Appendix 5-4 Addendum: Marine Megafauna Mitigation Plan

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Environmental Impact Assessment Report - Addendum
Appendix 5-4 Addendum: Marine Megafauna Mitigation Plan

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Acronyms

Term	Meaning
ADD	Acoustic Deterrent Device
CBRA	Cable Burial Risk Assessment
CTV	Crew Transfer Vessels
DBBC	Double Big Bubble Curtain
ECoW	Environmental Clerk of Works
EIAR	Environmental Impact Assessment Report
EMF	Electromagnetic Fields
EPA	Environmental Protection Agency
HWM	High Water Mark
IEF	Important Ecological Features
MEC	Maximum Export Capacity
MMMP	Marine Megafauna Mitigation Plan
MMO	Marine Mammal Observation
MPCP	Marine Protection Contingency Plan
NAS	Noise Abatement Systems
NMPF	National Marine Planning Framework
NMFS	National Marine Fisheries Service (USA Federal agency within NOAA)
NMS	Noise Mitigation Systems
NPWS	National Parks and Wildlife Service
OSS	Offshore Substation
OWL	Oriel Windfarm Limited
PAM	Passive Acoustic Monitoring
PTS	Permanent Threshold Shift
SAC	Special Area of Conservation
SAM	Static Acoustic Monitoring
SEL	Sound Exposure Level
SPL	Sound Pressure Level
TSS	Temporary Threshold Shift
WTG	Wind Turbine Generator

1 MARINE MEGAFAUNA MITIGATION PLAN

A Marine Megafauna Mitigation Plan (MMMP) for the proposed Oriel Wind Farm Project is included as part of the planning application documents submitted to An Coimisiún Pleanála (ACP) (formerly An Bord Pleanála) in May 2024 (see appendix 5-4 of EIAR volume 2A). This document provides an updated MMMP for the Project and supersedes the one provided in appendix 5-4 of the EIAR. The updates have been made to address the updated assessment on marine mammals and megafauna in chapter 10 Addendum: Marine Mammals and Megafauna in volume 2A Addendum (and associated appendices 10-4, 10-6 to 10-8, as outlined below in section 1.1). The updated assessment was prepared in response to the Request for Further Information (RFI) on marine mammals and megafauna (RFI 9).

1.1 Introduction

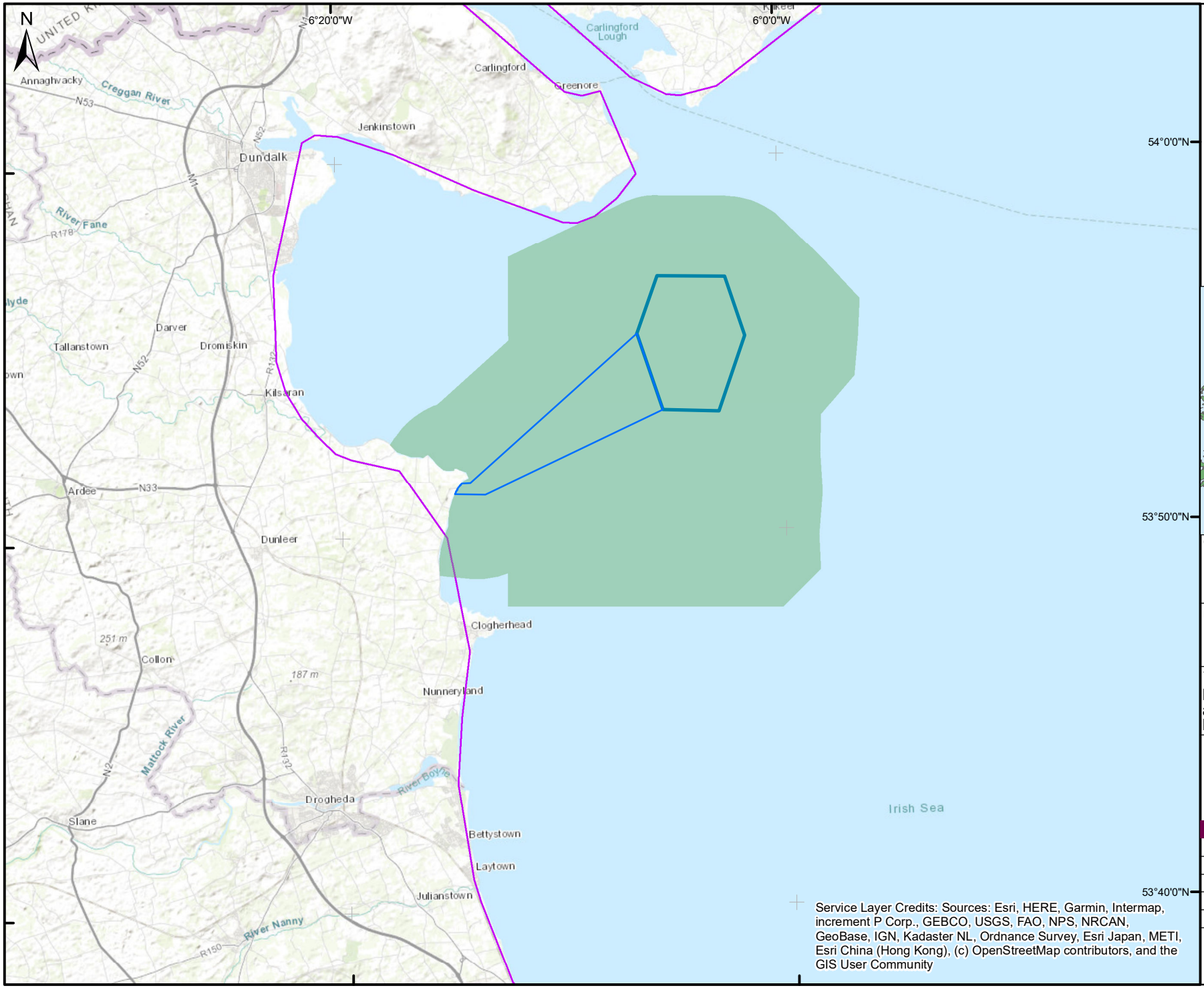
Oriel Windfarm Limited (OWL) (hereafter referred to as “the Applicant”), is promoting the development of the Oriel Wind Farm Project (hereafter referred to as “the Project”).

The Project is an offshore wind farm located in the Irish Sea, off the coast of County Louth (approximately 22 km east of Dundalk town centre and 18 km east of Blackrock) (Figure 1-1). The closest wind turbine will be approximately 6 km from the closest shore on the Cooley Peninsula. The offshore cable corridor extends approximately 11 km southwest from the offshore wind farm area to the landfall south of Dunany Point. The offshore infrastructure of the Project, such as the wind turbines, Offshore Substation (OSS) and inter-array cables, will be located within the offshore wind farm area, which covers approximately 27.7 km^2, being broadly hexagonal in shape with a length of approximately 5.3 km west to east and 6.6 km north to south. The Project will have 25 wind turbine generators (WTGs) and one OSS located within the offshore wind farm area and will have a Maximum Export Capacity (MEC) of 375 MW.

The offshore cable corridor connects the offshore wind farm area with the landfall south of Dunany Point. The offshore cable corridor is contiguous to the High-Water Mark (HWM) at the landfall and to the southwestern boundary of the offshore wind farm area. The offshore cable corridor is approximately 11 km in length and covers an area of approximately 25.3 km^2, indicated in Figure 1-1. The WTGs will be connected to each other by a network of inter-array cables, which will also connect into the OSS. The offshore cable will transfer the electricity from the OSS to shore, where it will connect to the onshore infrastructure.

This Marine Megafauna Mitigation Plan (MMMP) presents a summary of findings as assessed in the Environmental Impact Assessment Report (EIAR) and updated noise modelling presented in the EIAR Addendum on the potentially injurious effects of underwater noise during pile-driving and geophysical surveys, on marine mammals and other megafauna (hereafter referred to collectively as ‘marine megafauna’). Pile-driving has the potential to impact marine mammals and megafauna during the construction phase, and geophysical acoustic surveys have the potential to cause an impact during the operational and maintenance phase. This MMMP is informed by the following sections of the EIAR:

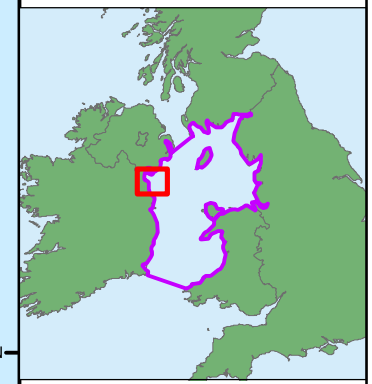
- Volume 2B, chapter 10: Marine Mammals and Megafauna;
- Volume 2B, appendix 10-1: Marine Mammals and Megafauna Technical Report;
- Volume 2B, appendix 10-2: Subsea Noise Technical Report;
- Volume 2B Addendum, chapter 10 Addendum: Marine Mammals and Megafauna;
- Volume 2B Addendum, appendix 10-4 Addendum: Updated Subsea Noise Modelling Report;
- Volume 2B Addendum, appendix 10-6 Addendum: NAS Modelling Report;
- Appendix 10-7: NAS Technical Note - Marine Mammals, Megafauna and Fish; and
- Appendix 10-8: Comprehensive Review of Relevant Mitigation (Noise Abatement).



Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor
- Marine Mammal and Megafauna Study Area
- Regional Marine Megafauna Study Area

Data Sources: Client.



Client

ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

Project

Oriel Wind Farm Project

Title

Figure 1-1
Marine Megafauna Study Area and Regional Marine Megafauna Study Area

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1.2 Purpose of the MMMP

The purpose of this MMMP is to present the means by which the potentially injurious effects of underwater noise resulting from pile-driving activity and geophysical surveys on marine mammals, fish (basking shark) and sea turtles are to be mitigated during the construction and operational and maintenance phases of the Project. Information presented in this MMMP is based on volume 2B, chapter 10: Marine Mammals and Megafauna and chapter 10 Addendum: Marine Mammals and Megafauna, which considers the potential impacts of the Project seaward of the HWM during the construction, operational and maintenance, and decommissioning phases. Only those impacts with the potential to cause auditory injury and for which specific measures have been proposed have been included in this MMMP.

