5.1.7 Additional details of the assumptions and limitations of cumulative PTS assessment are presented in **Paragraphs 2.5.5 – 2.5.28** of **Appendix 11.2: Marine mammal quantitative underwater noise impact assessment, Volume 4** of the ES (Document Reference: 6.4.11.2) **[APP-148]**.

5.1.8 In the Final Piling MMMP revised cumulative PTS will be modelled and measures detailed in the document ensure the assessed impact will be reduced to a non-significant effect level. One of the potential mitigation measures that will be considered at this point, will be the use of at-source noise reduction measures in order to reduce the potential for cumulative PTS-onset risk to negligible levels. For example, bubble curtains and double bubble curtains can be used to significantly reduce predicted impact ranges (see **Table 5-3**).

Marine mammal observers (MMOb)

5.1.9 JNCC recommends a pre-piling search of a minimum period of 30 minutes (JNCC 2010) for both the monopiles and pin-piles. The 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).

5.1.10 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.

5.1.11 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).

5.1.12 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.

Passive acoustic monitoring (PAM)

5.1.13 A PAM system may be used to allow a trained PAM operator 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 (for example: night, fog, high sea state. above sea state 4 as per JNCC 2010). If an animal has been detected acoustically, the PAM operative should use a range indication and their judgement to determine whether the marine mammal is within the mitigation zone. If an MMOb or PAM operative is uncertain whether marine mammals are present within the mitigation zone, they should advise that the activity should be delayed as a precaution until they are certain that no animals are present. If a PAM 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.

Pre-piling deployment of ADDs

ADD choice and specification

5.1.14 If an ADD is chosen as part of the suite of mitigation measures set out in the Final Piling MMMP, the ADD that is likely to be used is the Lofitech AS seal scarer, although this will be confirmed within the Final Piling MMMP. This ADD has been shown to have the most consistent effective deterrent ranges for harbour seals, grey seals, harbour porpoise and minke whales (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. 2013a; Brandt et al. 2016). Additionally, Lofitech AS seal scarer has been used as mitigation for UK projects such as Dudgeon Offshore Wind Farm (Vattenfall 2017) Beatrice Offshore Wind Farm and Race Bank Offshore Wind Farm (Seagreen Wind Energy Ltd, 2020).

5.1.15 An Offshore Renewables Joint Industry Programme (ORJIP) study undertook trials of ADD efficacy on minke whale (McGarry et al. 2017). The results presented in the ORJIP study demonstrate that the Lofitech ADD modifies the behaviour of free-ranging minke whales at both 500m and 1000m. Minke whales demonstrated a significant increase in swim speed, and an increase in the directness of their movement away from the site of the ADD playback. This indicates clear avoidance behaviour, which indicates utility as a mitigation tool for the deterrence of minke whales from a standard mitigation zone. Studies by Brandt et al., (2013a; 2013b) demonstrated that the Lofitech ADD resulted in significant deterrence effects on harbour porpoises up to 7.5 km away and all observed porpoises avoiding the seal scarer within 1.9 km.

5.1.16 There is currently no published evidence of the effectiveness of ADDs on bottlenose dolphins but deterrents only have to be effective over a small range for bottlenose dolphins in order to ensure these species are not at risk of instantaneous auditory injury. Further to this, it is also noted that this species is much less likely to be encountered at the site compared to harbour porpoise due to the lower densities of this species recorded in the area. As such, the likelihood of a bottlenose dolphins being exposed to the risk of auditory injury is considered to be extremely low.

5.1.17 It is important to note that there may be additional ADD models identified in the pre-construction phase for Rampion 2 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 Piling MMMP, the final ADD choice and specification would be confirmed within the Final Piling MMMP.

Duration of deployment

5.1.18 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.

5.1.19 A swim speed of 1.5 m/s (Otani et al. 2000; Lepper et al. 2012) is assumed for all marine mammals with the exception of minke whales. A swim speed of 3.25 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.

5.1.20 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).

