

MARINE LICENCE CML2365

CONDITION 3.26: MARINE MAMMAL MANAGEMENT PLAN (MMMP)

Liverpool Bay CCS Project

Marine and Coastal Access Act 2009

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1. INTRODUCTION

1.1. PURPOSE

1.1.1. This document is the **Marine Mammal Management Plan (MMMP)** for the Liverpool Bay CCS Project and provides information to fulfil the requirements for the discharge of **Condition 3.26** of Marine Licence **CML2365**, which states the following:

- *3.26.1 The Licence Holder must submit a MMMP which shall be in accordance with Outline MMMP (CML2365-LBA CCS Ltd_OFFSHORE ES_Appendix S MMMP_NRW_FINAL) to the Licensing Authority for written approval at least 4 months prior to commencement of the Licensed Activities. No Licensed Activities may be undertaken prior to written approval from the Licensing Authority.*
- *3.26.2 The Licence Holder must ensure that any actions outlined in the documents detailed in condition 3.26.1 are implemented as approved in writing by the Licensing Authority. Any proposed changes to the actions outlined in the documents must be submitted to and approved in writing by the Licensing Authority prior to any changes being enacted.*

1.1.2. This MMMP provides a summary of findings as assessed in the Marine Biodiversity chapter of the Environmental Statement (Volume 2, Chapter 7), on the potentially injurious effects of underwater noise on marine mammals and marine turtles during geophysical surveys and construction piling for the Liverpool Bay CCS Project. This MMMP was informed by the following sections of the Environmental Statement (ES):

- Volume 2, Chapter 7;
- Volume 3, Marine Biodiversity Technical Report (RPS Group, 2024) Appendix I; and
- Volume 3, Underwater Noise Technical Report (RPS Group and Seiche, 2024) Appendix J.

1.1.3. This MMMP has adopted a precautionary approach by implementing mitigation measures based on the maximum design envelope assessed in the Environmental Statement. This document has been updated for version B following consultee feedback with the following key amendments:

Mitigation for UXO clearance has been removed. In the unlikely event that clearance will be required, the Project will submit a detailed UXO MMMP for approval by consultees based on the results of the UXO survey campaign.

Mitigation for seismic surveys has been removed. This activity will take place during the operational phase and a separate marine licence will be sought accompanied by a MMMP with details of the equipment and source levels to determine the correct mitigation procedures.

1.1.4. This document has been updated for version C following further details provided by the piling contractor. Changes for version C are shown in green text. The following key amendments have been applied:

- Details of potential risks introduced by non-operational pauses on piling procedures;
- Further details on mitigations measures, including re-instatement of acoustic deterrent device (ADD; largely identical text from MMMP version A) and use of

thermal imaging binoculars for piling operations during low visibility and hours of darkness.

1.2. STUDY AREA

1.2.1. Marine mammals and turtles are known for being highly mobile and covering large distances within their range of distribution. Therefore, two study areas have been defined:

- **the Liverpool Bay CCS Project marine mammal study area:** this is defined as the area encompassing the Eni Development Area, (including the offshore pipeline, and associated cables in Liverpool Bay) plus a buffer of 10 km (**Figure 1.1**); and
- **the regional marine mammal study area:** this is defined as the area encompassing the wider Irish Sea (**Figure 1.1**). This area has been informed by marine mammal Management Units (MUs) and will provide wider context for characterising the baseline.

1.3. SCOPE OF THE MMMP

- 1.3.1. This MMMP provides practical procedures to minimise the risk of injury or disturbance to marine mammals during, piling activities, geophysical surveys and vessel operations. [The information contained herein can be used to produce a detailed task plan for use by the contracted marine mammal mitigation team and offshore operations teams in respect of each of the activities.](#) It ensures compliance with JNCC guidelines and all relevant marine licence conditions.
- 1.3.2. This plan applies to the following noise-generating activities:
- Impact piling for jacket installation.
 - Geophysical surveys.
- 1.3.3. [Potential disturbance and any risk of collision with vessels during any phase of the project will be mitigated via the Vessel Management Plan and is not covered in this MMMP.](#) This plan applies mainly to piling operations during installation of the Douglas CCS jacket. It defines roles, mitigation tools, operational procedures and regulatory obligations. At this stage the project is not planning to undertake UXO clearance operations or seismic surveys. All geophysical surveys and supporting vessel activities will continue to be managed under the Marine Licence notification process submitted through the UK Energy Portal.
- 1.3.4. The purpose of this MMMP is to present how the potentially injurious effects of underwater noise resulting from impact piling and geophysical surveys on marine mammals and marine turtles are to be mitigated during the pre-construction, construction and operation and maintenance phases of the Liverpool Bay CCS Project. Information presented in this MMMP is based on Offshore ES volume 2, chapter 7, which considers the potential impacts of the Liverpool Bay CCS Project seaward of MHWS during the construction, operation and maintenance, and decommissioning phases. Only those impacts with the potential to cause auditory injury and for which specific designed in measures have been proposed have been included in this MMMP.
- 1.3.5. The precautionary injury ranges for marine mammals established in the ES are based on the underwater noise modelling for the most sensitive species (see volume 3, Underwater Noise Technical Report (RPS Group and Seiche, 2024; appendix J), the parameters for which are based on the design parameters for the Liverpool Bay CCS Project. In conducting mitigation for these activities, any updated guidelines or changes in industry best practice [will be considered, noting that new guidance for geophysical survey mitigation is due to be released soon.](#) The LBCCS Project design parameters informing the assessment of potential impacts on marine mammals and marine turtles because of underwater noise during; geophysical surveys and piling is presented in **Table 1.1**.

Table 1.1: Summary Of Liverpool Bay CCS Project Design Parameters Used For The Assessment Of Potential Impacts On Marine Mammals And Marine Turtles relevant to activities covered by this MMMP. Full Details Of All Activities Are Presented In Volume 2, Chapter 7

Potential impact	Phase ^a			Liverpool Bay CCS Project design parameters	Justification
	C	O	D		
Injury and disturbance from underwater noise generated from piling	✓	X	X	Construction phase New Douglas platform foundations: • up to 4 piled jacket foundations, with one leg per foundation and up to 2 x 1.524 m diameter piles per leg (8 piles); • maximum hammer energy up to 3,000 kJ; • up to 100 minutes piling per pile; and piling of up to two adjacent piles at the same platform at one time.	Impact piling during construction may result in hearing damage/auditory injury, behavioural disturbance/displacement of marine mammals and marine turtles as well as barrier affects. The largest hammer energy could lead to the largest area of ensonification at any one time. The longest duration of piling at any location results in the greatest number of days when piling could occur.
Injury and disturbance from underwater noise generated during geophysical surveys	✓	✓	X	Construction phase Site investigation surveys will involve the use of up to two survey vessels and take place over a period of up to six months. • MBES (170 to 450 kHz; 220 dB re 1 µPa (Root Mean Squared (rms); pulse rate up to 60 Hz). • SBP (85 to 115 kHz, 247 dB re 1µPa (rms), pulse rate up to 40 Hz). Operation and maintenance phase Annual geophysical survey are estimated to occur over a fleet of two vessels.	• Geophysical surveys have the potential to cause direct and/or indirect effects (including injury or disturbance) on marine mammals and marine turtles as well as barrier effects. • Maximum range of geophysical surveys likely to be undertaken using equipment typically employed for these types of surveys will result in the greatest potential impact.

1.3.6. This MMMP has been prepared in accordance with the following guidance, and it is considered that compliance with these will reduce the risk of injury to marine mammals to negligible levels:

- Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise (JNCC, 2010a); and
- JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys (JNCC, 2017).

1.4. TARGET SPECIES

1.4.1. Marine mammals and marine turtle species were characterised based on their abundance and densities at a local scale (Liverpool Bay CCS Project marine mammal study area) and regional scale (regional marine mammal study area), via thorough review of key desktop datasets and reports as detailed in volume 2, chapter 7 and volume 3,

appendix I Marine Biodiversity Technical Report (RPS Group, 2024) of the ES. There were no site specific marine mammal surveys conducted for the Eni Development Area, so the results of site specific surveys undertaken for Offshore Wind Farms (OWF) near the Eni Development Area have been utilised. These include Gwynt y Môr OWF and Awel y Môr OWF.

CETACEANS

1.4.2. Five cetacean species likely to be present and/or occur regularly within the regional marine mammal study area:

- Bottlenose dolphin (*Tursiops truncatus*);
- Harbour porpoise (*Phocoena phocoena*);
- Minke whale (*Balaenoptera acutorostrata*);
- Risso's dolphin (*Grampus griseus*); and
- Short beaked common dolphin (hereafter: 'common dolphin'; *Delphinus delphus*).

1.4.3. As described in **Section 1.2**, the regional marine mammal study area was informed by species MUs and the most recent abundance estimates for each cetacean species are provided by the Inter-Agency Marine Mammal Working Group (IAMMWG, 2022), presented in **Table 1.2**. Further detail on the ecology, abundance, and densities of these five cetacean species is provided in Volume 3, Appendix I Marine Biodiversity Technical Report (RPS Group, 2024).

Table 1.2: Cetacean Abundance Estimates And Measures Of Uncertainty Within Respective MUs (Rogan et al., 2018; Hammond et al., 2021; IAMMWG, 2022)

Species	Management Unit (MU)	Abundance of animals in MU	95% Confidence Interval
Harbour porpoise	Celtic and Irish Sea	62,517 (CV = 0.13)	48,324 – 80,877
Bottlenose dolphin	Irish Sea	293 (CV = 0.54)	108 – 793
	Offshore Channel, Celtic Sea and South West England	10,947 (CV = 0.25)	6,727 – 17,814
Common dolphin	Celtic and Greater North Seas	102,656 (CV = 0.29)	58,932 – 178,822
Risso's dolphin		12,262 (CV = 0.46)	5,227 – 28,764
Minke whale		20,118 (CV = 0.18)	14,061 – 28,786

PINNIPEDS

1.4.4. Two pinniped species are considered likely to be present and/or occur regularly within the regional marine mammal study area: grey seal (*Halichoerus grypus*), and harbour seal (*Phoca vitulina*). As for cetaceans, the regional marine mammal study area has been informed by species MUs, of which five partially or fully coincide with the regional marine mammal study area: the Northern Ireland MU, Southwest (SW) Scotland MU, Northwest (NW) England MU, Wales MU and SW England MU.