The precautionary injury ranges for marine mammals established in the EIAR are based on the underwater noise modelling for the most sensitive species, the parameters for which are based on the project design parameters for the Project. It should be noted that this plan will be updated and finalised pre-construction following the refinement of the project design and refined marine mammal, fish and sea turtle injury ranges, with mitigation measures updated based on these refined ranges. Also any conditions of permission or updated guidelines or changes in industry best practice will be included. The project design parameters informing the assessment of potential impacts on marine mammals and megafauna as a result of underwater noise during pile-driving and geophysical site investigation surveys is presented in Table 1-1.

Table 1-1: Project design parameters used for the assessment of potential impacts on Marine Mammals and Megafauna.[1]

Potential impact	Phase[1]			Project design parameters	Justification
	C	O	D		
Injury and/or disturbance to marine megafauna from underwater noise during pile-driving	✓	✗	✗	• 26 monopiles (25 x WTGs and 1 x OSS) of 9.6 m diameter; • Absolute maximum hammer energy of 3,500 kJ. • On average, a maximum of 5 hours piling per pile across all WTG locations (no more than 8 hours at selected locations) with one pile expected to be installed in each 24-hour period. • Maximum days piling = 26 days.	The spatial extent of noise impacts is driven by key parameters including monopile diameter and hammer size, as well as associated hammer energy required to pile a monopile of this size (see appendix 10-2: Subsea Noise Technical Report). The minimum number of piles within a 24-hour period is likely to lead to the maximum period (number of piling days) over which piling could occur and the maximum within 24 hours would lead to the longest duration on any one day.
Injury and/or disturbance to marine megafauna from elevated underwater noise during site investigation surveys	✗	✓	✗	Routine geophysical surveys of wind turbine foundations, inter-array cables and offshore cable: • Multibeam echosounder (MBES) expected to be the only method of geophysical survey to be employed; • Survey campaigns estimated to occur once every five years for 40-year lifetime of Project; • Surveys to be conducted using one survey vessel; • Duration of 14 days per survey;	First survey campaign expected to occur in year 5, and final campaign in year 35, equating to seven survey campaigns. Assumes daily vessel trip for every day of each 14-day survey window.

[1] In the EIAR appendix 5-4: Marine Mammal Mitigation Plan, the table titled '*Project design parameters used for the assessment of potential impacts on Marine Mammals and Megafauna'* included all the potential impacts assessed in chapter 10: Marine Mammals and Megafauna. The MMMP is required to manage mitigation for activities that result in an increase in noise only. Therefore, only impacts associated with increases in noise require to be listed in the Project Design Parameters for this plan as outlined in Table 1-1 above.

Potential impact	Phase[1] C O D	Project design parameters	Justification
		• 42-day duration per survey campaign (three surveys per campaign); • 42 vessel round trips per survey campaign; and • Maximum total of 294 survey vessel round trips for lifetime of Project.	

1. C = Construction, O = Operation, D = Decommissioning

In addition to measures included in the Project (designed in and management measures (controls)) and mitigation proposed to reduce the injurious impacts on marine megafauna associated with pile-driving and geophysical surveying, a range of procedures will be applied to reduce other environmental impacts of the Project, including development and adherence to an Environmental Management Plan (EMP), which are summarised in Table 1-2.

Table 1-2: Management plans developed to reduce environmental impacts.

Consents Management Plan	Relevance to MMMP	Where presented
Environmental Management Plan (EMP)	The EMP provides the overarching framework for environmental management during the construction and operational and maintenance phases of the Project. The EMP also sets out the monitoring activities to be completed for the Project, as proposed in the EIAR, including proposed methodologies.	Appendix 5-2 (EIAR volume 2A & volume 2A Addendum)

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 and megafauna to negligible levels:

- National Parks and Wildlife Service (NPWS) (2014) Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters.
- National Marine Fisheries Service (NMFS) (2018) Revision to Technical Guidance for Assessing Effects of Anthropogenic Sound on Marine Mammal Hearing.

1.3 Target species

Marine mammals and megafauna species were characterised based on their abundance and densities at a regional scale (Regional Marine Megafauna Study Area) and local scale (Marine Megafauna Study Area), as detailed in EIAR (see volume 2B, chapter 10: Marine Mammals and Megafauna).

Boat-based visual surveys were conducted between March 2006 and August 2006, and between May 2018 and May 2020 (with the exception of February 2020 to April 2020 owing to COVID-19 restrictions), aerial digital surveys were carried out from April 2020 to September 2020, and Static Acoustic Monitoring (SAM) surveys were conducted between November 2019 and November 2020.

Marine mammals which were sighted regularly in site-specific surveys included minke whale *Balaenoptera acutorostrata* and grey seal *Halichoerus grypus*, and the most common cetacean species in the vicinity of the Project was harbour porpoise *Phocoena phocoena*. Common dolphin *Delphinus delphis* and harbour seal *Phoca vitulina* were sighted occasionally during site surveys, and whilst bottlenose dolphin *Tursiops truncatus* were not sighted during these surveys, a review of published datasets indicates that bottlenose dolphin may also be occasionally present in the area. Other marine mammal species may occur within the area in very low numbers (such as Risso's dolphin *Grampus griseus*, and although not identified as Important Ecological Features (IEF)s, would nonetheless also benefit from the measures set out in this MMMP.

Basking shark migrate through the Celtic Sea and Irish Sea during summer months, and during site-specific surveys, two basking sharks were sighted in the vicinity of the Project. Tagging studies have also shown that basking sharks have migrated through this area in previous years (Doherty *et al.,* 2017). Historical records show that three species of marine turtle are likely to regularly occur in Irish waters including leatherback (or 'leathery') turtle, loggerhead turtle *Caretta caretta* and Kemp's Ridley turtle *Lepidochelys kempii* (King and Berrow, 2009). Of these species, the leatherback turtle is distributed around the coast of Ireland, including the Irish Sea, and accounts for 80% of all sea turtle sightings (King and Berrow, 2009). Only leatherback turtle was identified as an IEF in the assessment, but as above, other species of turtle would benefit from this MMMP.

These species use sound for many aspects of their lives and are sensitive to underwater noise. Pile-driving during the construction phase and geophysical surveys during the operational and maintenance phases has the potential to result in elevated levels of subsea noise that are detectable by marine mammals and megafauna above background levels, which could result in injurious or behavioural effects. A detailed account of the marine mammal and megafauna baseline, and the effects of underwater noise on the marine megafauna species presented in this MMMP, can be found in volume 2B, chapter 10: Marine Mammals and Megafauna.

All of the marine mammal and megafauna species which could potentially be affected by the Project are protected by international legislation and/or are important from a conservation perspective at an international or national context (see volume 2B, chapter 10: Marine Mammals and Megafauna). Therefore, the value of marine megafauna IEFs was designated as either National or International (Table 1-3).

Table 1-3: Marine mammal and megafauna IEFs and their importance within the Marine Megafauna Study Area.

IEF	Value	Justification
Harbour porpoise	International	Annex II species protected under international legislation and designated feature of Rockabill to Dalkey Island SAC, North Channel SAC, North Anglesey Marine/Gogledd Môn Forol SAC and West Wales Marine/Gorllewin Cymru Forol SAC. Regularly sited within the Regional Marine Megafauna Study Area.
Bottlenose dolphin	International	Annex II species protected under international legislation and designated feature of Cardigan Bay/Bae Ceredigion SAC
Short-beaked common dolphin	National	Internationally protected species and Ireland Protected Species regularly sighted in the Regional Marine Megafauna Study Area.
Minke whale	National	Internationally protected species and Ireland Protected Species regularly sighted in the Regional Marine Megafauna Study Area.
Grey seal	International	Annex II species protected under international legislation and designated feature of Lambay Island SAC, Lleyn Peninsula and the Sarnau/Pen Llŷn a`r Sarnau SAC and Pembrokeshire Marine/Sir Benfro Forol SAC and is a qualifying feature of Cardigan Bay/Bae Ceredigion SAC. Regularly recorded in the Regional Marine Megafauna Study Area, with large haul-outs at Carlingford Lough, Clogherhead, the Skerries, Dublin Bay and Lambay Island.
Harbour seal	International	Annex II species protected under international legislation and designated feature of Lambay Island SAC and is a qualifying feature of Murlough SAC. Regularly recorded in the Regional Marine Megafauna Study Area, with large haul-outs at Carlingford Lough, Dundalk Bay, Clogherhead and the Skerries.
Basking shark	National	Internationally protected species/EPS listed on Ireland's Red List of Threatened Species (list No. 11) and UK BAP Species. Recorded migrating through Regional Marine Megafauna Study Area on an annual basis.
Leatherback turtle	National	Internationally protected species, listed on Ireland's Red List of Threatened Species (list No. 5) and UK BAP Species, reported regularly (largely stranded) in the Regional Marine Megafauna Study Area.

1.4 Measures included in the Project

A number of designed-in and management measures (controls) have been proposed as part of the project design process to reduce the potential for impacts on marine mammals and megafauna. These measures are considered standard industry practice for this type of development and, as there is a commitment to their implementation, are considered an inherent part of the design of the Project. Designed-in and management measures (in addition to this MMMP) have therefore been considered in the assessment of impacts presented in volume 2B, chapter 10: Marine Mammals and Megafauna and are summarised in Table 1-4.

The use of additional measures such as Acoustic Deterrent Devices (ADDs) will also be implemented and is further discussed in section 1.6, however these are mitigation measures and are not considered to be a measure included as part of the Project.

Table 1-4: Measures included in the Project, in addition to the MMMP.