Instantaneous PTS

5.1.21 Under the monopile WCS, the species with the maximum duration to flee the relevant PTS-onset range under the monopile WCS, is harbour porpoise (**Table 5-1**). The maximum instantaneous PTS-onset range is 680 m and given a swim speed of 1.5 m/s, animals starting at the pile location would take 7.6 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**).

5.1.22 For pin-piles, as with the monopiles, harbour porpoise have the largest instantaneous PTS-onset impact range, and thus the longest duration to flee the impact range (**Table 5-1**). The maximum instantaneous PTS-onset for pin-piles is range is 560 m and given a swim speed of 1.5 m/s, animals starting at the pile location would take 6.2 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**).

5.1.23 Therefore, in order to ensure that instantaneous PTS-onset range is free of individuals, ADD activation will be required for at least 7.6 minutes for monopiles and at least 6.2 minutes for pin-piles.

5.1.24 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 Natural England and JNCC to ensure that the mitigation ensures clearance of the mitigation zone without resulting in unnecessary disturbance impacts.

Table 5-1 Estimated time for marine mammals to flee the instantaneous PTS-onset impact zone

	Monopile WCS (4,400 kJ)				**Pin-pile WCS (2,500 kJ)**			
	HP	**MW**	**BD CD**	**GS HS**	**HP**	**MW**	**BD CD**	**GS HS**
Maximum instantaneous PTS onset range (m)	680	<50	<50	60	560	<50	<50	<50
Swim speed (m/s)	1.5	3.25	1.5	1.5	1.5	3.25	1.5	1.5
Time to flee mitigation zone (min)	7.6	<1	<1	<1	6.2	<1	<1	<1

Cumulative PTS

5.1.25 The maximum cumulative PTS-onset range for harbour porpoise is 7,400 m and given a swim speed of 1.5 m/s, animals starting at the pile location would take 82 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**).

5.1.26 The maximum cumulative PTS-onset for pin-piles is range is 13,000 m for minke whales and given a swim speed of 3.25 m/s, animals starting at the pile location would take 67 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 pin-piles (**Table 5-2**).

5.1.27 Therefore, in order to ensure that cumulative PTS-onset range is free of individuals, ADD activation will be required for at least 82 minutes for monopiles and 67 minutes for pin-piles.

Table 5-2 Estimated time for marine mammals to flee SELcum PTS impact zone

	Monopile WCS (4,400 kJ)				Pin-pile WCS (2,500 kJ)			
	HP	**MW**	**BD CD**	**GS HS**	**HP**	**MW**	**BD CD**	**GS HS**
Maximum cumulative PTS onset range (m)	7,400	15,000	<100	<100	5,900	13,000	<100	<100
Swim speed (m/s)	1.5	3.25	1.5	1.5	1.5	3.25	1.5	1.5
Time to flee cumulative PTS zone (min)	82	77	<2	<2	66	67	2	2

ADD deployment procedure

5.1.28 It is expected that during monopile or pin-pile installation, one ADD would be deployed from the deck of the piling platform/ vessel to an appropriate depth for at least 7.6 minutes, 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.

ADD operator training and responsibilities

5.1.29 A trained and dedicated ADD operator will 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 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 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 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.

Soft start and ramp up procedure

5.1.30 Following the pre-piling deployment of the ADDs and the marine mammal observer pre-piling watch, the installation of each foundation will commence with an initial maximum of 20% of the maximum hammer energy for a duration of 7.5 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. Hammer energy will not exceed 80% of the maximum hammer energy before 30 minutes from the initial hammer strike. The hammer energy will not be increased above the hammer energy required to complete each installation for example: 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. The gradual 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.