1.4.5. The most recent abundance estimates for each pinniped species' respective MU are provided by the Special Committee on Seals (SCOS) and are presented in **Table 1.3**. Grey seal population estimates are unavailable for the NW England MU, Wales MU and SW England MU, and harbour seal population estimates should be regarded as rough

estimates only. Further detail on the ecology, abundance, and densities of grey seal and harbour seal is provided in Volume 3, Appendix I Marine Biodiversity Technical Report (RPS Group, 2024).

Table 1.3: August Haul Out Counts And Population Estimates Of Grey Seal And Harbour Seal In Respective Mus (SCOS, 2020, 2021)

Management Unit (MU)	Grey Seal		Harbour Seal	
	August Haul Out Count	Population Estimate	August Haul Out Count	Population Estimate
Northern Ireland	505	2,113	1,012	1,405
SW Scotland	517	2,163	1,709	2,373
NW England	250	-	5	6
Wales	900	-	10	13
SW England	500	-	0	0
OSPAR Region III	60,780		Not applicable	

MARINE TURTLES

- 1.4.6. Six species of marine turtle have been documented within UK and Irish waters (Botterell et al., 2020):
- Green turtle (*Chelonia mydas*);
 - Hawksbill turtle (*Eretmochelys imbricata*);
 - Kemp's ridley turtle (*Lepidochelys kempii*);
 - Leatherback turtle (*Dermochelys coriacea*);
 - Loggerhead turtle (*Caretta caretta*); and
 - Olive ridley turtle (*L. Olivacea*).
- 1.4.7. Due to the relative paucity of information surrounding the ecology, distribution, and abundance of these six species within UK and Irish waters in comparison to that available for marine mammals, they have been grouped together as 'marine turtles' for the purposes of this assessment.
- 1.4.8. There are no MUs available for marine turtles in UK and Irish waters, with most of the information surrounding their abundance, seasonality, and distribution coming from records of sightings and strandings. These data have been recorded since 1748, and are reported annually by Marine Environmental Monitoring, most recently for 2021 (Penrose et al., 2022). Overall, a total of 2,882 marine turtles have been recorded throughout this 273 year dataset, with the majority attributed to leatherback turtle (n = 2,172), followed by unidentified species (n = 394), loggerhead turtle (n = 268), Kemp's ridley turtle (n = 76), green turtle (n = 15), hawksbill turtle (n = 1), and olive ridley turtle (n = 1) (Penrose et al., 2022). Of these 2,882 records, the majority have been recorded in the Republic of Ireland (Table 1.5).

Table 1.4: Number Of Sightings And Strandings Of All Marine Turtles Between 1748 And 2021 By Country (Penrose Et Al., 2022)

Country	Number of Sightings and Strandings of all Marine Turtle Species	
	2021	1748 to 2021
Republic of Ireland	6	1,358
England	7	699
Scotland	11	425
Wales	5	292
Northern Ireland	0	41
Isle of Man	1	37
Channel Islands	0	17
Offshore waters	0	13
Total	30	2,882

1.5. DESIGNED IN MANAGEMENT MEASURES.

- 1.5.1. In addition to the MMMP the LBCCS project will implement the following mitigation measures presented in Table 1.5

Table 1.5: Measures Adopted As Part Of The Liverpool Bay CCS Project,

Measures included in the Liverpool Bay CCS Project	Justification
Development of and adherence to Construction Environmental Management Plans (CEMPs) that have and will continue to be prepared covering and implemented during the construction, operation and maintenance, and decommissioning phases of the Liverpool Bay CCS Project. The CEMPs include appendices detailing actions to minimise INNS (the INNSMP), and a Marine Protection Contingency Plan (MPCP) will be developed which include planning for accidental spills, addressing all potential contaminant releases and include key emergency contact details.	Measures are being adopted to ensure that the potential for release of pollutants from construction, operation and maintenance, and decommissioning plant is minimised. These include designated areas for refuelling where spillages can be easily contained, storage of chemicals in secure designated areas in line with appropriate regulations and guidelines, double skinning of pipes and tanks containing hazardous substances, and storage of these substances in impenetrable bunds. All vessels are required to comply with the standards set out in the International Convention for the Prevention of Pollution from Ships (MARPOL).
Implementation of piling initiation, soft start, and ramp up measures within the Marine Mammal Management Plan (MMMP). An initiation stage and soft starts will be used during the installation of pin piles. This involves the implementation of an initial low hammer energy with a low number of strikes, followed by lower hammer energies at a higher strike rate at the beginning of the piling sequence before energy input is 'ramped up' (increased) over time to required higher levels.	This measure will minimise the risk of injury to some fish, marine mammal, and marine turtle species in the immediate vicinity of piling activities, allowing individuals to move away from the area before noise levels reach a level at which injury may occur.
Development and adherence to the Cable Specification and Installation Plan (CSIP) which includes cable burial where possible (in accordance with the specific policies set out in the North West Inshore and North West Offshore	The CSIP sets out the cable burial depth (min 2.0m) in accordance with industry good practice, minimising the risk of cable exposure. The CSIP ensures that cable crossings are appropriately designed to mitigate environmental effects, these crossings have been agreed with relevant parties

Measures included in the Liverpool Bay CCS Project	Justification
Coast Marine Plans (MMO, 2021)) and cable protection, as necessary (Condition 3.19 CML2365)	in advance of CSIP submission. The CSIP includes detailed Cable Burial Risk Assessments (CBRAs) to enable informed judgements regarding burial depth to maximise the chance of cables remaining buried whilst limiting the amount of sediment disturbance to that which is necessary. Burial measures reduce the amount of EMF which benthic and fish and shellfish receptors are exposed to during the operations and maintenance phase by increasing the distance between the seabed surface and the surface of the cables.
A VMP has been developed which determines vessel routing to and from construction areas and ports to avoid areas of high risk to marine mammals (Condition 3.27 & 3.29 covering Vessel management Plan and navigation safety Plan – CML2365).	The VMP has been issued to all vessel operators, requiring them to: • not deliberately approach marine mammals, marine turtles, and basking sharks; • keep vessel speed to a minimum; and • avoid abrupt changes in course or speed should marine mammals approach the vessel to bow ride.
Geophysical surveys undertaken during the operational and maintenance phase will adopt similar measures as for piling operations, including the implementation of an approved MMMP and Vessel Code of Conduct. Measures include the use of a mitigation zone around operations, within which Marine Mammal Observer (MMOs) and Passive Acoustic Monitoring (PAM) will ensure that no marine megafauna are present in the vicinity of the geophysical survey vessel, and the use of a soft start to survey operation, where possible	The implementation of an approved MMMP will mitigate for the risk of physical or permanent auditory injury to marine mammals within a 500 m radial mitigation zone as determined by JNCC guidance (JNCC, 2017). The soft-start will use a lower-energy output, increasing over a 20-minute period to the maximum data-acquisition energy output to provide an audible cue to allow marine mammals and megafauna to flee the area before geophysical surveying commences. It is understood that the JNCC (2017) guidance is currently being updated, and this MMMP will follow the latest guidance once publicly available. These activities will continue to be managed under the Marine Licence notification process submitted through the UK Energy Portal when they are carried out in the future.
Development of, and adherence to, a Decommissioning Plan	The aim of this plan is to adhere to the relevant UK and international legislation and guidance in place at the time, with decommissioning industry practice applied to reduce the amount of long-term disturbance to the environment so far as reasonably practicable.

1.6. SUMMARY OF VOLUME 2, CHAPTER 7 (MARINE MAMMALS AND MARINE TURTLES)

- 1.6.1. Auditory injury in marine mammals can occur as either a Permanent Threshold Shift (PTS), where there is no hearing recovery, or as a Temporary Threshold Shift (TTS), where recovery from tissue damage is possible. The most likely response of an animal exposed to noise levels that could induce TTS or impairment is, however, to flee [from the source](#). It is therefore considered that animals exposed to noise levels with the potential to induce TTS or impairment are likely to simply move away from the [ensounded](#) area.

- 1.6.2. Sound propagation models can be constructed to allow the received noise level at different distances from the source to be calculated. To determine the consequence of these received levels on any marine mammals which might experience such noise emissions, it is necessary to relate the levels to known or estimated impact thresholds. The injury criteria proposed by Southall et al. (2019) are based on a combination of linear (i.e. un-weighted) peak pressure levels and mammal hearing weighted sound exposure levels (SEL). The hearing weighting function is designed to represent the bandwidth for each group within which acoustic exposures can have auditory effects. The categories include:
- Low Frequency (LF) cetaceans: marine mammal species such as minke whale;
 - High Frequency (HF) cetaceans: marine mammal species such as bottlenose dolphin, common dolphin, Risso's dolphin;
 - Very High Frequency (VHF) cetaceans: marine mammal species such as harbour porpoise, generally with auditory centre frequencies above 100 kHz); and
 - Phocid Carnivores in Water (PCW): marine mammal species such as grey seal and harbour seal.
- 1.6.3. In basking sharks and sea turtles, injury is assessed as 'mortality and potential mortal injury' (immediate or delayed death) or 'impairment' (recoverable injury) (Popper et al., 2014). This dual criteria approach was used to assess the potential for PTS and TTS in marine mammals and 'mortality and mortal injury' and 'impairment' in basking shark and sea turtles.
- 1.6.4. Where insufficient data exist to determine a quantitative guideline value, the risk is categorised in relative terms as "high", "moderate" or "low" at three distances from the source: "near" (i.e. in the tens of metres), "intermediate" (i.e. in the hundreds of metres) or "far" (i.e. in the thousands of metres). These qualitative criteria cannot differentiate between exposures to different noise levels and therefore all sources of noise would be assumed to elicit the same response (Popper et al., 2014).
- 1.6.5. Injury criteria were modelled based on two different types of underwater noise:
- **Impulsive sound:** which are typically transient, brief (less than 1 s), broadband, and consist of high peak sound pressure with rapid rise time and rapid decay ((ANSI, 1986, 2005; NIOSH, 1998). This category includes sound sources such as seismic surveys, impact piling and underwater explosions.
 - **Non impulsive sound:** which can be broadband, narrowband or tonal, brief or prolonged, continuous or intermittent and typically do not have a high peak sound pressure with rapid rise/decay time that impulsive sounds do (ANSI 1995; NIOSH 1998). This category includes sound sources such as continuous, drilling, sonar (including that used in geophysical surveying) and vessels.