Measures included in the Project	Justification
An Environmental Management Plan (EMP) (see volume 2A, appendix 5-2: Environmental Management Plan) will be implemented during the construction, operational and maintenance, and decommissioning phases of the Project. The EMP will include Project mitigation/monitoring measures and commitments and a Marine Pollution Contingency Plan (MPCP) which will include key emergency contact details (e.g. Environmental Protection Agency (EPA)). The EMP will include mitigation such as 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. In this manner, accidental release of contaminants from vessels will be strictly controlled, thus providing protection for marine life across all phases of the Project.	Measures will be included to ensure that the potential for release of pollutants from construction, operational and maintenance, and decommissioning plant is minimised.
During piling operations, soft starts will be used, following NPWS (2014) guidelines. This will involve the implementation of lower hammer energies (i.e. approximately 10-15% of the maximum hammer energy) at the beginning of the piling sequence before energy input is 'ramped up' (increased) over time to required higher levels (also known as a soft-start).	The soft-start will provide an audible cue to allow marine mammals and megafauna to flee the area before piling at increased hammer energy commences. The soft/slow-start will help to mitigate any potential auditory injury.
A Marine Megafauna Vessel Code of Conduct (see appendix 5-5: Marine Megafauna: Vessel Code of Conduct) will be issued to all Project vessel operators, requiring them to: • Not deliberately approach marine megafauna; • Keep vessel speed to a minimum; and • Avoid abrupt changes in course or speed should marine mammals approach the vessel to bow-ride. The Marine Megafauna Vessel Code of Conduct will be adhered to at all times.	To minimise the potential for collision risk, or potential injury to, marine megafauna.
Drive-drill-drive methodology for monopile installation. Use of MODIGA technology for impact piling.	Despite the assessment of injury and disturbance to marine megafauna from underwater noise during pile driving concluding no significant impact, the Project is committed to the consideration of noise abatement measures for the purpose of reducing sound levels from construction piling. The Project will use a drive-drill methodology for the monopile installation which minimises the impact piling duration (using sacrificial casing) and proposes to use a casing-option known as MODIGA as its noise abatement solution (see appendix 10-8: Comprehensive Review of Relevant Mitigation (Noise Abatement)). See chapter 10

Measures included in the Project	Justification
	Addendum: Marine mammals and megafauna for full details but it is expected that this will result in a noise abatement compared to an unmitigated piling scenario similar to the in-line hammer noise reduction unit (PULSE) technology. Further detail is provided in section 1.5.1 'Piling Technology'.

1.5 Summary of Impacts Requiring Mitigation

1.5.1 Pile-driving

Pile-driving during the construction phase of the Project has the potential to result in elevated levels of subsea noise that are detectable by marine mammals and megafauna above background levels and could result in injurious or behavioural effects on IEFs. A detailed revised underwater noise modelling assessment was carried out to investigate the potential for injurious and behavioural effects on marine mammal, fish and sea turtle IEFs as a result of impulsive sounds from pile-driving (appendix 10-4 Addendum: Updated Subsea Noise Modelling Report). The results of this modelling were drawn upon to provide a comparison with the original underwater noise modelling assessment and to inform the revised marine mammal and megafauna impact assessment (chapter 10 Addendum: Marine Mammals and Megafauna (EIAR volume 2B Addendum).

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 (i.e. reversible injury). Irish guidance recommends that TTS is included as a potential injury risk as this could impair the ability of animals to use natural sounds, with potential consequences to fitness (NPWS, 2014). In basking sharks and sea turtles, injury is assessed as 'mortality and mortal injury' (immediate or delayed death) or 'impairment' (recoverable injury). 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.

The most likely response of an animal exposed to noise levels that could induce TTS or impairment is, however, to flee the ensonified area and therefore NPWS (2014) suggests that TTS may also be a behavioural (disturbance) response. It is considered that disturbance can overlap with potential injury ranges, and therefore animals exposed to noise levels with the potential to induce TTS or impairment are likely to simply move away from the area.

Injury from PTS and reversible injury (and disturbance) from TTS were investigated with respect to two metrics over the entire piling sequence from hammer initiation to maximum hammer energy (3,500 kJ) based on one pile being installed within a 24-hour period (see project design parameters in Table 1-1). Peak Sound Pressure Level (SPL_{pk}) was used to determine ranges for instantaneous injury 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 (3,500 kJ) would be reached at all locations;
- Subsea noise would remain impulsive at all distances;
- 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 and conservative swim rate; and
- Time spent at the surface, where sound pressure levels are reduced, was not considered.

Where insufficient data existed to determine a quantitative guideline value (i.e. there are no thresholds for TTS in leatherback turtle), the risk was 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).

Instantaneous injury ranges (PTS based on the SPL_{pk} metric) were largest for harbour porpoise, with a range of up to 653 m predicted for the first strike following ramp up. At maximum hammer energy the predicted instantaneous PTS injury range is up to 1,638 m for harbour porpoise, however, at this final stage in the piling sequence animals will have moved away from the source and therefore the key focus for instantaneous injury is on the first strike. Modelling of TTS predicted effect ranges of up to 1,051 m (harbour porpoise). For all other species, including leatherback turtle and basking shark the PTS and TTS ranges from exposure to peak pressure were less than the ranges predicted for harbour porpoise.

A summary of PTS/TTS ranges for all IEFs is presented in Table 1-5. Assessment of permanent injury due to cumulative exposure over time (as an animals moves away) applied the SEL_{cum} metric and found that the largest PTS ranges were for minke whale, as a low frequency cetacean, with maximum predicted ranges of up 1,135 m. TTS ranges for all species (with exception of bottlenose dolphin) extended over several kilometres and up to a maximum 21,500 m for minke whale).

The ranges predicted for the SEL_{cum} metric should, however, be interpreted with caution (see bullet list summary above). The TTS threshold is inherently conservative as it represents the onset of a 6 dB hearing shift and has been derived on the basis of “the minimum amount of threshold shift that can be differentiated in most experimental conditions” (NMFS, 2018). Furthermore, the underwater sound model accounts for the SEL_{cum} metric as an equal-energy rule, where exposures of equal-energy are assumed to produce the same sound-induced threshold shift regardless of how the energy is distributed over time. Since for intermittent sound (such as piling) the quiet periods between sound exposures will allow some recovery of hearing compared to continuous sound, the equal-energy rule is likely to overestimate the extent of impact these ranges. Additionally, over ranges of tens of kilometres, such as the range predicted for minke whale, the impulsive sound is likely to undergo transition into non-impulsive sound at distance from the sound source due to a combination of factors (e.g. dispersion of the waveform, multiple reflections from sea surface and seafloor, and molecular absorption of high frequency energy). The empirical evidence suggests that such shifts in impulsivity could occur within 10km from the sound source (Hastie et al., 2019). For this reason, the instantaneous injury metric is considered to represent a more realistic interpretation of predicted injury ranges from the modelling although both were presented following the guidance (NPWS, 2014).

Table 1-5: Summary of marine mammal injury (PTS and TTS) onset acoustic thresholds (NMFS, 2018) and criteria for onset of injury to fish due to impulsive noise (Popper *et al.*, 2014) (N/E = threshold not exceeded). White rows indicate SPL_{pk}, grey rows indicate SEL_{cum}, and blank cells indicate scenarios which were not modelled.

Species	PTS (marine mammals) or Mortality and mortal injury (fish/sea turtles)			TTS (marine mammals) or TTS/Impairment (fish/sea turtles)		
	Threshold	Range (m)		Threshold	Range (m)	
		Soft Start - First Strike	Max Energy		Soft Start - First Strike	Max Energy
Harbour porpoise	202 dB re 1 µPa	653	1,638	196 dB re 1 µPa	1,051	2,638
	155 dB re 1 µPa²s	815	-	140 dB re 1 µPa²s	14,500	-
Bottlenose dolphin	230 dB re 1 µPa	71	177	224 dB re 1 µPa	114	286
	185 dB re 1 µPa²s	N/E	-	170 dB re 1 µPa²s	21	-
Common dolphin	230 dB re 1 µPa	71	177	224 dB re 1 µPa	114	286
	185 dB re 1 µPa²s	N/E	-	170 dB re 1 µPa²s	21	-
Minke whale	219 dB re 1 µPa	169	425	213 dB re 1 µPa	273	684
	183 dB re 1 µPa²s	1,135	-	168 dB re 1 µPa²s	21,500	-
Grey seal	218 dB re 1 µPa	183	460	212 dB re 1 µPa	295	741
	185 dB re 1 µPa²s	11	-	170 dB re 1 µPa²s	5,520	-
Harbour seal	218 dB re 1 µPa	183	179	212 dB re 1 µPa	295	741
	185 dB re 1 µPa²s	11	-	170 dB re 1 µPa²s	5,520	-
Basking shark	>213 dB re 1 µPa	273	684	>213 dB re 1 µPa	273	684
	>219 dB re 1 µPa²s	N/E	-	>186 dB re 1 µPa²s	5,520	-
Leatherback turtle	>207 dB re 1 µPa	172	357	(*Near*) High (*Intermediate*) Low (*Far*) Low		
	210 dB re 1 µPa²s	21	-			

Therefore, even considering the conservative assumptions of the subsea noise modelling that estimated highly precautionary injury ranges, across all species, the maximum range over which permanent injury could occur, using either metric, for most species, was predicted to be less than the standard 1,000 m mitigation zone for pile-driving proposed by NPWS (2014). The exception was for minke whale where the 1,135 m maximum predicted range (SEL_{cum}) slightly exceeded this standard mitigation zone. For TTS, instantaneous (temporary) injury ranges also fell within the 1,000 m mitigation, with the exception of harbour porpoise, where the predicted range at first strike was 1,051 m. TTS from cumulative exposure exceeded the standard 1,000 m mitigation zone for some species (harbour porpoise, minke whale, grey seal and harbour seal) but not in others (bottlenose dolphin, common dolphin, basking shark and leatherback turtle).

Mitigation measures will be applied by use of an ADD to reduce the potential for PTS and TTS, (see Section 1.6). There are a number of ADDs on the market with different sound source characteristics (see McGarry *et al.*, 2022) and a suitable device will be selected based on the key species requiring mitigation for the Project. The selected device will typically be deployed from the piling vessel and activated for a pre-determined duration to allow animals sufficient time to move away from the sound source, whilst also minimising the additional noise introduced into the marine environment.

Revised noise modelling was carried out for the SEL_{cum} metric to determine the potential efficacy of using an ADD to deter marine mammals from the injury zone (see appendix 10-7 Addendum: Noise Abatement System - Technical Report - Marine Mammals, Megafauna and Fish). The modelled scenario included the activation of an ADD for a period of 15 minutes prior to initiation of piling and was compared to the scenario with measures included in the Project only (i.e. initiation + soft start + ramp up) to determine whether deployment of an ADD was of potential benefit to reducing the risk of injury to marine mammals. There is no evidence for the effectiveness of ADDs as a tool to deter basking shark and sea turtle and therefore this was not considered in the modelling for these species.