Noise abatement

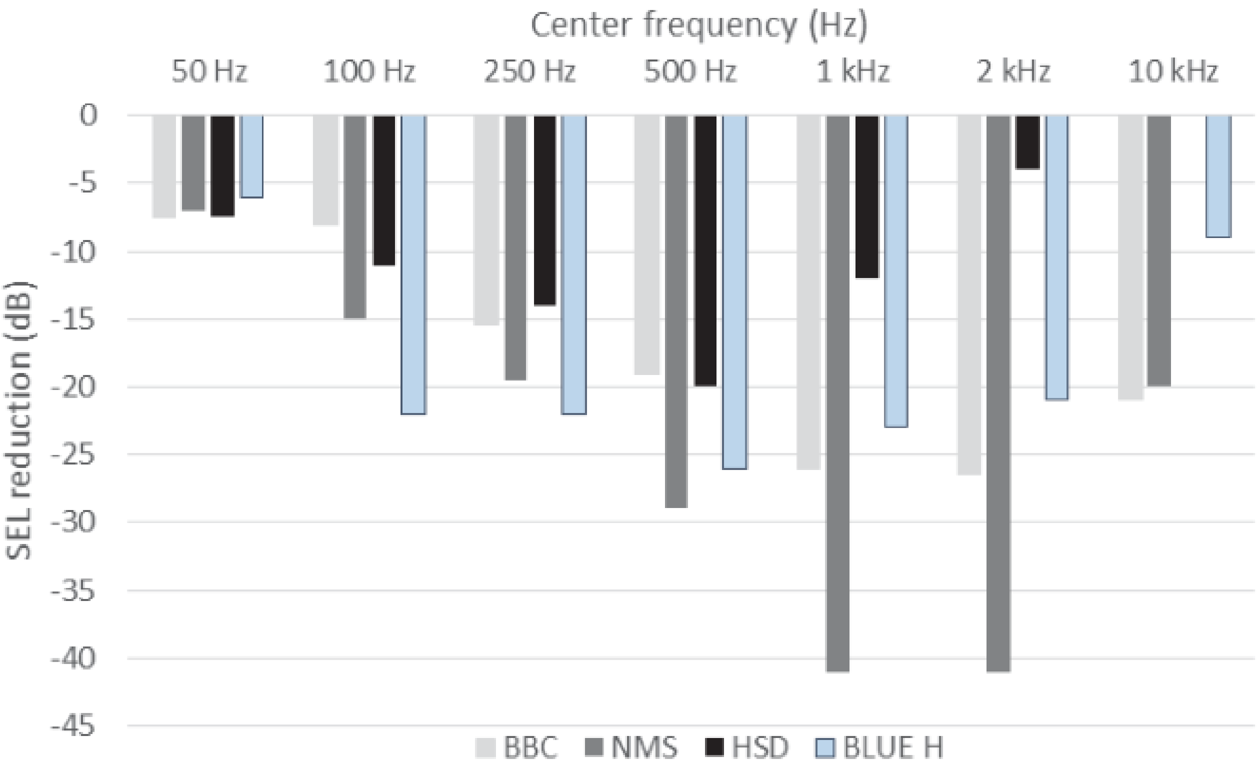
5.1.31 There are several different noise abatement systems that have been commercially deployed at offshore wind farm projects, including: Big Bubble Curtains, the IHC Noise Mitigation System, the Hydrosound damper and vibro-hammers. In addition to these, other methods have undergone, or are currently 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.

5.1.32 At the time of preparing this draft MMMP, the degree of noise reduction that can be achieved by these different methods, alone and in combination, is outlined in **Table 5-3** and **Graphic 5.1**. A review of noise abatement methods and their limitations is provided in Verfuss et al. (2019).

Table 5-3 Minimum and maximum noise reduction efficacy. Data obtained from Verfuss et al., (2019), Koschinki and Lüdemann (2020).