Table 1.6: Summary Of PTS And TTS Onset Thresholds For Marine Mammals, Based On Southall et al., 2019. Values for SPL_{pk} are expressed as dB re 1 μ pa, and those for SEL_{cum} are expressed as dB re 1 μ pa2s

Hearing Group	Parameter	PTS Onset Threshold		TTS Onset Threshold	
		Impulsive	Non impulsive	Impulsive	Non impulsive
LF	SPL_{pk} , unweighted	219	-	213	-
	SEL_{cum} , LF weighted	183	199	168	179
HF	SPL_{pk} , unweighted	230	-	224	-
	SEL_{cum} , HF weighted	185	198	170	178
VHF	SPL_{pk} , unweighted	202	-	196	-
	SEL_{cum} , VHF weighted	155	173	140	153
PCW	SPL_{pk} , unweighted	218	-	212	-
	SEL_{cum} , PCW weighted	185	201	170	181

PILING

- 1.6.6. Piling during the construction phase of the Liverpool Bay CCS Project has the potential to result in elevated levels of underwater noise that are detectable by marine mammals and megafauna above background levels, and which could result in injurious or behavioural effects on Important Ecological Features (IEFs). A detailed underwater noise modelling assessment has been carried out to investigate the potential for injurious and behavioural effects on marine mammal, fish and sea turtle IEFs because of impulsive sounds from piling (Volume 3, Appendix J Underwater Noise Technical Report (RPS Group and Seiche, 2024)). The results of this modelling were drawn upon to inform the impact assessment presented in Volume 2, Chapter 7.
- 1.6.7. [Permanent injury](#) from PTS and [temporary injury/ onset of fleeing from](#) TTS were investigated with respect to two metrics over the entire piling sequence from hammer initiation to maximum hammer energy (3,000 kJ) based on up to one pile being installed within a 24 hour period (see Liverpool Bay CCS Project design parameters in **Table 1.1**). Peak Sound Pressure Level (SPL_{pk}) was used to determine ranges for instantaneous injury at the highest point over the piling sequence whilst cumulative Sound Exposure Level (SEL_{cum}) was modelled to estimate the injury range from cumulative exposure as an animal flees the area. The SEL_{cum} metric can lead to overestimates in effect ranges which means that subsea noise modelling results in a precautionary assessment due to the conservative assumptions adopted, namely:
- maximum hammer energy (3,000 kJ) would be reached at all locations;
 - underwater noise would remain impulsive at all distances, and not transition to a non-impulsive character;
 - the soft start procedure does not include short pauses in piling which would reduce the noise exposure that fleeing animals experience;
 - animals would swim away from the noise source at the onset of activity at a constant rate and in a straight line; and
 - time spent at the surface, where sound levels are reduced, was not considered.
- 1.6.8. Injury ranges from underwater noise modelling for impact piling [of a single pile](#) are summarised in **Table 1.8** and **Table 1.9**. [Whilst consecutive piling was also modelled as a](#)

precautionary assumption in the assessment (i.e. continuous piling with no breaks between each pile), the Project engineers have confirmed that, in practice, this is not logistically feasible as the order of events necessitates a pause of 30 minutes or more between each pile and for this reason the mitigation focusses on single piling only.

- 1.6.9. For all species except LF cetaceans, permanent injury (PTS) ranges based on the SPL_{pk} metric were greater (Table 1.7), with the greatest distance being 490 m for VHF cetaceans (e.g. harbour porpoise), compared with 20 m for SEL_{cum} . For LF cetaceans (which includes minke whale), injury ranges based on the SEL_{cum} metric were greater, at distances up to 1,000 m (compared with 180 m for SPL_{pk}). The modelling for the EIA was repeated to illustrate the reduction in risk by application of an ADD for up to 30 minutes (Table 1.7), however, the Defra noise policy¹ requires that all sources of noise are minimised in the marine environment and the ADD should therefore only be applied where there is a residual risk of injury following standard industry best practice. In this case, harbour porpoise can be visually and acoustically detected over the maximum predicted injury range of 490 m whilst minke whale, as a larger cetacean, can be visually and acoustically detected over distances of 1,000 m. Thus, following Natural England advice on this MMMP, the Project has determined that no ADD is required in respect of mitigation during piling in daylight hours. However piling during hours of darkness will require use of ADD and Version C of this MMMP reflects this update.
- 1.6.10. Temporary injury/fleeing (TTS) ranges were also greater for SEL_{cum} across species, except for HF cetaceans (such as bottlenose dolphin). For these species, TTS may be experienced out to 69 m at maximum hammer energy (SPL_{pk}) compared to the SEL_{cum} threshold of 170 dB re 1 μPa^2s not being exceeded.

Table 1.7: Auditory Injury Ranges Based On The SEL_{cum} Metric For Marine Mammals Due To Impact Piling Of The Platform Jackets, With And Without The Use Of An ADD (N/E = Threshold Not Exceeded)

Hearing Group	Threshold (Weighted SEL)	Range (m)	
		Without ADD	With 30 mins ADD
LF	PTS – 183 dB re 1 μPa^2s	1,000	N/E
	TTS – 168 dB re 1 μPa^2s	35,300	31,400
HF	PTS – 185 dB re 1 μPa^2s	N/E	N/E
	TTS – 170 dB re 1 μPa^2s	N/E	N/E
VHF	PTS – 155 dB re 1 μPa^2s	20	N/E
	TTS – 140 dB re 1 μPa^2s	8,660	5,960
PCW	PTS – 185 dB re 1 μPa^2s	N/E	N/E
	TTS – 170 dB re 1 μPa^2s	3,710	585
Marine turtles	Mortality – 210 dB re 1 μPa^2s	N/E	N/E

¹ <https://www.gov.uk/government/publications/reducing-marine-noise/reducing-marine-noise>

Table 1.8: Summary Of Peak Pressure (SPL_{pk}) Injury Ranges For Marine Mammals And Marine Turtles Due To The Phase Of Impact Piling At Maximum Hammer Energy, And At The First Hammer Strike

Hearing Group	Threshold (Unweighted Peak)	Range (m)	
		Max Hammer Energy	First Hammer Strike
LF	PTS – 219 dB re 1 µPa (pk)	180	45
	TTS – 213 dB re 1 µPa (pk)	184	77
HF	PTS – 230 dB re 1 µPa (pk)	41	17
	TTS – 224 dB re 1 µPa (pk)	69	29
VHF	PTS – 202 dB re 1 µPa (pk)	490	204
	TTS – 196 dB re 1 µPa (pk)	836	349
PCW	PTS – 218 dB re 1 µPa (pk)	118	49
	TTS – 212 dB re 1 µPa (pk)	201	84
Marine turtles	Mortality – 207 dB re 1 µPa (pk)	314	131

- 1.6.11. Although the underwater noise modelling in the Environmental Statement (ES) assessed worst case underwater noise impacts based on a conservative maximum hammer energy of 3,000 kJ as indicated above, the actual piling works for the Liverpool Bay CCS Project will be undertaken using hydraulic hammers with substantially lower output. The hammers selected for installation, the MHU 2100 and MHU 1700, have rated energies of 2,100 kJ and 1,700 kJ, respectively, and deliver resulting energies in the pile of 1,810 kJ and 1,465 kJ once wave equation efficiency is applied.
- 1.6.12. As a result, **the real underwater noise emissions during construction will be significantly lower than those modelled**. This ensures that the ES predicted PTS/TTS injury ranges (Tables 1.8–1.10) are precautionary and that actual piling operations remain comfortably within the assessed impact envelope.
- 1.6.13. This alignment confirms that the embedded mitigation, [following industry best practice](#), will continue to achieve the outcomes predicted by the modelling and will maintain compliance with the noise impact scenarios authorised in the Marine Licence. The clarification also demonstrates that installation practice is directly linked to, and more conservative than, the ES assumptions.
- 1.6.14. Prior to commencement of hammer start-up, during piling of the new Douglas CCS jacket, it will be confirmed that no marine mammals are in the vicinity of the piling location. Next to the Marine Mammal Observer (MMO) on board, a Passive Acoustic Monitoring (PAM) system will be deployed from the installation vessel with a coverage extending 500 m from the installation site
- 1.6.15. The pile driving will commence with a “soft start”; pile driving will start at minimum energy level and in short single blows. Continuous hammering with increased energy will commence when sufficient resistance has been observed and a minimum duration has passed.

GEOPHYSICAL SURVEYING

- 1.6.16. Geophysical site investigation surveys during the construction and operation and maintenance phases have the potential to cause direct or indirect effects (including injury or disturbance). A detailed underwater noise modelling assessment has been carried out to investigate the potential for injurious and behavioural effects because of these surveys, using the latest criteria (**Volume 3, Appendix J Underwater Noise Technical Report** (RPS Group and Seiche, 2024)).
- 1.6.17. Sonar based survey types will be used for the geophysical surveys to be conducted within the Eni Development Area, including multi beam echo sounder (MBES) and sub bottom profiler (SBP) methods. The equipment likely to be used can typically work at a range of signal frequencies, depending on the distance to the sea floor and the required resolution. The signal is highly directional, acting like a beam, and is emitted in pulses. Sonar based sources are considered as continuous (non-impulsive) because they generally compromise a single (or multiple discrete) frequency as opposed to a broadband signal with high kurtosis, high peak pressures and rapid rise times. The modelling results for MBES and SBP activities are presented in **Table 1.9**. Qualitative estimates of injury thresholds for marine turtles are presented in **Table 1.10**.

Table 1.9: Potential Impact Ranges For Marine Mammals During The Geophysical Surveys Based On Comparison To Southall Et Al. (2019) SEL_{cum} Thresholds For Non Impulsive Sound.

Survey type	Hearing group	Range (m)	
		PTS	TTS
MBES	LF	N/E	40
	HF	105	290
	VHF	345	485
	PCW	5	80
SBP	LF	45	50
	HF	50	260
	VHF	335	655
	PCW	40	50

Table 1.10: Thresholds And Relative Risk For Onset Of Injury To Sea Turtles During the Geophysical Surveys Due To Non Impulsive Sound (Popper Et Al., 2014).

Sound type	Parameter	Mortality and Potential Mortal Injury	Recoverable Injury	TTS
Non impulsive (e.g. MBES, SBP)	n/a	(Near) Low (Intermediate) Low (Far) Low	(Near) Low (Intermediate) Low (Far) Low	(Near) Moderate (Intermediate) Low (Far) Low

1.7. ROLES AND RESPONSIBILITIES

MITIGATION TEAM

- 1.7.1. The mitigation teams for piling and geophysical surveys will comprise the following roles, although it should be noted that not all roles will be required for all operations. A summary of roles relevant to respective operations is presented in **Table 1.18**.