Results of modelling the use of an ADD suggest that the risk of injury occurring in marine mammal receptors would be reduced. For example, based on the SEL_{cum} metric, ADD use would avoid thresholds for PTS being exceeded in all species as animals are expected to flee beyond the injury zones prior to the start of piling. In particular, minke whale, for which modelled SEL_{cum} injury ranges were greatest (Table 1-5) have been shown to make directed movements and increase their net swim speed at distances of greater than 1,000 m (which coincides with the mitigation zone for pile-driving proposed by NPWS) from an ADD (Boisseau *et al.*, 2021).

The use of an ADD will also reduce the risk of TTS occurring in marine mammals. With an ADD deployed the range at which the SEL_{cum} threshold for TTS would be reduced to 19,500 m for minke whale; 13,000 m for harbour porpoise; 3,890 m for grey seal and harbour seal and for high-frequency cetaceans (bottlenose dolphin and common dolphin) the TTS thresholds would not be exceeded (Table 1-6). Note that the ranges using an ADD were not modelled for basking shark and leatherback turtle, however, it is anticipated that risk of TTS would be reduced in all megafauna species. Although the SEL_{cum} effect ranges are likely to be overestimates, the subsea noise modelling illustrated that the use of an ADD can, nonetheless, reduce the risk of temporary auditory impairment. Furthermore, this assessment was based upon a standard percussive piling sequence, whereas the Oriel Project has now determined that a drive-drill approach using MODIGA technology will be adopted. Further information on this approach is provided below in the section on 'Piling Technology'.

Table 1-6 Changes in range of injury (PTS) and disturbance (TTS) from unmitigated piling (including designed-in and management measures) and mitigated piling (including use of ADD).

Species	Threshold (Weighted) SEL_{cum}	Measures	Range (m)
Harbour porpoise	PTS – 155 dB re 1 μPa^2s	Soft start	815
	TTS - 140 dB re 1 μPa^2s		14,500
	PTS - 155 dB re 1 μPa^2s	Soft start + ADD	N/E
	TTS - 140 dB re 1 μPa^2s		13,000
Bottlenose dolphin	PTS - 185 dB re 1 μPa^2s	Soft start	*N/E*
	TTS - 170 dB re 1 μPa^2s		21
	PTS - 185 dB re 1 μPa^2s	Soft start + ADD	*N/E*
	TTS - 170 dB re 1 μPa^2s		*N/E*
Common dolphin	PTS - 185 dB re 1 μPa^2s	Soft start	*N/E*
	TTS - 170 dB re 1 μPa^2s		21
	PTS - 185 dB re 1 μPa^2s	Soft start + ADD	*N/E*
	TTS - 170 dB re 1 μPa^2s		*N/E*
Minke whale	PTS - 183 dB re 1 μPa^2s	Soft start	1,135
	TTS - 168 dB re 1 μPa^2s		21,500
	PTS - 183 dB re 1 μPa^2s	Soft start + ADD	*N/E*
	TTS - 168 dB re 1 μPa^2s		19,500
Grey seal	PTS - 185 dB re 1 μPa^2s	Soft start	11
	TTS - 170 dB re 1 μPa^2s		5,520
	PTS - 185 dB re 1 μPa^2s	Soft start + ADD	*N/E*
	TTS - 170 dB re 1 μPa^2s		*3,890*
Harbour seal	PTS - 185 dB re 1 μPa^2s	Soft start	11
	TTS - 170 dB re 1 μPa^2s		5,520
	PTS - 185 dB re 1 μPa^2s	Soft start + ADD	*N/E*
	TTS - 170 dB re 1 μPa^2s		*3,890*

It is highlighted that, whilst ADDs deployed for such short durations are unlikely to lead to injury, there may be some trade-off with an increase in disturbance during the period of activation. Depending on the device employed, ADDs may elicit a strong behavioural response and lead to displacement over ranges exceeding

a kilometre or more, and potentially lasting slightly beyond the point at which the ADD has been deactivated. Whilst this is useful for reducing the risk of injury to marine mammals there needs to be a balance to ensure that ADDs do not lead to significant additional disturbance themselves. This can be achieved by optimising both ADD source signals and deployment schedules (Thompson *et al.*, 2020). Since the effect of ADDs on marine mammals is likely to be a short-term disturbance response over a relatively localised area (within a maximum of few kilometres) and animals are likely to quickly recover to baseline levels (within a few hours) the additional risk of disturbance, in the context of the whole piling sequence, is likely to be negligible.

Piling Technology

As mentioned in section 5.5.5 of chapter 5 Addendum: Project Description (EIAR volume 2A Addendum) adoption of the MODIGA technology will provide a designed in measure to reduce the risk of injury to marine mammals and other megafauna by attenuating sound levels.

MODIGA, which is a type of casing technology with an internal air bubble ring, will act as a Noise Abatement System (NAS) by creating a 'barrier' to reduce the sound propagated through the water column. A full review of all noise reduction technology has been provided in appendix 10.8: Comprehensive Review of Relevant Mitigation (Noise Abatement).

The system manufacturer states that the MODIGA - fitted with an internal air bubble ring- can provide underwater noise reduction during piling. The MODIGA will be placed on the seabed into which the sacrificial casing will be lowered. A hammer pile will then be inserted into the MODIGA and the sacrificial casing hammer piled through the unconsolidated sediments before inserting the monopile (see Figure 1-2 and Figure 1-3). The air bubble ring within the MODIGA will actively attenuate noise. It has been demonstrated that air-filled casings can offer a highly effective noise mitigation strategy for marine mammal and fish receptors, reducing received SEL and peak SPL sound levels by several decibels (precise reduction being dependent upon specific configurations (see section 1.3.2 in appendix 10-8). The proposed MODIGA with internal air bubble ring will lower sound transmission due to the acoustic impedance of air by reducing the proportion of vibrational energy from the pile transmitted through the air layer into the surrounding water. It was not possible to model the precise level of reduction of noise levels at this stage as this system will be bespoke to the Project, however, a noise modelling study was undertaken for a range of NAS options to demonstrate the efficacy of applying commercially available NAS technology during piling at the Project (appendix 10-6: NAS Modelling Report). The level of noise abatement resulting from the air bubble ring inside the MODIGA casing will be modelled during the detailed design of the MODIGA system. Conservatively, it is expected that this will result in a noise abatement similar to the in-line hammer noise reduction unit (PULSE) technology.

Whilst the MODIGA with an internal air bubble ring, was used at two offshore wind farms in the Bay of Biscay in France (see appendix 5-11: Supporting Information Demonstrating the Applicant's Experience on Other Offshore Wind Farm Projects (EIAR volume 2A), there was no data available to demonstrate the noise reductions at these projects. For the existing commercially available systems that were modelled for the Project, the results demonstrated a reduction in SEL_{cum} and SPL_{pk} in effect ranges for marine mammal and fish receptors (appendix 10-6: NAS Modelling Report). NAS modelled included: big bubble curtains (BBC), Double big bubble curtains (DBBC) and the in-line hammer PULSE (Piling Under Limited Stress Equivalent) technology. Therefore, taking the theoretical considerations into account and the manufacturer's technical statement, the Project is confident that the MODIGA technology will also provide suitable mitigation for piling.

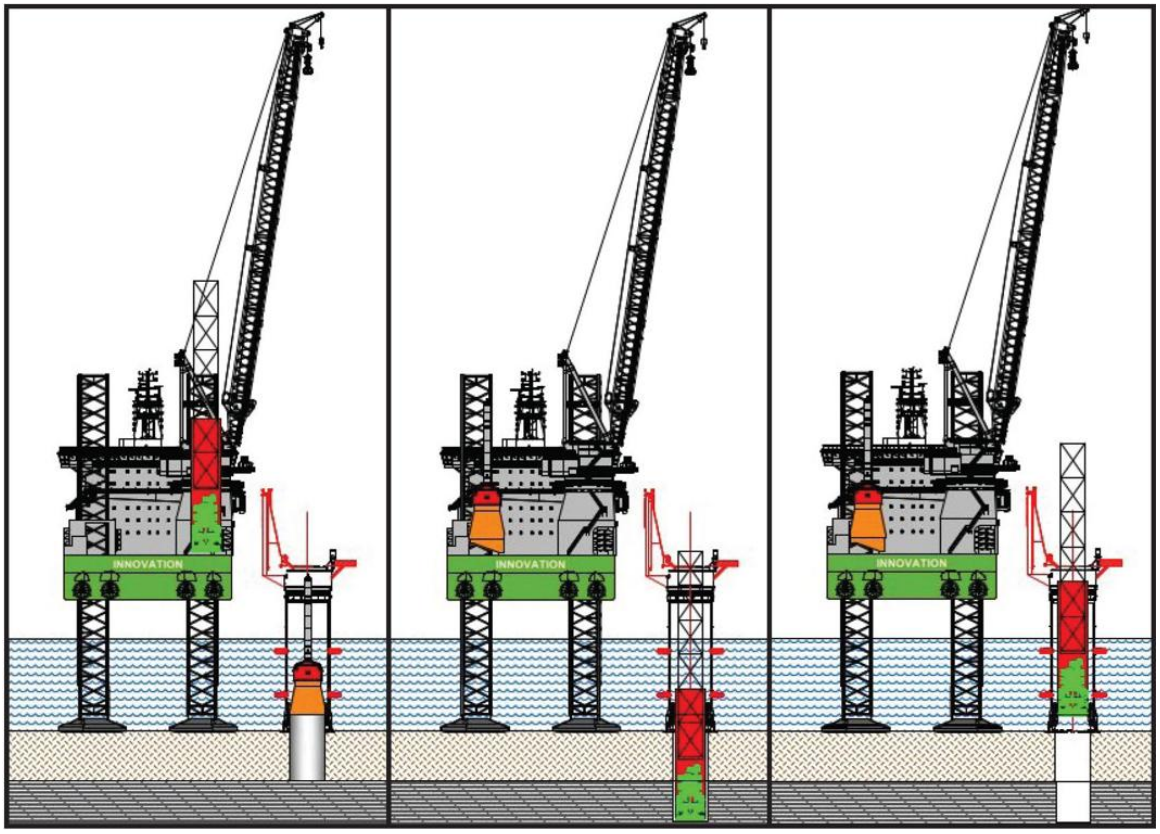

Figure 1-2: Installation of foundations (steps 1-3): 1. Placement of MODIGA and piling of sacrificial casing; 2. Drdrilling of rock to embedment depth; 3. Removal of drill