Noise abatement system	Water depth	Noise reduction SEL_{ss} (dB)
Big Bubble Curtain (BBC) (>0.3m³/min*m)	~ 40 m	7 – 11
Double Bubble Curtain (DBBC) (>0.3m³/min*m)	~ 40 m	8 – 13
DBBC (>0.4m³/min*m)	~ 40 m	12 – 18
DBBC (>0.5m³/min*m)	~ 40 m	~ 15 – 16 (based on 1 pile)
Noise Mitigation System (NMS)	Up to 40	13 – 16
Hydro Sound Dampner (HSD)	Up to 40	10 – 12
NMS + optimised BBC (>0.4m³/min*m)	~ 40 m	17 – 18
NMS + optimised BBC (>0.5m³/min*m)	~ 40 m	18 – 20
HSD + optimised BBC (>0.4m³/min*m)	~ 30 m	15 – 20
HSD + optimised DBBC (0.48m³/min*m)	20-40 m	15 – 28
HSD + optimised DBBC (>0.5m³/min*m)	<45 m	18 – 19
Blue hammer	22 m	19 – 24

Graphic 5.1 Reduction in SEL at the frequencies 100 Hz, 350 Hz, 500 Hz, 1 kHz and 2 kHz in the 1/3rd octave and frequency spectrum of a pile strike when comparing mitigated versus unmitigated piling. From Verfuss et al., (2019)



5.1.33 A review of the efficacy of noise mitigation / abatement techniques with respect to site conditions at Rampion 2 Offshore Wind Farm was undertaken in **Information to support efficacy of noise mitigation / abatement techniques with respect to site conditions at Rampion 2 Offshore Windfarm** **[REP4-067]** (Document reference 8.40) and **In Principle Sensitive Features Mitigation Plan** **[REP5-082]** (Document reference 7.17). The degree of noise reduction that can be achieved by these different methods, alone and in combination, is outlined in **Table 5-4**.

Table 5-4 Noise reduction from noise abatement systems in ITAP (2024) and In Principle Sensitive Features Mitigation Plan [REP5-082] (Document reference 8.40)

Noise abatement system	Water depth	Noise reduction (dB)
Double Big Bubble Curtain (DBBC) (>0.3m³/min*m)	Up to 40 m	15
Enhanced Big Bubble Curtain (eBBC) (1.2m³/min*m)	Not stated	<15
IHC Noise Mitigation Screen	Up to 40 m	15
Hydro Sound Damper (HSD)	Up to 40 m	10
AdBm system	Not stated	< 10
PULSE hammer (by IHC IQIP)	Not stated	6 - 10
MNRU hammer (by MENCK)	Not stated	9 - 12
HSD + DBBC	Up to 40 m	18 -19
IHC-NMS + DBBC	Up to 40 m	22
DBBC and another noise mitigation measure	Not stated	20

5.1.34 Importantly water depth is a primary environmental factor influencing the efficacy of noise mitigation systems, with BBC, HSD and NMS having been commercially deployed in OWF projects in water depths up to 45m (Verfuss et al., (2019). Within the Rampion 2 array area, water depths vary from 13m to 63m LAT (specifically 17.4m at the Northwest location and 53.4m at the South location considered in the underwater noise modelling). Therefore, the majority of the Rampion 2 array area is in water depths similar to the sites given in **Table 5-3** and **Table 5-4**, and thus the noise reduction levels provided are expected to be reasonable estimates of the expected noise reduction levels achievable at Rampion 2. However, as parts of the Rampion 2 site, especially at the south, are deeper (>50m) this may affect the performance of the noise abatement systems.

5.1.35 Tidal currents also influence the efficacy of noise mitigation systems. The tidal currents within the study area are generally energetic with peak spring current speeds between 0.75 and 1.1m/s in the offshore are areas (**Chapter 6: Coastal processes, Volume 2** of the ES **[APP-047]** (Document reference 6.2.6) (updated at Deadline 6)). The effectiveness of bubble curtains may be impacted by higher tidal as it could lead to increased bubble dispersion and therefore a reduction of the barrier effect, in Verfuss et al., (2019) bubble curtains can be used in areas with current speeds up to 3m/s.