Onshore Environmental Manager

- 1.7.2. The Applicant's Onshore Environmental Manager (OEM) is responsible for ensuring that all compliance documents, including this MMMP, are included in construction contract documents, including those pertaining to piling and geophysical surveys. The OEM will also be responsible for providing a pre works introduction session/s, and for ensuring that all activities are conducted in accordance with this MMMP, with other related consent management plans, and with all relevant regulations and legislation. The OEM is responsible for decision making regarding halts to operations in the event of a non-compliance with the MMMP and/or consent conditions and will report marine mammal monitoring and activities related to geophysical surveying and piling activities along with all non-compliances, to MMO/JNCC.

Works Supervisor

- 1.7.3. The 'Works Supervisor' is the individual/s who hold overall responsibility for operations during piling and geophysical/seismic surveying, based on the piling or survey vessel, and is likely to be a different individual for each activity. The Works Supervisor is in control of initiating, delaying or pausing operations and is the main point of communication between the MMObs, Passive Acoustic Monitoring (PAM) Operator and the operations teams (i.e. those personnel responsible for carrying out piling and geophysical survey activities).

Marine Mammal Observers

- 1.7.4. At least two dedicated and trained Marine Mammal Observers (MMObs) will be used to survey the mitigation zone at any one time and conduct the pre start searches (and post detonation searches in the case of UXO clearance). The MMObs will be JNCC certified and have an appropriate level of field experience (i.e. a minimum of one year's MMObs experience on offshore projects).
- 1.7.5. The MMObs will be responsible for recording all marine mammal sightings in the appropriate format, along with other environmental data. Together with the PAM Operator, the MMObs will be responsible for compiling all data on marine mammal observations, mitigation activities and instances of noncompliance for reporting to MMO/JNCC and the Marine Noise Registry (see **Section 1.9**).
- 1.7.6. The MMObs must be familiar with the regulatory procedures pertaining to managing risk to marine mammals from underwater sound and to ensure compliance must be provided with full details of all licence/consent conditions relevant to the performance of their role in advance of activity commencing. The MMObs, together with the PAM Operator, will provide a detailed introduction during the pre-works introduction session/s to advise the offshore team on the implementation of the procedures set out in this MMMP.

- 1.7.7. The MMObs will be equipped with reticule binoculars (thermal imaging cameras during hours of darkness, see paragraph 1.8.29) and Marine Mammal Reporting forms and will be capable of determining the extent of the search zone in relation to their viewing platform. A range stick may be used to aid the estimation of distance of the sighting from the survey vessel. The lead MMObs should also be equipped with a two way radio to ensure communication with both the vessel crew and the PAM Operator. This is to allow any visual or acoustic detections of marine mammals in the mitigation zone and any subsequent delay required to the commencement of surveying to be communicated quickly and effectively between all parties.
- 1.7.8. The MMObs should ensure their efforts are concentrated on the mitigation periods, (i.e. the pre start search and soft start time periods). JNCC guidelines, and this MMMP, should not be interpreted to imply that MMObs should continue a visual search during all available hours, unless specified as a survey consent or licence condition.
- 1.7.9. The MMObs will have the necessary authority (or support by Works Supervisor) to implement the plan and advise a stop works if necessary.

Passive Acoustic Monitoring Operators

- 1.7.10. Dedicated PAM Operators will be responsible for deployment, maintenance and operation of the PAM hydrophone, including spares. The PAM Operators will be based on the vessel together with the MMObs and will be responsible for recording all acoustic marine mammal detections in the appropriate format. Together with the MMObs, PAM Operators will be responsible for compiling all the data on marine mammal observations, mitigation activities (including ADDs and soft start) and instances of noncompliance, for reporting to MMO/JNCC and the Marine Noise Registry (see Section 1.9).
- 1.7.11. The PAM Operator should ensure their efforts are concentrated on the mitigation periods, (i.e. the pre start search and soft start time periods). JNCC guidelines, and this MMMP, should not be interpreted to imply that PAM Operators should continue a visual search during all available hours, unless specified as a survey consent or licence condition.
- 1.7.12. To ensure compliance they must be provided with full details of all licence/consent conditions relevant to the performance of their role in advance of activity commencing. The PAM Operator, together with the MMObs, will provide a detailed introduction during the pre-works introduction session/s to advise the offshore team on the implementation of the procedures set out in this MMMP.
- 1.7.13. The PAM Operator will be suitably trained in passive acoustic monitoring and the use of PAMGuard, with training having been provided by an appropriate organisation (e.g. Seiche). The PAM Operators will also have an appropriate level of field experience (i.e. a minimum of one year PAM experience on offshore projects) and must be familiar with the UK regulatory procedures pertaining to managing risk to marine mammals and marine turtles from underwater sound.
- 1.7.14. PAM Operators will be responsible for confirming the correct functioning of the ADD (via PAMGuard software) and communicating to the ADD Operator if the ADD is not operating properly and will have the necessary authority (and/or support by Works Supervisor) to implement this MMMP and advise a stop works if necessary.

Acoustic Deterrent Device Operators

- 1.7.15. A trained and dedicated Acoustic Deterrent Device (ADD) Operator will be responsible for ADD maintenance, operation and reporting (see paragraph 1.8.13). The ADD Operator will be responsible for deploying the ADD from the installation vessel, verifying the operation of the ADD before deployment, operating the ADD, ensuring that batteries are fully charged, and that spare equipment is available.
- 1.7.16. The ADD Operator will also record and report to the Works Supervisor/MMObs/PAM Operator on all ADD and piling activity so the details of any ADD used, and any relevant observations on their efficacy, can be reported as a part of the Operations/Marine Mammal Observer/Passive Acoustic Monitoring Report (see paragraph 1.8.13).

Table 1.11: Summary Of Roles And Involvement Of Personnel In Respective Operations

Role	Operation	
	Piling	Geophysical survey
Onshore Environmental Manager	✓	✓
Works Supervisor	✓	✓
MMObs	✓	✓
PAM Operator	✓	✓
ADD Operator	✓	

COMMUNICATION

- 1.7.17. At the planning stage the communication channels between MMObs, PAM Operator and ADD Operator, and the vessel crew are to be established. The MMObs and PAM Operator must also ensure there is a workable communication procedure in place so that any visual and acoustic detections can be corroborated by both. In addition, a formal chain of communication from the MMObs or PAM Operator to the person who can start/stop operations must be established. This is important, because contractors working to a tight timetable may not fully appreciate the roles and responsibilities of the MMObs and PAM Operators. To establish the chain of communication and command MMObs and PAM Operators should attend any relevant pre-mobilisation meetings.

1.8. MITIGATION METHODS AND PROCEDURES

- 1.8.1. The following specific mitigation measures are proposed for the planned implementation of piling operations and geophysical surveys. The mitigation measures presented below include designed in management measures and tertiary mitigation measures (IEMA, 2016) to reduce the risk of injury to marine mammals as described in Volume 2, Chapter 7.

MITIGATION ZONE

- 1.8.2. The mitigation zone is the area within which mitigation measures are implemented to ensure avoidance of injury to marine mammals. The JNCC guidelines for minimising the risk of injury to marine mammals from piling noise (JNCC, 2010a), geophysical surveys (JNCC, 2017) and the use of explosives (i.e. UXO clearance) (JNCC, 2025) varies according to activity.

- 1.8.3. The mitigation zone is defined as the area over which pre start monitoring will be undertaken to record the presence of marine mammals. If marine mammals are recorded within the mitigation zone during the pre-start search, the operations will be delayed until such a time as there have been no sightings of marine mammals and/or acoustic recordings of marine mammals within the mitigation zone for a minimum of 20 minutes.
- 1.8.4. JNCC guidelines state that the *minimum* mitigation zones for pre start monitoring are 500 m from the source of piling noise (JNCC, 2010a) and geophysical surveys (JNCC, 2017). These mitigation zones will, however, be extended based on the project-specific assessment for each activity. The extent to which the PAM will be able to acoustically record marine mammals will depend on the equipment used and the species present. For example, typically PAM can detect harbour porpoise over a range of approximately 300 m, but this may extend to more than a kilometre for low frequency cetaceans (e.g. minke whale).

PILING

Mitigation zone

- 1.8.5. As per the JNCC (2010a) guidance, a constant effort pre piling search will be undertaken by at least two accredited and experienced MMObs to monitor a radial mitigation zone of at least 500 m for all species with the exception of minke whale where a 1,000 m mitigation zone will be monitored. The Works Supervisor will notify the MMObs and PAM Operator and ADD Operator at least one hour prior to the planned start of the piling initiation to allow sufficient time for the search period, soft start and use of ADD (as necessary; see paragraphs 1.8.26 to 1.8.34 for further information on use of ADD).

Visual monitoring

- 1.8.6. During daylight hours at least two dedicated and qualified MMObs will conduct pre start monitoring of the mitigation zone from a vessel, at least 30 minutes prior to the start of piling. Visual monitoring for marine mammals will be conducted from a suitable platform on the vessel (such as the ship's bridge), that allows 360° visualisation, and full coverage of the mitigation zones. MMObs must concentrate their efforts on the appropriate measures to be implemented in advance of and during commencement, breaks in and resumption of piling activity.
- 1.8.7. The MMObs will be equipped with reticule binoculars and Marine Mammal Reporting forms (see Annex A) and will be capable of determining the extent of the mitigation zone in relation to their viewing platform. A range stick may be used to aid the estimation of distance of the sighting from the observation vessel. The lead MMObs should also be equipped with a two way radio to ensure communication with both the vessel crew and the PAM Operator. This is to allow any visual or acoustic detections of marine mammals in the mitigation zone and any subsequent delay required to the commencement of piling to be communicated quickly and effectively between all parties. If marine mammals and/or marine turtles are detected within the mitigation zone during the pre-piling search, then piling will not commence.
- 1.8.8. During low visibility or hours of darkness the MMObs will be equipped with suitable thermal imaging binoculars to carry out a search as described above.

- 1.8.9. Along with the PAM Operator, the MMObs will communicate with the EOD Supervisor to confirm that the mitigation zone is clear of marine mammals, and that the piling operation (including soft start) can commence. The lines of communication and sequencing of events are shown in **Figure 1.2**.