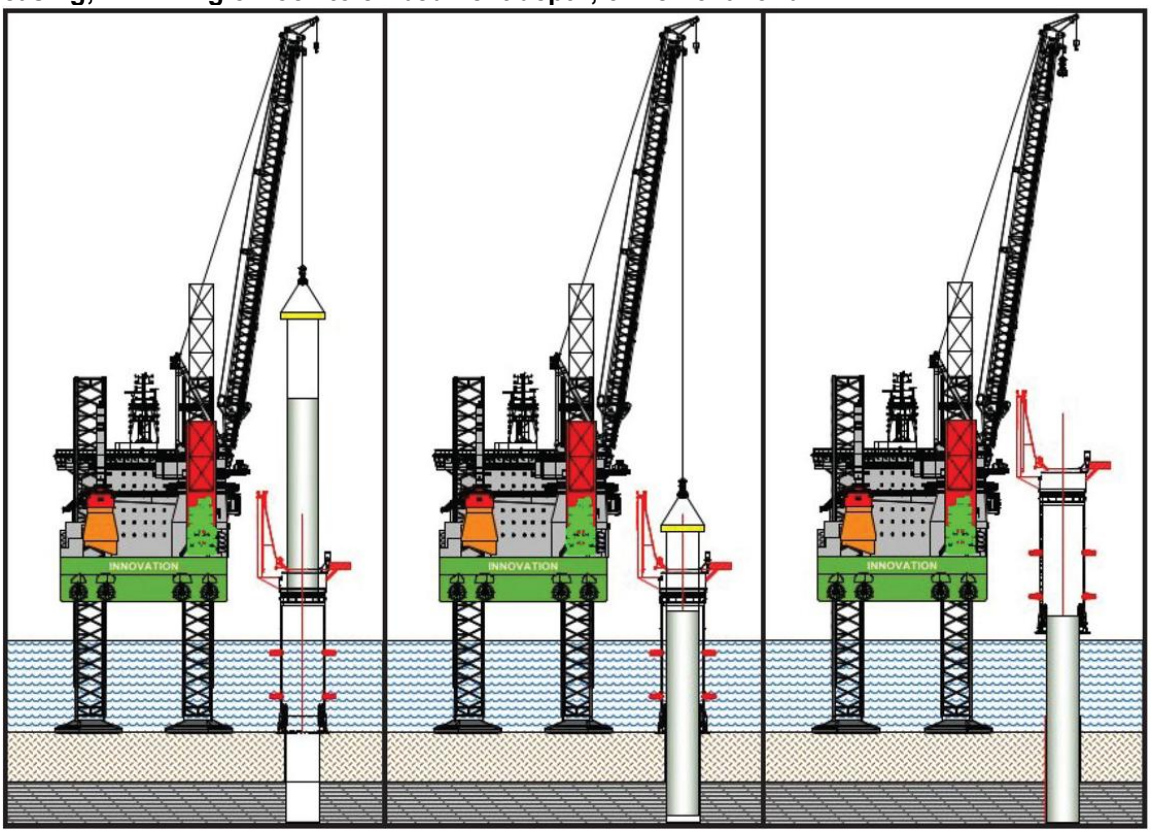

Figure 1-3: Installation of foundations (steps 4-6): 4. Insertion of monopile; 5. Grouting of monopile, 6. Removal of MODIGA.

To demonstrate efficacy of current NAS options, (and in the absence of empirical measurements for the MODIGA with internal air bubble), PTS and TTS during impact piling of monopiles was modelled for scenarios with and without other NAS technology (see appendix 10-6: NAS Modelling Report for full details) with the outputs of ecological noise modelling interpretation on marine mammals (and fish) presented in 10-7 Addendum - NAS Comparison Technical Note - Marine Mammals, Megafauna and Fish. Two mitigation methods were considered against the unmitigated base scenario: PULSE and DBBC (see Table 1-7).

Table 1-7 Summary of modelling scenarios: all modelled at the east of the offshore wind farm area.

Scenario	Description
Unmitigated	Unmitigated scenario of piling of monopile.
PULSE	Mitigated piling with use of in-line hammer noise reduction unit (PULSE) (i.e. using hydraulic pistons positioned between hammer and sleeve, filled with liquid dampening the sound).
DBBC	Mitigated piling with use of DBBC (i.e. compressed air pumped through nozzle hoses laid on the seafloor which builds two large circular curtains of bubbles).

Results of the modelling are presented in Table 1-8 to Table 1-10. Overall modelling for impact piling of monopiles with NAS scenarios results in reduced impact ranges based on instantaneous injury and cumulative exposure. Furthermore, the application of just 15 minutes of ADD resulted in a reduction such that the PTS ranges were not exceeded in any species, and the TTS ranges were considerably reduced across all species, suggesting that different types of NAS can offer suitable mitigation for both permanent and temporary injury (Table 1-9).

Table 1-8 Potential auditory injury (PTS) and TTS ranges for marine mammals from installation of a single pile based on SEL_{cum} metric, without ADD.

Species	Threshold, SEL_{cum} (dB re 1 μPa^2s)	Range (m)		
		Unmitigated	PULSE	DBBC
Minke whale	PTS – 183 dB re 1 μPa^2s	1,135	635	98
	TTS – 168 dB re 1 μPa^2s	21,500	16,500	1,145
Bottlenose dolphin Common dolphin	PTS – 185 dB re 1 μPa^2s	N/E	N/E	N/E
	TTS – 170 dB re 1 μPa^2s	21	19	<curtain
Harbour porpoise	PTS – 155 dB re 1 μPa^2s	815	454	280
	TTS – 140 dB re 1 μPa^2s	14,500	7,720	2,050
Harbour seal Grey seal	PTS – 185 dB re 1 μPa^2s	11	N/E	<curtain
	TTS – 170 dB re 1 μPa^2s	5,520	2,470	<curtain

N/E = threshold not exceeded, < curtain = injury range contained within DBBC.

Table 1-9 Potential auditory injury (PTS) ranges for marine mammals from installation of a single pile based on the SEL_{cum} metric, with 15 minutes ADD.

Species	Threshold, SEL (dB re 1 μPa^2s)	Range (m)		
		Unmitigated	PULSE	DBBC
Minke whale	PTS – 183 dB re 1 μPa^2s	N/E	N/E	N/E
	TTS – 168 dB re 1 μPa^2s	19,500	15,000	<curtain
Bottlenose dolphin Common dolphin	PTS – 185 dB re 1 μPa^2s	N/E	N/E	N/E
	TTS – 170 dB re 1 μPa^2s	N/E	N/E	N/E
Harbour porpoise	PTS – 155 dB re 1 μPa^2s	N/E	N/E	N/E

Species	Threshold, SEL (dB re 1 μPa^{2}s)	Range (m)		
		Unmitigated	PULSE	DBBC
Harbour seal Grey seal	TTS – 140 dB re 1 μPa^{2}s	13,000	6,280	725
	PTS – 185 dB re 1 μPa^{2}s	N/E	N/E	N/E
	TTS – 170 dB re 1 μPa^{2}s	3,890	910	<curtain

N/E = threshold not exceeded, < curtain = injury range contained within DBBC.

Table 1-10 Potential auditory injury (PTS) and TTS ranges for marine mammals from installation of a single pile based on the SPL_{pk} metric, for the first hammer strike and highest energy hammer strike.

Species	Threshold, Lp,0-pk, dB re 1 μPa	Range (m)					
		Unmitigated		PULSE		DBBC	
		First Strike	Max Energy	First Strike	Max Energy	First Strike	Max Energy
Minke whale	PTS – 219 dB re 1 μPa (pk)	169	425	144	285	< curtain	147
	TTS – 213 dB re 1 μPa (pk)	273	684	241	424	106	208
Bottlenose dolphin	PTS – 230 dB re 1 μPa (pk)	71	177	56	120	< curtain	77
Common dolphin	TTS – 224 dB re 1 μPa (pk)	114	286	93	180	< curtain	110
Harbour porpoise	PTS – 202 dB re 1 μPa (pk)	653	1,638	624	804	201	395
	TTS – 196 dB re 1 μPa (pk)	1,051	2,638	1,048	1,178	285	559
Harbour seal Grey seal	PTS – 218 dB re 1 μPa (pk)	183	460	157	307	< curtain	156
	TTS – 212 dB re 1 μPa (pk)	295	741	263	454	112	221

< curtain = injury range contained within DBBC.

1.5.2 Geophysical acoustic surveys

Site investigation surveys to facilitate the inspection of offshore infrastructure foundations, inter-array cables and offshore cable during the operational and maintenance phase of the Project have the potential to cause direct or indirect effects (including injury or disturbance) on marine megafauna IEFs. An underwater noise modelling assessment was carried out to investigate the potential for injurious and behavioural effects as a result of geophysical surveys using the latest criteria (volume 2B, appendix 10-2: Subsea Noise Technical Report), which is drawn upon in the information below.

Underwater noise modelling for geophysical surveys has been undertaken based upon the likely parameters of the equipment expected to be employed. The Kongsberg EM710 MBES unit has been modelled operating at 105 kHz, 231 dB re: 1μPa @ 1 m (rms) (see Table 1-11 below), although this equipment can typically work at a range of signal frequencies, depending on the distance to the seabed and the required resolution. In response to RFI 9.J, Ultra-short Baseline (USBL) positioning systems has been included for the assessment of PTS and TTS.

For sonar-like sources 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 comprise a single (or multiple discrete) frequency as opposed to a broadband signal with high kurtosis, high peak pressures and rapid rise times (see volume 2B, appendix 10-2: Subsea Noise Technical Report, wherein a full description of the source sound levels for geophysical survey activities is provided).

Table 1-11: Typical Sonar-based survey equipment parameters used in assessment.

Survey Type	Unit	Frequency (kHz)	Source Level (dB re 1 µPa (rms))	Pulse Rate (s^{-1})	Pulse Width (ms)	Beam Width (degrees)	Swathe Beam Width (degrees)
MBES	Kongsberg EM710	105	231	30	0.2	2	140
USBL	-	14	200	3	100	80	-

Noise modelling was undertaken only for MBES and USBL surveying methods and did not consider non-impulsive sources to be a key potential impact for basking shark and sea turtles. These species were subsequently screened out, and the focus of the assessment was on marine mammal species only. As for the impact of pile-driving, the potential effect upon marine mammals was either auditory injury (PTS or TTS) or behavioural disturbance.