5.1.36 Based on the conclusions of **Information to support efficacy of noise mitigation / abatement techniques with respect to site conditions at Rampion**

2 Offshore Windfarm **[REP4-067]** (Document reference 8.40) and given the impacts to fish and shellfish receptors from underwater noise, Rampion 2 have committed to using a DBBC for all piled foundations installations for the proposed development (C-265). The use of DBBC will reduce the instantaneous PTS-onset impact ranges. A combination of BBC, MMOb, PAM and short duration ADD use will be sufficient to ensure animals are out of the impact zone prior to piling commencing.

5.1.37 Although there is no empirical evaluation of achievable overall noise reduction by any BBC system in water depth >40m is currently available, it is known that achievable noise reduction slightly decreases with increasing water depth. It is anticipated that the effectiveness of any BBC will slightly decrease by 1 dB in 50m water depth as opposed to 40m. Increases in performance of BBC can be achieved by increasing the air flow, which could mitigate the effect of greater depth. Alternatively, the application of an eBBC as an inner ring in combination with a BBC as an outer ring (similar in design to a DBBC) would be expected to compensate or minimize the effect of the increased water depth, as the first application with this configuration achieved 1 to 2 dB higher overall noise reductions as the DBBC in 40m depth. As part of the strategy to ensuring bubble curtains will provide the appropriate level of mitigation in deeper waters (-15 dB), the Applicant will be evaluating the increased mitigation efficacy provided by the use of eBBC in order to achieve -15 dB throughout the Proposed Development site.

5.1.38 Rampion 2 have also committed that any piling within the black seabream nesting period (1st March to 31st July) will be subject to mitigation using the DBBC and another noise mitigation measure which results in a noise reduction of 20 dB, compared to 15 dB for DBBC alone.

Breaks in piling

5.1.39 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 Natural England and set out within the Final Piling MMMP.

Delays in commencement of piling

5.1.40 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.

Communications

5.1.41 The Final Piling MMMP will detail the responsibilities for the MMOb, PAM operator, ADD operator, construction manager and any other crew members. A communications protocol will be developed that will detail the actions that individuals are responsible for, this includes notifying the ADD operator to set up equipment and PAM operator and MMOb to begin soft-start observation.

5.1.42 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.

Reporting

5.1.43 A report detailing the piling activity and mitigation measures implemented will be prepared for submission to the MMO. Where appropriate this will include, but 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 including duration of marine mammal observer pre-piling watch;
- environmental conditions during the pre-piling watch, description of any marine mammal sightings and any actions taken and a record of any incidental sightings made during out with the pre-piling watch;
- 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.

5.1.44 A final report will be provided following the completion of the construction activity which will be submitted to the MMO within 6 weeks of project completion. The final report will include any data collected during piling operations, details of ADD deployment, details of accordance with Final MMMP, details of marine mammal observer watch 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.

6. Glossary of terms and abbreviations

Table 6-1 Glossary of terms and abbreviations

Term	Definition
ADD	Acoustic Deterrent Device
BBC	Big Bubble Curtain
BD	Bottlenose dolphin
CD	Common dolphin
DBBC	Double Bubble Curtain
DCO	Development Consent Order
DML	Deemed Marine Licence
EIA	Environmental Impact Assessment
ES	Environmental Statement
GS	Grey seal
HS	Harbour seal
HSD	Hydro Sound Damper
HP	Harbour Porpoise
JNCC	Joint Nature Conservation Committee
MDS	Maximum Design Scenario
MMMP	Marine Mammal Mitigation Protocol
MMO	Marine Management Organisation
MMOb	Marine Mammal Observer
MW	Minke whale
NMS	Noise Mitigation Screen
OWF	Offshore Wind Farm
PAM	Passive Acoustic Monitoring
PEIR	Preliminary Environmental Information Report

Term	Definition
PTS	Permanent Threshold Shift
RED	Rampion Extension Development
SEL	Sound Exposure Level
SNCB	Statutory Nature Conservation Body
SPL	Sound Pressure Level
TWT	The Wildlife Trust
VMP	Vessel Management Plan
WCS	Worst Case Scenario
WTG	Wind Turbine Generator

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