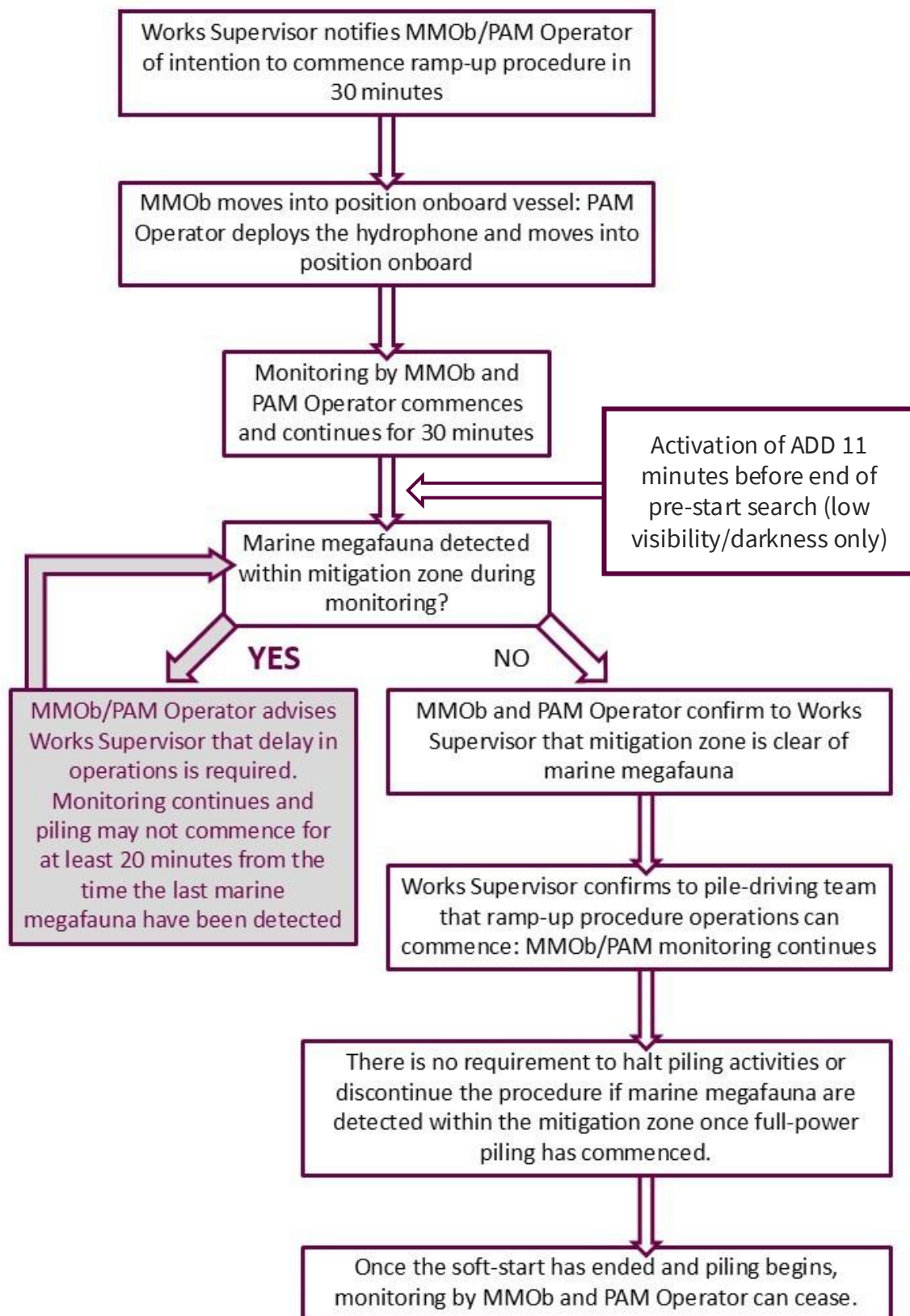


Figure 1.2: Task And Communication Plan For Piling Procedures Start Up

Passive Acoustic Monitoring

- 1.8.10. PAM will be undertaken during pre-start monitoring, soft start and piling activities. The PAM Operator will acoustically track vocalising marine mammals using a hydrophone, deployed to a suitable depth from the operation vessel. The hydrophone data will be monitored by the PAM Operator via a computer interface using the software PAMGuard. This allows the Operator to detect vocalisations, and signal strengths give an indication of the position of the animal relative to the hydrophone (i.e. the signal becomes weaker as the animal moves further away). The PAM Operator can communicate with the MMObs to 'ground truth' any detection of marine mammals in order to validate species identification and determine approximate position.
- 1.8.11. The PAM Operator should also be equipped with a two way radio to ensure communication with both the vessel crew and the lead MMOb. This is to allow any visual or acoustic detections of marine mammals in the mitigation zone and any subsequent delay required to the commencement of piling to be communicated quickly and effectively between all parties.
- 1.8.12. Along with the MMObs, the PAM Operator will communicate with the Works Supervisor to confirm that the mitigation zone is clear of marine mammals, and that the initiation of piling (including soft start) can commence. The lines of communication and sequencing of events are shown in **Figure 1.2**.

Acoustic Deterrent Devices

- 1.8.13. In addition to visual and acoustic monitoring, an ADD will be deployed at the start of the pre piling search in close proximity to the pile to be installed. ADDs should only be used in conjunction with visual and/or acoustic monitoring, and not as a replacement. It is expected that these devices would always be used in accordance with recommended conditions that would prevent the exposure of animals to disturbance. It should be noted that a wildlife licence under the Wildlife and Countryside Act 1981 (within 12nm) might be required to authorise a potential intentional disturbance.
- 1.8.14. The PAM Operator will communicate to the ADD Operator when 11 minutes have elapsed since the start of the pre piling search period and at this point the ADD will be deployed and activated for a minimum of 11 minutes to allow animals sufficient time to disperse, while also minimising the additional noise produced by the device and emitted into the marine environment. Visual and acoustic monitoring will continue throughout the ADD deployment to ensure that marine mammals have left the mitigation zone prior to the start of piling. The PAM Operator will communicate to the ADD Operator if there are any problems with the functioning of the ADDs through their role in Passive Acoustic Monitoring.
- 1.8.15. The ADDs will be deactivated and recovered to the vessel prior to the soft start sequence once it has been confirmed by the MMObs and PAM Operator that the mitigation zone has been clear of marine mammals for at least 20 minutes. The ADDs may remain activated up to the point when this has been confirmed.

Soft start

- 1.8.16. After the 30 minute pre piling search and ADD activation period has elapsed, the piling initiation, soft start and ramp up designed in measures will commence with hammer

initiation at the lowest hammer energy and strike rate (600 kJ). The ADD will be turned off immediately after the piling activity has commenced. The soft start is the gradual, incremental increase of piling power over a minimum of 20 minutes. This allows time for marine mammals to move away from the noise source, thereby reducing the risk of exposing animals to noise levels which could cause injury.

- 1.8.17. The initiation and soft start stages allow for alignment piles and for marine mammals to leave the area and involve a hammer energy of 600 kJ. The ramp up stage is a progressive increase in hammer energy following the soft start and involves an initial hammer energy of 750 kJ which builds up to a maximum of 3,000 kJ over the 9 minute period. The maximum hammer energy proposed for the Liverpool Bay CCS Project is 3,000 kJ. However, the actual energy used when piling will be significantly lower for most of the time and the hammer energy will be raised to 3,000 kJ only when absolutely necessary. A summary of the piling stages and associated strike energies is presented in **Table 1.12**.

Table 1.12: Impact Piling Schedule Used In The Underwater Noise Modelling

Activity/ stage	Duration, minutes	Hammer Energy (kJ)	Strike Rate (strikes/min)	Number of strikes	Notes/description
Pile self weight penetration	N/A	N/A	N/A	N/A	Pile self weight penetration where the pile will sink into the seabed under its own weight.
Soft start	20	600	3	60	Slow start at low hammer energy
Ramp Up	20	750 – 3,000	30	600	Minimise hammer energies at levels sufficient for pile installation, resulting in energy ramp up throughout the piling operation
Piling	60	3,000	40	2,400	Steady hammer at normal operating mode

- 1.8.18. These above activities were included in subsea noise modelling (with the inclusion of an ADD for 30 minutes prior to commencement of any piling activity) in Volume 3, Appendix J Underwater Noise Technical Report (RPS Group and Seiche, 2024). The ADD itself was assumed to not contribute towards any injury to marine mammals.
- 1.8.19. If marine mammals are detected within the mitigation zone during the soft start, then whenever possible piling should cease, or at least the hammer energy should not be further increased until at least 20 minutes after the last visual or acoustic detection of the animal. The MMObs and PAM Operator will track any marine mammals detected and ensure that they have left the mitigation zone before piling commences or the soft start continues.

During piling operations

- 1.8.20. It is acknowledged that, for engineering reasons, it may not be possible to stop piling at full power until the pile is in final position. Therefore, if marine mammals are detected in

the mitigation zone during full power piling, there will be no requirement to cease piling or to reduce piling energy as the animal would be deemed to have entered the area “voluntarily”. **Figure 1.2** illustrates the sequence of events and lines of communication required to implement the MMMP.