Potential impacts of site investigation surveys depend on the characteristic of the sound source, survey design, frequency bands and water depth. Sonar-based sources have very strong directivity which effectively means that there is only potential for injury when a marine mammal is directly underneath the sound source. Once the animal moves outside of the main beam, there is no potential for injury.

Based on underwater noise modelling presented in volume 2B, appendix 10-2: Subsea Noise Technical Report (for MBES) and appendix 10-6: NAS Modelling Report (for USBL) PTS has the potential to occur out to a maximum of 227 m for harbour porpoise (Table 1-12 and), up to 124 m for dolphin species and up to 12 m for minke whale. and in pinniped species the maximum range for PTS to occur is out to 34 m from the sound source. TTS has the potential to occur out to a maximum of 449 m in harbour porpoise, 1,284 m for dolphin species, and up to 107 m for minke whale. In pinniped species this range is predicted out to 123 m from the sound source.

Table 1-12: PTS and TTS onset thresholds and potential impact ranges for marine mammal species during non-impulsive MBES geophysical site investigation surveys, based on comparison to Southall *et al*. (2019) SEL thresholds.

Species	Hearing group (NMFS, 2018)	Injury type	SEL threshold (dB re 1 μPa^2s)	Impact range (m)
Minke whale	LF	PTS	199	12
		TTS	179	107
Bottlenose dolphin	MF	PTS	198	124
		TTS	178	172
White-beaked common dolphin	MF	PTS	198	124
		TTS	178	172
Harbour porpoise	HF	PTS	173	227
		TTS	153	449
Harbour seal	PCW	PTS	201	34
		TTS	181	123
Grey seal	PCW	PTS	201	34
		TTS	181	123

Table 1-13: Potential impact ranges (m) for marine mammals during USBL, based on the non-impulsive SEL thresholds from Southall *et al.* (2019) (N/E refers to a threshold not exceeded).

Survey type	Effect	Hearing group impact range, m			
		LF	HF	VHF	PCW
USBL	PTS	N/E	N/E	53	N/E
	TTS	18	31	1,284	20

The number of marine mammals with the potential to be injured within the modelled ranges for PTS and TTS presented in Table 1-13 for USBL and was estimated using the most up to date species-specific density estimates. Due to low predicted injury ranges, for all marine mammal species, it is predicted that no more than one animal has the potential to experience PTS or TTS as a result of geophysical site investigation surveys.

Mitigation for injury during geophysical site investigation surveys from a conventional vessel will involve the use of MMOs and PAM to ensure that the risk of injury over the defined mitigation zone is reduced in line with NPWS guidance (NPWS, 2014). A soft start will also be implemented where this is within technical capabilities of the survey equipment.

1.6 Mitigation methods and procedures

The mitigation measures presented below include designed-in and management measures (measures included in the Project) and mitigation measures to reduce the risk of injury to marine mammals as described in volume 2B, chapter 10: Marine Mammals and Megafauna.

1.6.1 Pile-driving

As per the NPWS (2014) guidance, a 30-minute constant effort pre-piling search will be undertaken by at least two accredited and experienced marine mammal observers (MMO) using binoculars and a range finding stick as required and a Passive Acoustic Monitoring (PAM) operator to monitor the specified 1,000 m radial mitigation zone in order to minimise the likelihood of marine mammals being present within this range.

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. The ADD will be activated for a minimum period of 15 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.

Pile driving activities will only commence in daylight hours where effective visual monitoring, as performed and determined by the MMO, has been achieved. Where effective visual monitoring, as determined by the MMO, is not possible (including in circumstances in which poor visibility prevents the 1,000 m mitigation zone from being visually monitored) the sound-producing activities will be postponed until effective visual monitoring is possible.

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 (525 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 or megafauna to move away from the noise source, thereby reducing the risk of exposing animals to noise levels which can cause injury.

The initiation and soft start stages allow for alignment piles and for marine megafauna to leave the area and involve a hammer energy of 525 kJ. The ramp up stage is a progressive increase in hammer energy following the soft start and involves an initial hammer energy of 525 kJ which builds 2,500 kJ over the 9-minute period. The maximum hammer energy proposed for the Project is 3,500 kJ. However, the actual

energy used when piling will be significantly lower for the majority of the time and the driving energy will be raised to 3,500 kJ only when absolutely necessary. A summary of the piling stages and associated strike energies is presented in Table 1-14.

Table 1-14: Piling scenario for monopile installation using a maximum hammer energy of 3,500 kJ.

Stage	Energy (kJ)	SEL per strike (dB re 1 μPa^2s)	SPL_{pk} (dB re 1 µPa)	Duration (mins)	Strike rate (strikes per minute)	Number of strikes
Initiation	525	205	246	1	6	6
Soft start	525	205	246	20	30	600
Ramp up	525 to 2,500	205 - 212	246 - 255	9	30	270
Standard operation	2,500	212	255	150	30	4500
Full power	3,500	213	258	120	30	3600
Total	**-**	**-**	**-**	**300**	**-**	**8,976**

These above activities were included in subsea noise modelling (with the inclusion of an ADD for 15 minutes prior to commencement of any piling activity) in volume 2B, appendix 10-2: Subsea Noise Technical Report and Appendix 10-4 Addendum: Updated Subsea Noise Modelling Report. The ADD itself was assumed to not contribute towards any injury to marine megafauna.

If marine megafauna are detected within the mitigation zone during the pre-piling search of soft-start, piling will not commence or at least the hammer energy should not be further increased until at least 30 minutes after the last visual or acoustic detection of the animal. The MMOs and PAM operative will track any marine megafauna detected and ensure that they have left the mitigation zone before piling commences or the soft start continues. Once the ramp up procedure commences there is no requirement to halt or discontinue the pile-driving if marine mammals are detected within the mitigation zone. Likewise, if marine megafauna are detected in the mitigation zone during piling at full power, there will be no requirement to cease piling. It may also not be possible to stop piling at full power due to engineering restrictions. Figure 1-4 illustrates the sequence of events and lines of communication required to implement the MMMP.

If for any reason there is a break in piling activity for greater than 10 minutes, then the pre-piling search and ADD activation, and a full soft start and ramp up procedure should be repeated before piling recommences.

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 megafauna is considered to be of **imperceptible or slight significance**, which is not significant in EIA terms.

Application of ADDs

The type of Acoustic Deterrent Device (ADD) and device specifications will need to be considered carefully when selecting the final ADD to be used for the Project. The choice of ADD to be used for the Project will include consideration of the optimal acoustic characteristics required to provide protection against injury, balanced against minimising disturbance range, and will be appropriate to the species and risk, in line with the latest available guidance.

Recent ADD guidance from JNCC (Phillips *et al.,* 2025) (updating McGarry *et al.* (2022)) reviews the evidence on the effectiveness of acoustic devices at deterring different marine mammal species, summarising the acoustic characterisation of devices and provides details of impact ranges per species from a broad literature review/technical details provided by manufacturers, which will be a useful tool for supporting the decision-making process.

While careful consideration of active ADD deployment is necessary when designing mitigation strategies to prevent potential habituation or voluntary risk behaviour, there is substantial evidence to demonstrate that ADDs are effective at deterring animals from potential injury zones, and that animals often return to the area

after ADD operation (Voss et al., 2023). Phillips *et al*. (2025) demonstrated there is a wide range of ADDs available with deterrence evidence backed by peer-reviewed studies for different species. For example for harbour porpoise, ADDs with high evidence scores (assessment of confidence in the evidence for an ADD's effectiveness) include the Lofitech seal scarer, SaveWave: SealSalmon Saver, Ace Aquatec: Midfrequency Acoustic Startle Response Device, Ace Aquatec Fauna Guard: Porpoise Module, Gael Force: SeaGuard seal deterrent and Future Oceans: 60 kHz – 120 kHz Netguard Dolphin Pinger (Phillips *et al*., 2025). The primary target species for ADD selection will be harbour porpoise, and therefore it is considered that there are commercially available ADDs that would represent an appropriate ADD for deterring harbour porpoise from the auditory injury zone (i.e. any one of the ADDs listed above).

In finalising the details of this MMMP, the most appropriate device, target species to deter, alongside factors such as the number of ADD's required to cover the risk zone (considering the geographic extent of ensonification) or whether one ADD is sufficient to target multiple species/hearing groups if desired (i.e. if a single device has the capability to deter all the necessary species/hearing groups from the risk zone or whether multiple devices that target different hearing groups are required).

These details will be finalised post-consent, as part of the procurement process based upon the final project design, prior to construction and will be detailed in the final MMMP. The mitigation protocol will align with up to date guidelines and in consultation with appropriate experts and relevant stakeholders. ADD use will be considered carefully, and on a case-by-case basis. ADD will be used as part of a wider suite of mitigation measures as detailed in this MMMP (including soft starts, Marine Mammal Observers (MMO) / Passive Acoustic Monitoring (PAM)).

Any implementation of ADDs (as set out in this MMMP) will align with Recommendation 18 of the Irish Whale and Dolphin Group (IWDG) Policy on Offshore Windfarm Development; specifically, ADDs will be used to reduce the threat of auditory injury from pile driving (where they are known to be effective for the species present). ADD use will not exceed the noise levels of the mitigated activity set out in the MMMP and would be only used prior to commencing those activities.

Marine Mammal Observer

During daylight hours at least two dedicated and qualified Marine Mammal Observer (MMO) will conduct a visual search of the mitigation zone and conduct the pre-start searches from a vessel prior to the start of the piling (see section 1.6 for details). Visual monitoring for marine mammals will be conducted from a suitable platform on the vessel such as the ship's bridge, that allows 360-degree visualisation, and full coverage of the mitigation zone. MMOs must concentrate their efforts on the measures to be taken in advance of and during commencement, breaks in and resumption of the sound-producing activity (NPWS, 2014).