- 1.8.21. Following further evidence from the engineering team, it has been necessary to make some adjustments to the Marine Mammal Mitigation Protocol (MMMP) to ensure that the risk of injury is full mitigated whilst also ensuring the temporal duration (namely the number of days on which piling occurs) is kept to a minimum such that disturbance to marine mammals is also minimised.
- 1.8.22. The contractor engineers have advised that once a pile is placed and has undergone self-weight penetration, there is a time-critical period within which piling needs to be completed quickly to reduce the risk of refusal. There are a number of factors whereby delays in piling could potentially extend the overall duration of piling (i.e. number of hours piling per pile) and consequently lead to more days over which piling could occur.
- 1.8.23. The following technical information was provided by the engineers to describe the consequences of a delay between piling of piles once they are placed within the frame. In summary, The established pile-driving criteria distinguish between continuous driving and driving following an interruption, with separate refusal criteria applying in each case. During ongoing driving, refusal is defined as a minimum of 125 blows per 0.25 m over six consecutive intervals, or 200 blows per 0.25 m over two consecutive intervals. Where driving has been interrupted for one hour or more, refusal at re-start is redefined as 325 or more blows per 0.25 m over two consecutive intervals. Expected blow count at target penetration is 20 to 25 blows per 0.25 m. The substantially higher re-start criterion reflects recovery of soil resistance around the pile shaft during the interruption. Hammer energy is separately restricted to a maximum of 1,470 kJ for the MHU-2100 hammer (70% of rated energy), due to allowable driving stress in the pile (i.e. considerably less than the 3000 kJ maximum energy assessed). The restriction applies for the full duration of driving, from self-weight penetration to target penetration, so energy cannot be increased to overcome recovered soil resistance. A pile left standing mid-drive therefore carries a material risk of refusal above the 20 m target penetration.
- 1.8.24. The required sequence of events is as follows:
 - For each batch of piles (4 piles) in each batch, two batches total 8 piles) the contractor will place the pile within the pile sleeve and each pile will undergo self-weight penetration;
 - The contractor will commence piling at the first pile using a 20-minute soft-start procedure;
 - The interval between completion of driving one pile and commencement of the next is approximately 30 minutes, being the time required to lift the hammer clear and stab it on the following pile. A 30-minute pre-search (and use of ADD during low visibility and hours of darkness) will apply, as detailed below;
 - Moving to the next pile in the batch, the contractor would start piling without soft start, providing a watch has been maintained for the duration;
 - Time between each batch will typically be several hours, and expected to be no more than 6 hours;

- Piling may be required to start or restart at any point over the 24-hour period (day or night).
- 1.8.25. If for any reason there is a break in piling activity for greater than 10 minutes, then the pre piling search, and a full soft start and ramp up procedure should be repeated before piling recommences if there has been no watch during this time. If a watch has been kept during the piling operation, the MMObs or PAM Operator should be able to confirm the presence or absence of marine mammals, and it may be possible to commence the soft start immediately. However, if there has been no watch, the complete pre piling search and soft start procedure should be undertaken.
- 1.8.26. Based on the additional operational contractor information (see paragraphs 1.8.21 to 1.8.23), Mitigation measures will be necessary to support the piling sequence, including an ADD. The use of ADD is an accepted mitigation tool in the JNCC 2010 guidance, as standard industry practice alongside MMObs and PAM. The Project Environmental Impact Assessment (EIA) included an assessment of ADD as part of the mitigation sequence and ADD formed part of the mitigation measures in the original MMMP.
- 1.8.27. However, in developing the MMMP a pause of several hours or more between each pile was expected, and Natural England suggested removal of the ADD from the MMMP, citing the Defra noise policy on reducing noise in the marine environment (April 2026 comments on MMMP Version A). In response LBCCS Ltd removed the use of ADD from the MMMP (Version B). However, the interval between piles within a batch is now understood to be approximately 30 minutes, considerably less than the originally-expected several hours. Over the 30-minute interval recovery of soil resistance is limited, however a full 20-minute soft start at each pile would add approximately two hours of low-energy strikes, extend exposure to set-up, and increase the number of days on which piling occurs across the whole campaign.
- 1.8.28. Given the implications of prolonging the piling phase without the ADD, the Project needs to re-introduce this mitigation tool as part of the measures. In their consultation response the SNCBs also suggested tailoring the duration of the ADD. A 30-minute ADD was assessed within the EIA but the maximum range for instantaneous injury (i.e. injury from the initial strike at maximum energy) is estimated as 490 m based on the maximum design scenario of a 3,000 kJ hammer energy. Applying a conservative marine mammal swim speed of 1.5 m/s, and ORJIP advice to deter animals over approximately twice the injury range (Herschel *et al.* 2013), an activation duration of 11 minutes would be sufficient to mitigate for instantaneous injury to 1 km. Note that this is also the range over which cumulative exposure (SEL_{cum}) could occur.
- 1.8.29. Furthermore, the Project will include the use of thermal imaging binoculars to allow effective monitoring of the mitigation zone by MMObs during hours of darkness or low visibility. This will ensure that piling can continue over a 24-hour period, thus significantly reducing the risk of prolonging the piling period, compared to piling during daylight hours only.

Piling Mitigation

- 1.8.30. for start of piling works standard mitigation procedures will apply, including:
- During daylight hours - 30 minutes monitoring of the mitigation zone by Marine Mammal Observers (MMOs) and Passive Acoustic Monitoring (PAM);

- During night-time or low visibility - PAM pre-search and visual search using thermal imaging binoculars for 30 minutes and use of ADD for a period of 11 minutes;
- 20 minutes of soft-start ramp up to full energy as required.

1.8.31. Where there is a break of up to 10 minutes:

- Piling resumes at full power.

1.8.32. Where there is a break of between 10 minutes and 40 minutes the procedure will be:

- During daylight hours - MMObs and PAM pre-search for 30 minutes;
- During night-time or low visibility - PAM pre-search and visual search using thermal imaging binoculars for 30 minutes and ADD for a period of 11 minutes.

1.8.33. For breaks of more than 40 minutes the procedure will be:

- During daylight hours - MMObs and PAM pre-search;
- During night-time or low visibility – PAM pre-search and visual search using thermal imaging binoculars for 30 minutes and ADD (11 minutes);
- 20 minutes of soft-start ramp up to full energy as required.

1.8.34. The designed in and mitigation measures detailed in this MMMP reduce the risk of auditory injury to an acceptable level in terms of PTS. With mitigation in place, the potential effect of piling (auditory injury) on marine mammals is of minor significance, which is not significant in Environmental Impact Assessment (EIA) terms.

GEOPHYSICAL SURVEYING

1.8.35. The assessment of geophysical surveys equipment (MBES and SBP) predicted a maximum injury range of 345 m, noting that the sound generated will be highly directional and animals only likely to be within the injury zone directly below the sound source. As per the JNCC (2017) guidance, a constant effort pre survey search will be undertaken by at least two accredited and experienced MMObs (using binoculars and a range finding stick as required) and a PAM Operator to monitor up to the recommended 500 m radial mitigation zone to minimise the likelihood of marine mammals being present within this range. MMObs shall conduct pre start up monitoring at least 30 minutes before the survey activity is due to commence and sound producing activity shall not commence until at least 30 minutes have elapsed with no marine mammals detected by the MMObs within the mitigation zone.

1.8.36. Sound producing activities shall only commence in daylight hours where effective visual monitoring, as performed and determined by the MMObs, has been achieved. Where effective visual monitoring, as determined by the MMObs, is not possible (including in circumstances in which poor visibility prevents the 500 m mitigation zone from being visually monitored) the sound producing activities shall be postponed until effective visual monitoring is possible.

1.8.37. An agreed and clear on site communication signal must be used between the MMObs and the Works Supervisor as to whether the relevant activity may or may not proceed, or resume following a break (see below). It shall only proceed on positive confirmation with the MMObs.

- 1.8.38. This prescribed pre survey monitoring shall subsequently be followed by a ramp- up procedure (i.e. a soft start) which should include continued monitoring by the MMObs.
- 1.8.39. If there is a break in sound output for a period greater than 10 minutes (e.g. due to equipment failure, shut down, survey line or station change) then all pre survey monitoring and a subsequent soft start procedure (where appropriate) must be undertaken.
- 1.8.40. The designed in and mitigation measures detailed in this MMMP reduce the risk of auditory injury to an acceptable level in terms of PTS. With mitigation in place, the potential effect of geophysical acoustic surveys (auditory injury) on marine mammals is of minor significance, which is not significant in EIA terms. **Figure 1.3** illustrates the sequence of events and lines of communication required to implement the MMMP.

Mitigation zone

- 1.8.41. As per the JNCC (2017) guidance, a constant effort pre survey search will be undertaken by at least two accredited and experienced marine mammal observers (MMObs) to monitor a radial search zone of 500 m from the sound source to minimise the likelihood of marine mammals being present within this range. The Works Supervisor will notify the MMObs and PAM Operator at least one hour prior to the planned start of survey operations to allow sufficient time for the search period and soft start.

Visual monitoring

- 1.8.42. Surveying shall commence during daylight hours only, when visual monitoring of the mitigation zone is possible. At least two dedicated and qualified MMObs will conduct a visual search of the mitigation zone and conduct the pre start searches from a vessel prior to the start of surveying. Visual monitoring for marine mammals will be conducted from a suitable platform on the vessel such as the ship's bridge, that allows 360° visualisation, and full coverage of the mitigation zone. MMObs must concentrate their efforts on the appropriate measures to be implemented in advance of and during commencement, breaks in and resumption of surveying.
- 1.8.43. The MMO will be equipped with reticule binoculars and Marine Mammal Reporting forms and will be capable of determining the extent of the mitigation zone in relation to their viewing platform. A range stick may be used to aid the estimation of distance of the sighting from the survey vessel. The lead MMObs should also be equipped with a two way radio to ensure communication with both the vessel crew and the PAM Operator. This is to allow any visual or acoustic detections of marine mammals in the mitigation zone and any subsequent delay required to the commencement of surveying to be communicated quickly and effectively between all parties.
- 1.8.44. Along with the PAM Operator, the MMObs will communicate with the EOD Supervisor to confirm that the mitigation zone is clear of marine mammals, and that the detonation operation (including soft start) can commence. The lines of communication and sequencing of events are shown in **Figure 1.3**.

Passive Acoustic Monitoring

- 1.8.45. PAM will be undertaken during pre-start, ramp up/soft start and surveying activities. Two dedicated and qualified PAM Operators will be responsible for deployment, maintenance

and operation of the PAM hydrophone, including spares. Both PAM Operators will be suitably trained in passive acoustic monitoring and the use of PAMGuard, with training having been provided by an appropriate organisation (e.g. Seiche). PAM Operators will also have an appropriate level of field experience (i.e. a minimum of one year PAM experience on offshore projects).

- 1.8.46. PAM Operators will be based on the vessel together with the MMObs. PAM Operators will be responsible for recording all acoustic marine mammal detections in the appropriate format, and together with the MMObs, will be responsible for compiling all the data on marine mammal observations and mitigation activities for reporting to JNCC. The PAM Operator should also be equipped with a two way radio to ensure communication with both the vessel crew and the lead MMObs. This is to allow any visual or acoustic detections of marine mammals in the mitigation zone and any subsequent delay required to the commencement of surveying to be communicated quickly and effectively between all parties.
- 1.8.47. PAM Operators must be experienced and familiar with the UK regulatory procedures pertaining to managing risk to marine mammals from underwater sound and to ensure compliance must be provided with full details of all licence/consent conditions relevant to the performance of their role in advance of activity commencement. PAM Operators will have the necessary authority (or support by Works Supervisor) to implement the plan and stop works if necessary.
- 1.8.48. Along with the MMObs, the PAM Operator will communicate with the EOD Supervisor to confirm that the mitigation zone is clear of marine mammals, and that the detonation operation (including soft start) can commence. The lines of communication and sequencing of events are shown in **Figure 1.3**.

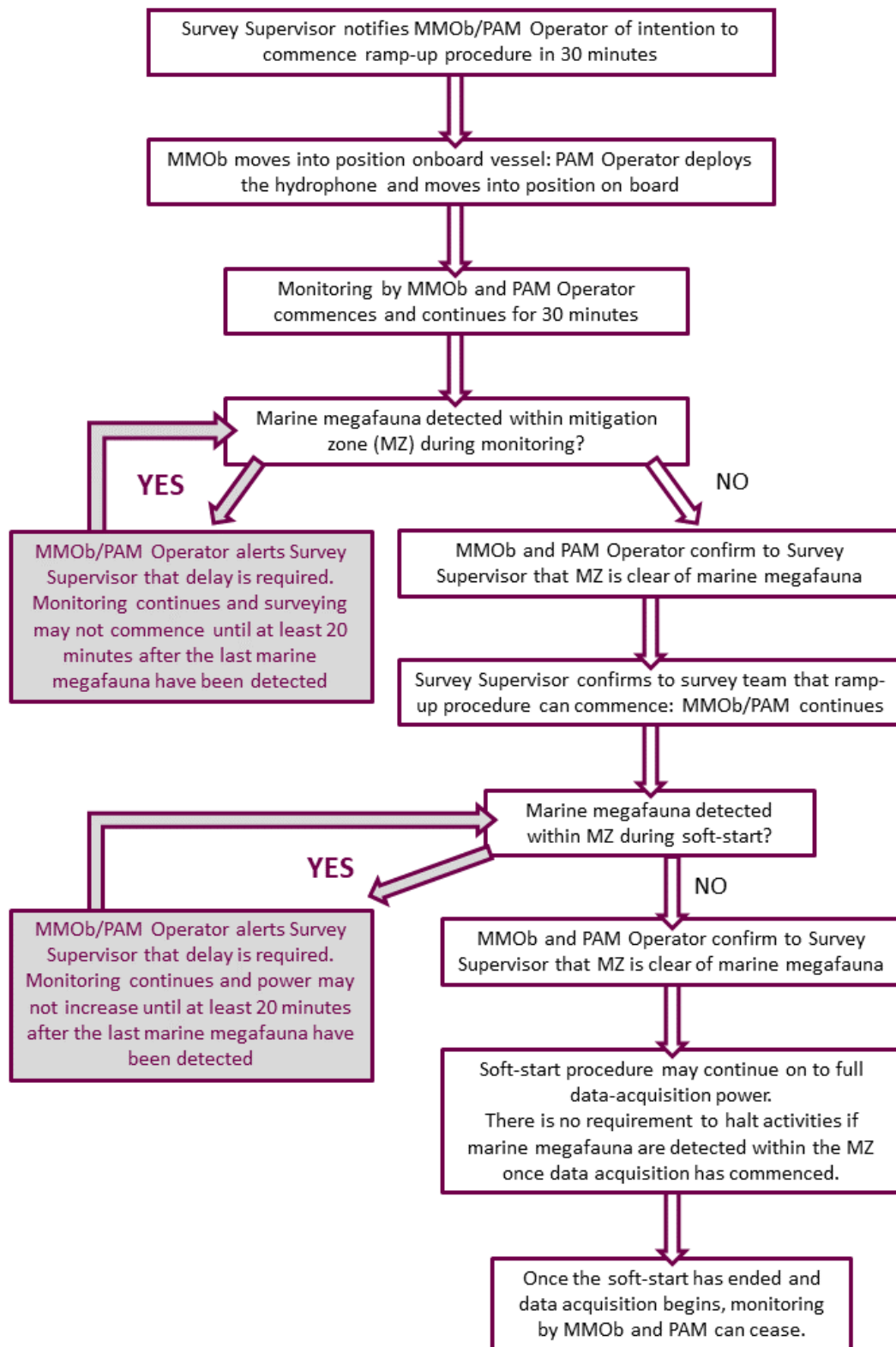


Figure 1.3: Task And Communication Plan For Geophysical Procedures Start Up

Soft start

- 1.8.49. In commencing [the geophysical survey operations to be used for this project](#) (SBP, and MBES), the following soft start procedure must be used, including during any testing of acoustic sources:

- where it is possible according to the operational parameters of the equipment employed, the device's acoustic energy output should start from a lower energy output and be allowed to gradually build up to data acquisition output level over a minimum period of 20 minutes.
- The controlled build-up of acoustic energy output should occur in consistent stages to provide a steady and gradual increase over the ramp up period.
- Where the measures outlined above are not possible according to the operational parameters of the equipment, the device should be switched "on" and "off" in a consistent sequential manner. The duration between shots should begin with a greater interval than is required for data acquisition, reducing over a period of 20 minutes to full necessary output.

1.8.50. In all cases where a soft start is employed the delay between the end of the soft start and the necessary full output must be minimised to prevent unnecessary high level sound introduction into the environment.

1.8.51. Once the soft start commences, there is no requirement to halt or discontinue the procedure if weather or visibility conditions deteriorate, nor if marine mammals occur within the 500 m radial mitigation zone. Marine mammals present at this point are deemed to have entered the ensonified area willingly.

1.9. REPORTING

1.9.1. The OEM will be responsible for monitoring piling operations **and** geophysical, as well as implementation of this MMMP, and will keep a detailed record of operations, mitigation procedures and any marine mammal sightings.

1.9.2. These records will be prepared and submitted in compliance with consent and/or license conditions to MMO/JNCC and will include completing and submitting Marine Mammal Recording Forms provided by JNCC (Annex A). Marine Mammal Deck Forms are also provided in Annex B.

1.9.3. As well as the above reporting, data on loud, low to medium frequency (10 Hz – 10 kHz) impulsive noise should be submitted to the Defra/JNCC Marine Noise Registry (<https://mnr.jncc.gov.uk/>). Activities for which data should be submitted include:

- sub bottom profiling;
- impact piling;
- MBES devices (≤ 12 kHz).

1.9.4. Data specifics include location, dates and source property data, including (where relevant) source frequency, maximum hammer energy, sound pressure level and sound exposure level.

PILING

1.9.5. An MMObs report must be submitted to MMO/JNCC upon completion of piling operations and should include the information detailed below. It should be accompanied by completed JNCC marine mammal recording forms (i.e. the raw data in the excel spreadsheets) and a copy of the relevant survey consent or licence, as well as the excel spreadsheets in their original format (i.e. do not convert to pdf).

Operator details

- 1.9.6. Include brief details of the company awarded the consent or licence, relevant contractor details if appropriate, and the survey consent or licence reference number issued by the Regulator. Highlight contact details for whoever is responsible for the piling operations in case JNCC has any follow up questions.

Operational details

Provide a summary of the piling operations, including:

- date and location of piling operations;
- a record of all occasions when piling occurred, including details of the duration of the pre piling search and soft start procedures, and any occasions when piling activity was delayed or stopped due to presence of marine mammals;
- details of watches made for marine mammals, including details of any sightings, details of the PAM equipment and detections, and details of the piling activity during the watches;
- details of any Acoustic Deterrent Devices (ADDs) used, and any relevant observations on their efficacy;
- details of any problems encountered during the piling process including instances of non-compliance with the agreed piling protocol; and
- any recommendations for amendment of the protocol.

MMO/PAM effort and detections

- 1.9.7. Include details of the number of staff employed, whether they were dedicated or non-dedicated staff and their working location(s) on the vessel. Also, include details of their experience (i.e. level of training, number of previous mitigation assignments or previous experience of observing if new to the role). A brief CV could be added as an appendix if easier. Provide details of the lead operative responsible for the report who can be contacted if JNCC has any follow up questions.
- 1.9.8. If PAM has been used on the vessel, include details of the equipment and software and a summary of how often it was deployed. Also, detail any technical issues encountered (e.g. equipment failure or deployment issues). Screenshots of spectrograms can also be helpful but are not essential.
- 1.9.9. Details of all monitoring effort should be included in the recording forms (Annex A) but should also be summarised within the report. Also, summarise details of any marine mammals encountered, either visually or acoustically, distinguishing between those recorded inside and outside the mitigation zone.

Application of mitigation procedures

- 1.9.10. Include details of any piling specific arrangements agreed with the Regulator as part of the consent conditions prior to the start of piling operations (e.g. changes to the size of the mitigation zone).
- 1.9.11. Provide a summary of mitigation procedures applied, including details of soft starts implemented and whether delays in piling were required. Again, only a summary is

required as further details will be provided in the accompanying recording forms (Annex A).

- 1.9.12. Details of any issues that have arisen relating to understanding or interpreting the JNCC guidelines should be included in the MMO report, describing the issue and how it was resolved, or including suggestions as to how it could have been resolved, to aid JNCC with future revisions of the guidelines.
- 1.9.13. Any issues encountered in complying with the consent or licence conditions that relate to marine mammal mitigation should also be summarised in the report.

Submission of data to Marine Noise Registry

- 1.9.14. Where it has been possible to do so, data collected using the PAM system during piling operations will be submitted to the MNR, and should (where possible) include:
- source properties:
 - SPL, dB re 1 μ Pa (peak) @ 1 m;
 - SEL, dB re 1 μ Pa²s (per pulse) @ 1 m;
 - maximum hammer energy;
 - actual location of activity:
 - latitude/longitude point (decimal degrees);
 - quadrant/Block (UK oil and gas licensing blocks); and
 - actual dates on which activity took place in correspondence with the location.

Additional information

- 1.9.15. Additional information, for example, photographs of marine mammals observed, can be included at the end of the report if available.

GEOPHYSICAL SURVEYING

- 1.9.16. An MMObs report must be submitted to MMO/JNCC upon completion of a geophysical survey and should include the information detailed below. It should be accompanied by completed JNCC marine mammal recording forms (Annex A) (i.e. the raw data in the excel spreadsheets) and a copy of the relevant survey consent or licence, as well as the excel spreadsheets in their original format (i.e. do not convert to PDF).

Operator details

- 1.9.17. Include brief details of the company awarded the consent or licence, relevant contractor details if appropriate, and the survey consent or licence reference number issued by the Regulator. Highlight contact details for whoever is responsible for the survey in case JNCC has any follow up questions.