The MMO will be equipped with reticule binoculars and Marine Mammal Reporting forms (NPWS, 2014) 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 MMO 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 or megafauna in the mitigation zone and any subsequent delay required to the commencement of piling to be communicated quickly and effectively between all parties. The MMO will be responsible for recording all marine mammal sightings in the appropriate format, along with other environmental data. Together with the PAM Operator, the MMO will be responsible for compiling all the data on marine mammal observations and mitigation activities for reporting to NPWS.

The MMO must be experienced and familiar with the Irish regulatory procedures pertaining to managing risk to marine mammals from underwater sound and must be provided with full details of all licence/consent conditions relevant to the performance of their role in advance of activity commencement, to ensure compliance. The MMO will have the necessary authority (or support by Works Superintendent) to implement the plan and stop works if necessary. The use of distance estimation formula will follow the same approach suggested for distance estimation by the Joint Nature Conservation Committee (JNCC) (JNCC, 2017) (as discussed in Marine Mammal Observer Association (MMOA) (2024)) and will use standard trigonometric equations for calculation.

PAM Operator

PAM will be undertaken during pre-start, ramp-up and pilling activities. A vertical PAM system will be used, as opposed to a towed system as the vessels are likely to use dynamic positioning rather than transiting during the pre-start monitoring phase.

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 PAM 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).

PAM Operators will be based on the vessel together with the MMO. PAM Operators will be responsible for recording all acoustic marine mammal detections in the appropriate format, and together with the MMO, will be responsible for compiling all the data on marine mammal observations and mitigation activities for reporting to NPWS. The PAM operator should also be equipped with a two-way radio to ensure communication with both the vessel crew and the lead MMO. This is to allow any visual or acoustic detections of marine mammals or megafauna in the mitigation zone and any subsequent delay required to the commencement of piling to be communicated quickly and effectively between all parties.

PAM Operators must be experienced and 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 commencement. PAM Operators will have the necessary authority (or support by Works Superintendent) to implement the plan and stop works if necessary.

ADD Operator

A trained and dedicated ADD operator will be responsible for ADD maintenance, operation and reporting. 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.

The ADD Operator will also record and report to the Works Superintendent/MMO/PAM on all ADD and piling activity so the details of any ADD used (see section 1.6), and any relevant observations on their efficacy can be reported as a part of the Operational/Marine Mammal Observer/Passive Acoustic Monitoring Report (see section 1.8).

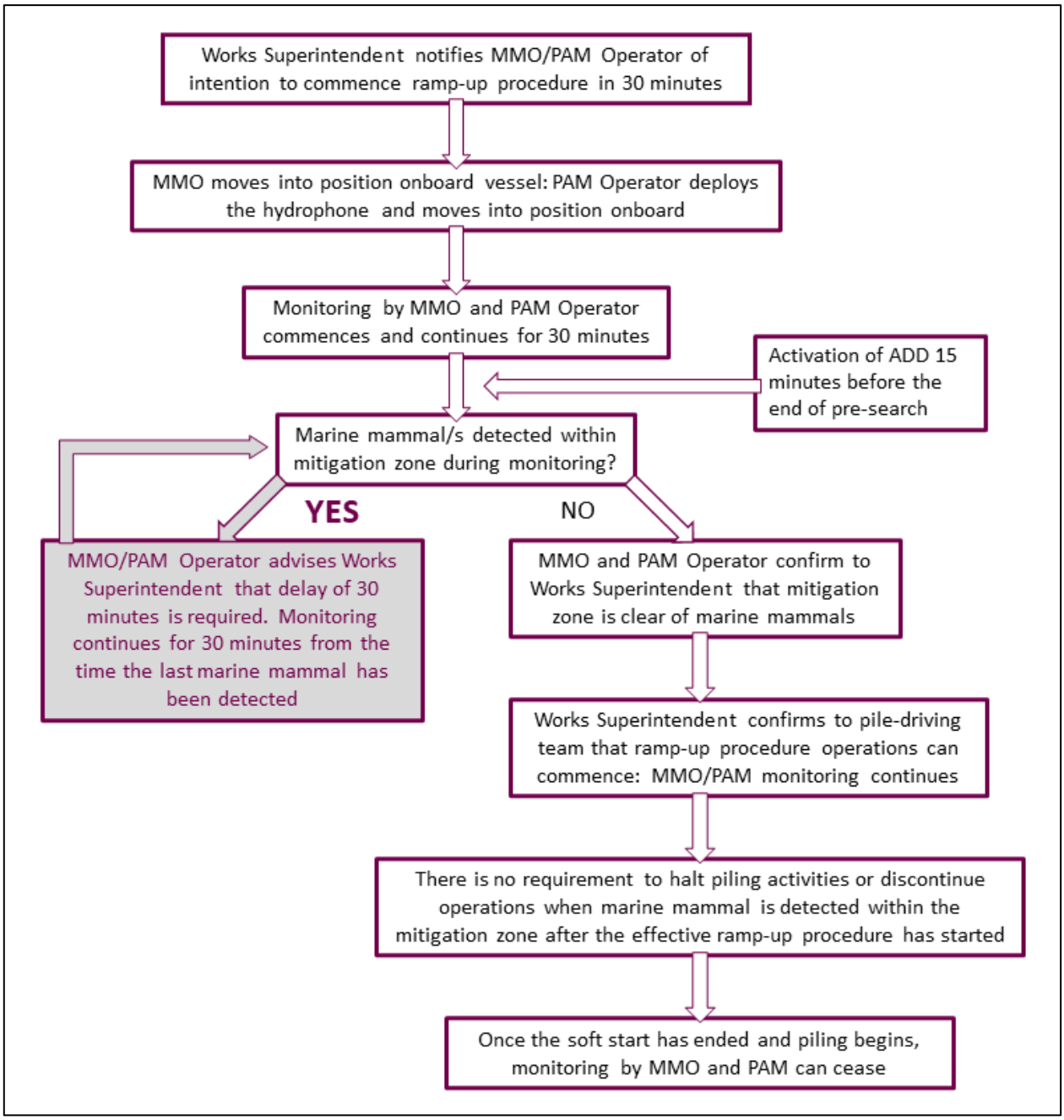

Figure 1-4: Task and communication plan for piling procedures start-up.

1.6.2 Field records during pile-driving

Operations report

As per NPWS guidelines (2014) the Operations report will be provided to NPWS on completion of pile-driving activities as outlined below and must include use of the standard data forms provided in NPWS (2014):

- Details of the Client/Contractor involved in the plan/project;
- Details of the Platform/Vessel type(s) participating in the plan/project;
- Survey reference number supplied by the Regulatory Authority or other statutory body;

- Date and location of the plan/project;
- Latitudes, longitudes or grid references for the area of operations;
- Specifications and acoustic characteristics of all sound-producing equipment used;
- A daily log of how and when the sound-producing equipment was used; and
- Information on any technical problems encountered during pre-start-up procedures or during full scale operation/activity.

Marine Mammal Observer/PAM Report

The Marine Mammal Observer/Passive Acoustic Monitoring Report will include:

- An Executive Summary: a concise text at the beginning of the report highlighting the MMO/PAM work undertaken and summarising in turn:
  - All marine mammal detections made during the piling;
  - All detections made prior to the commencement of the piling activity (pre-search and ramp-up procedures);
  - All operational responses to the presence of animals in the area and the associated outcomes;
  - All occurrences of night-time operation/activity, continuation into poor weather and stoppages;
  - Any and all problems arising during implementation of the prescribed mitigation;
  - Any recommendations based on the project and any marine mammal sightings/behaviour encountered during the piling operations which could benefit future projects; and
  - A concluding statement regarding the operational efficacy of the mitigation measures performed.
- Date and location(s) of the plan/project;
- Name, address and qualifications of the MMO, PAM and ADD operators on the Platform/Vessel;
- Name of any other Platform/Vessel involved in the operation/activity;
- Latitudes, Longitudes or Grid references for the area(s) of operations monitored by the MMO;
- Details of the observation platform used for marine mammal monitoring, including its height above sea level;
- Details of all sound-producing operations/activities undertaken during the period of survey;
- Details of monitoring watches conducted for marine mammals;
- Details of all marine mammal sightings recorded during monitoring watches;
- Details of all marine mammal sightings recorded outside monitoring watches (e.g. incidental observations), including records from additional personnel on board;
- Details of any problems encountered during marine mammal monitoring, start-up procedures or during full scale operation/activity; and
- Details of any instances of non-compliance with NPWS guidelines.

1.6.3 Geophysical acoustic surveys

As per the NPWS (2014) guidance, a constant effort pre-survey search will be undertaken by at least two accredited and experienced MMOs (using binoculars and a range finding stick as required) and a PAM Operator to monitor the specified 500 m radial mitigation zone to minimise the likelihood of marine mammals being present within this range. In waters up to 200 m deep (which includes the offshore array area and offshore cable corridor), the MMO shall conduct pre-start-up visual monitoring at least 30 minutes before the sound-producing activity is due to commence. Sound-producing activity shall not commence until at least 30 minutes have elapsed with no marine mammals detected by the MMO within the mitigation zone.

Sound-producing activities will only commence in daylight hours where effective visual monitoring, as performed and determined by the MMO, has been achieved. Where effective visual monitoring, as determined by the MMO, 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.

An agreed and clear on-site communication signal must be used between the MMO and the Works Superintendent 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 MMO.

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 MMO.

In commencing a geophysical acoustic survey operation, the following soft-start procedure must be used, including during any testing of acoustic sources, where the output peak SPL from any source exceeds 170 dB re: 1 µPa @ 1 m:

a. Where it is possible according to the operational parameters of the equipment concerned, the device's acoustic energy output shall commence from a lower energy start-up (i.e. a peak SPL not exceeding 170 dB re 1 µPa @ 1 m) and thereafter be allowed to gradually build up to the necessary maximum output over a period of 20 minutes;

b. This controlled build-up of acoustic energy output shall occur in consistent stages to provide a steady and gradual increase over the ramp-up period; and

c. Where the acoustic output measures outlined in steps (a) and (b) are not possible according to the operational parameters of any such equipment, the device shall be switched "on" and "off" in a consistent sequential manner over a period of 20 minutes prior to commencement of the full necessary output.

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.

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.

If there is a break in sound output for a period greater than 30 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.