Survey details

- 1.9.18. Provide a summary of the survey including:
- date and location of survey;
 - details of any other acoustic energy used (e.g. SBP);

- descriptions of any technical problems encountered and what, if any, actions were taken;
- average duration of all pre survey watches, soft starts and line changes, and the number of occasions when guideline durations were not met (specific times are included in the accompanying MMObs excel recording forms (Annex A));
- any problems encountered and instances of non-compliances with the JNCC guidelines (2017), MMMP, and variations from agreed procedures;
- summary of MMObs/PAM activities for each monitoring period, including specifics of the conducted surveys and any relevant observations on the efficacy of PAM equipment (i.e. full excel recording forms of operations (Annex A) and brief written summary);
- number and types of vessels involved in the survey; and
- presence, location, and activity of other vessels during geophysical surveying.

1.9.19. The geographical coordinates of the survey area and, if appropriate, the greater working area will have been included in the initial application, but a map illustrating the location of the survey (or the licence blocks within which it occurred) can be beneficial, as can be an illustration of the completed survey lines.

1.9.20. It should also be highlighted if the survey has occurred within or close to a protected area which includes marine mammals as a feature. Note, general details of likely marine mammal presence in the survey area will have already been included in the application and does not need repeating here.

MMO/PAM effort and detections

1.9.21. Include details of the number of staff employed, whether they were dedicated or non-dedicated staff and their working location(s) on the vessel. Also, include details of their experience (i.e. level of training, number of previous mitigation assignments or previous experience of observing if new to the role). A brief CV could be added as an appendix if easier. Provide details of the lead operative responsible for the report who can be contacted if JNCC has any follow up questions.

1.9.22. If PAM has been used on the vessel, include details of the equipment and software and a summary of how often it was deployed. Also, detail any technical issues encountered (e.g. equipment failure or deployment issues). Screenshots of spectrograms can also be helpful but are not essential.

1.9.23. Details of all monitoring effort should be included in the recording forms (Annex A) but should also be summarised within the report. Also, summarise details of any marine mammals encountered, either visually or acoustically, distinguishing between those recorded inside and outside the mitigation zone.

Application of mitigation procedures

1.9.24. Include details of any survey specific arrangements agreed with the Regulator as part of the survey consent conditions prior to the start of the survey (e.g. changes to the size of the mitigation zone).

1.9.25. Provide a summary of mitigation procedures applied, including details of soft starts implemented and whether delays in firing were required. Again, only a summary is

required as further details will be provided in the accompanying recording forms (Annex A).

- 1.9.26. Details of any issues that have arisen relating to understanding or interpreting the JNCC guidelines should be included in the MMO report, describing the issue and how it was resolved, or including suggestions as to how it could have been resolved, to aid JNCC with future revisions of the guidelines.
- 1.9.27. Any issues encountered in complying with the consent or licence conditions that relate to marine mammal mitigation should also be summarised in the report.

Submission of data to Marine Noise Registry

- 1.9.28. Where it has been possible to do so, data collected using the PAM system during surveying operations from seismic, SBP and MBES sound sources will be submitted to the MNR, and should (where possible) include:
- source properties;
 - SPL, dB re 1 μ Pa (peak) @ 1 m;
 - SEL, dB re 1 μ Pa²s (per pulse) @ 1 m;
 - actual location of activity;
 - latitude/longitude point (decimal degrees);
 - quadrant/Block (UK oil and gas licensing blocks); and
 - actual dates on which activity took place in correspondence with the location.

Additional information

- 1.9.29. Additional information, for example, photographs of marine mammals observed, can be included at the end of the report if available.

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ANNEX A: JNCC MARINE MAMMAL RECORDING FORM

Excel spreadsheet available direct from JNCC, which **should be submitted** to MMO/JNCC in **original format** (i.e. as a spreadsheet file, and not converted to PDF).

Marine Mammal Recording Form available at: <https://hub.jncc.gov.uk/assets/e2a46de5-43d4-43f0-b296-c62134397ce4>.

ANNEX B: JNCC MARINE MAMMAL DECK FORMS

MARINE MAMMAL RECORDING FORM - COVER PAGE

Regulatory reference number (e.g. DECC no., BOEM permit no., OCS lease no., etc.)	Country	Location	Ship/ platform name
Client	Contractor		Survey type ☐ site ☐ VSP ☐ 2D ☐ WAZ ☐ 3D ☐ piling ☐ 4D ☐ explosives ☐ OBC ☐ other ☐ 4C
Start date	End date		

Number of source vessels	Type of source (e.g. airguns)	Number of airguns (only if airguns used)	Source volume (cu. in.)
Source depth (metres)	Frequency (range in which peak energy is emitted, in Hz)	Intensity (primary peak-to-peak amplitude in dB re. 1µPa or bar metres)	Shot point interval (metres)
Method of soft start ☐ increase number of guns ☐ increase frequency (where permitted) ☐ increase pressure (where permitted) ☐ increase number and frequency ☐ increase number and pressure ☐ other			

Visual monitoring equipment used (e.g. binoculars, big eyes, etc.)	Magnification of optical equipment (e.g. binoculars)	Height of eye above water surface (metres)	How was distance of animals estimated? ☐ by eye ☐ with laser rangefinder ☐ with rangefinder stick/callipers ☐ with reticle binoculars ☐ by relating to object at known distance ☐ other
Number of dedicated MMOs	Training of MMOs ☐ JNCC approved MMO training course for UK waters ☐ PSO training course for the Gulf of Mexico ☐ MMO training course for Irish waters ☐ MMO training course for New Zealand waters ☐ other ☐ none		

Was PAM used? ☐ yes ☐ no	Number of PAM operators	
Description of PAM equipment 		
Range of PAM hydrophones from airguns (metres)	Bearing of PAM hydrophones from airguns (relative to direction of travel)	Depth of PAM hydrophones (metres)

MARINE MAMMAL RECORDING FORM - OPERATIONS

Regulatory reference number

(e.g. DECC no., BOEM permit no., OCS lease no., etc.)

Ship/ platform name

Complete this form every time the airguns are used, including overnight, whether for shooting a line or for testing or for any purpose.

Times should be in UTC, using the 24 hour clock.

[illegible]

MARINE MAMMAL RECORDING FORM - EFFORT

Regulatory reference number

(e.g. DECC no., BOEM permit no., OCS lease no., etc.)

Ship/platform name

Record the following for all watches, even if no marine mammals are seen.

START A NEW LINE IF SOURCE ACTIVITY OR WEATHER CHANGES. ENTER DATA AT LEAST EVERY HOUR.

Date	Visual watch or PAM (v/ p)	Observer's/ operator's name(s)	Time of start of section of watch (UTC, 24hr clock)	Time of end of section of watch (UTC, 24hr clock)	Source activity (f/ s/ r/ n/ v)	Start position (latitude and longitude)	Depth at start (m)	End position (latitude and longitude)	Depth at end (m)	Speed of vessel (knots)	Wind dir'n	Wind force (B'fort scale)	Sea state (g/ s/ c/ r)	Swell (o/ m/ l)	Vis. (visual watch only) (p/ m/ g)	Sun glare (visual watch only) (n/ wf/ sf/ vf/ wb/ sb/ vb)	Precip. (n/ l/ m/ h/ s)

Visual watch or PAM: v = visual watch; p = PAM

Source activity: f = full power; s = soft start; r = reduced power (not soft start); n = not active; v = variable (e.g. tests)

Sea state: g = glassy (like mirror); s = slight (no/ few white caps); c = choppy (many white caps); r = rough (big waves, foam, spray)

Swell: o = low (< 2 m); m = medium (2-4 m); l = large (> 4 m)

Visibility: p = poor (< 1 km); m = moderate (1-5 km); g = good (> 5 km)

Sun glare: n = none; wf = weak forward; sf = strong forward; vf = variable forward; wb = weak behind; sb = strong behind; vb = variable behind

Precipitation: n = none; l = light rain; m = moderate rain; h = heavy rain; s = snow

MARINE MAMMAL RECORDING FORM - SIGHTINGS

Regulatory reference number (e.g. DECC no., BOEM permit no., OCS lease no., etc.)	Ship/ platform name	Sighting number (start at 1 for first sighting of survey)	Acoustic detection number (start at 500 for first detection of survey)
Date		Time at start of encounter (UTC, 24hr clock)	Time at end of encounter (UTC, 24hr clock)
Were animals detected visually and/or acoustically? ☐ visual ☐ acoustic ☐ both	How were the animals first detected? ☐ visually detected by observer keeping a continuous watch ☐ visually spotted incidentally by observer or someone else ☐ acoustically detected by PAM ☐ both visually and acoustically before operators/ observers informed each other		
Observer's/operator's name	Position (latitude and longitude)		Water depth (metres)
Species/species group		Description (include features such as overall size; shape of head; colour and pattern; size, shape and position of dorsal fin; height, direction and shape of blow; characteristics of whistles/ clicks)	
Bearing to animal (when first seen or heard) (bearing from true north)	Range to animal (when first seen or heard) (metres)		
Total number	Number of adults (visual sightings only)	Number of juveniles (visual sightings only)	Number of calves (visual sightings only)
Photograph taken ☐ yes ☐ no			
Behaviour (visual sightings only)			
Direction of travel (relative to ship) ☐ towards ship ☐ variable ☐ away from ship ☐ milling ☐ parallel to ship in same direction as ship ☐ stationary ☐ parallel to opposite direction to ship ☐ crossing perpendicular ahead of ship		Direction of travel (compass points) ☐ N ☐ W ☐ NE ☐ NW ☐ E ☐ variable ☐ SE ☐ stationary ☐ S ☐ unknown ☐ SW	
Airgun (or other source) activity when animals first detected ☐ full power ☐ not firing ☐ soft start ☐ reduced power (other than soft start)	Airgun (or other source) activity when animals last detected ☐ full power ☐ not firing ☐ soft start ☐ reduced power (other than soft start)	Time animals entered mitigation/ exclusion zone (UTC, 24hr clock)	Time animals left mitigation/ exclusion zone (UTC, 24hr clock)
		Closest distance of animals from airguns (or other source) (metres)	Time of closest approach (UTC, 24hr clock)

If seen during soft start give: First distance Closest distance Last distance during soft start (metres)	What action was taken? (according to requirements of guidelines/ regulations in country concerned) ☐ none required ☐ delay start of firing ☐ shut-down of active source ☐ power-down of active source ☐ power-down then shut-down of active source	Length of power-down and/ or shut-down (if relevant) (length of time until subsequent soft start, in minutes)	Estimated loss of production (if relevant) due to mitigating actions (km)
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