For higher output survey operations which have the potential to produce injurious levels of underwater sound (including the MBES methods expected to be employed in geophysical surveying for the Project) as informed by the associated risk assessment, there will be a regulatory requirement to adopt a shorter 5-10 minute break limit after which period all pre-survey monitoring and a subsequent soft-start (where appropriate following pre-survey monitoring) shall recommence as for start-up.

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 megafauna is considered to be of **slight significance**, which is not

significant in EIA terms. Figure 1-5 illustrates the sequence of events and lines of communication required to implement the MMMP.

Marine Mammal Observer

During daylight hours at least two dedicated and qualified MMOs will conduct a visual search of the mitigation zone and conduct the pre-start searches from a vessel prior to the start of surveying (see section 1.6 for details). Visual monitoring for marine mammals will be conducted from a suitable platform on the vessel such as the ship's bridge, that allows 360-degree visualisation, and full coverage of the mitigation zone. MMOs must concentrate their efforts on the measures to be taken in advance of and during commencement, breaks in and resumption of the sound-producing activity (NPWS, 2014).

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 MMO 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 or megafauna in the mitigation zone and any subsequent delay required to the commencement of surveying to be communicated quickly and effectively between all parties. The MMO will be responsible for recording all marine mammal sightings in the appropriate format, along with other environmental data. Together with the PAM Operator, the MMO will be responsible for compiling all the data on marine mammal observations and mitigation activities for reporting to NPWS.

The MMO must be experienced and familiar with the Irish regulatory procedures pertaining to managing risk to marine mammals from underwater sound and must be provided with full details of all licence/consent conditions relevant to the performance of their role in advance of activity commencement, to ensure compliance. The MMO will have the necessary authority (or support by Works Superintendent) to implement the plan and stop works if necessary.

PAM Operator

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 PAM 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).

PAM Operators will be based on the vessel together with the MMO. PAM Operators will be responsible for recording all acoustic marine mammal detections in the appropriate format, and together with the MMO, will be responsible for compiling all the data on marine mammal observations and mitigation activities for reporting to NPWS. The PAM operator should also be equipped with a two-way radio to ensure communication with both the vessel crew and the lead MMO. This is to allow any visual or acoustic detections of marine mammals or megafauna in the mitigation zone and any subsequent delay required to the commencement of surveying to be communicated quickly and effectively between all parties.

PAM Operators must be experienced and familiar with the Irish 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 Superintendent) to implement the plan and stop works if necessary.

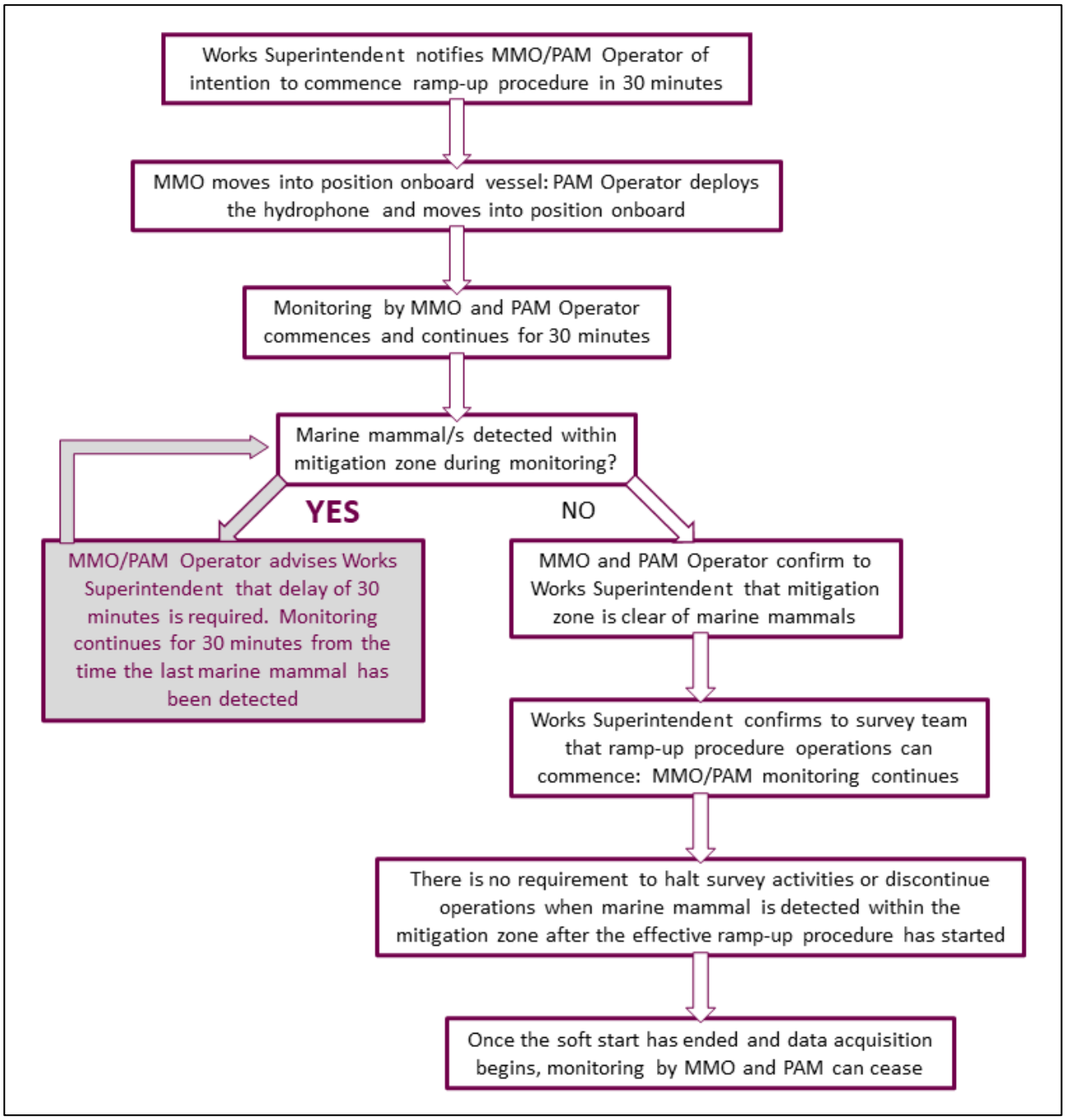

Figure 1-5: Task and communication plan for geophysical survey procedures start-up.

1.6.4 Field records during geophysical acoustic surveying

Operations report

As per NPWS guidelines (2014) the Operations report will be provided to NPWS on completion of geophysical acoustic survey activities as outlined below and must include use of standard NPWS data forms provided in NPWS (2014):

- Details of the Client/Contractor involved in the plan/project;
- Details of the Platform/Vessel type(s) participating in the plan/project;
- The survey reference number supplied by the Regulatory Authority or other statutory body;
- Date and location of the plan/project;
- Latitudes, longitudes or grid references for the area of operations;
- Specifications and acoustic characteristics of all sound-producing equipment used;
- For seismic surveys: number and volume of each airgun used and a calculated total volume of the array;
- A daily log of how and when the sound-producing equipment was used including during ramp-up (soft-start) procedures, where relevant;
- Information on any technical problems encountered during pre-start-up procedures, ramp-up (soft-start) procedures or during full scale operation/activity.

Marine Mammal Observer/PAM Report

The Marine Mammal Observer/Passive Acoustic Monitoring Report will include:

- An Executive Summary: a concise text at the beginning of the report highlighting the MMO work undertaken and summarising in turn:
  - All marine mammal detections made during the survey programme;
  - All detections made prior to the commencement of the operation/activity (e.g. before ramp-up);
  - All operational responses to the presence of animals in the area and the associated outcomes;
  - All occurrences of night-time operation/activity, continuation into poor weather and stoppages;
  - Any and all problems arising during implementation of the prescribed mitigation;
  - Any recommendations based on the project and any marine mammal sightings/behaviour encountered during the survey operations which could benefit future projects; and
  - A concluding statement regarding the operational efficacy of the mitigation measures performed.
- Date and location(s) of the plan/project;
- Name, address and qualifications of the MMO(s) on the Platform/Vessel;
- Name of any other Platform/Vessel involved in the operation/activity;
- Latitudes, longitudes or grid references for the area(s) of operations monitored by the MMO;

- Details of the observation platform used for marine mammal monitoring, including its height above sea level;
- Details of all sound-producing operations/activities undertaken during the period of survey;
- Details of monitoring watches conducted for marine mammals;
- Details of all marine mammal sightings recorded during monitoring watches;
- Details of all marine mammal sightings recorded outside monitoring watches (e.g. incidental observations), including records from additional personnel on board;
- Details of any problems encountered during marine mammal monitoring, start-up procedures, ramp-up (soft-start) procedures or during full scale operation/activity; and
- Details of any instances of non-compliance with NPWS guidelines.

1.7 Roles and responsibilities

1.7.1 Overview

This section sets out the key roles and responsibilities and lines of communications in relation to the MMMP. It identifies each key role involved in the construction phase of the Project and lists responsibilities associated with each role in relation to the MMMP.

1.7.2 Key roles

OWL Project Manager

The Project Manager has responsibility for ensuring that sufficient resources and processes are in place by the contractor and their subcontractors to implement the MMMP. The Project Manager will be responsible for ensuring that contractual obligations are met for contractors in relation to the MMMP, requiring that all construction personnel and contractors assist and support the Environmental Manager for the delivery of the commitments made under this MMMP.

The Project Manager will also ensure that the relevant Package Manager (in this case, the Marine Installation Package Manager) is responsible for:

- Requiring that sufficient resources and processes are in place to deliver/comply with the MMMP;
- Requiring that provision is made for matters relating to the delivery of the MMMP to form part of construction progress meetings and project inductions (e.g. outlining soft start and mitigation procedures as required by the MMMP; see section 1.6);
- Requiring that all construction personnel and contractors assist and support the MMOs and PAM and ADD operators (see below) and the Contractors Environmental Manager in delivering the MMMP and monitoring or auditing compliance with the MMMP;
- Ensuring contractual obligations are met for key contractors and their subcontractors in relation to the MMMP; and
- Reporting to the Project Manager on matters related to the MMMP (see section 1.8).

OWL Environmental Manager and OWL Environmental Clerk of Works

The OWL Environmental Manager is responsible for requiring contractor compliance with the Project consents and environmental legislation. Responsibilities of the OWL Environmental Manager/OWL Environmental Clerk of Works (ECoW) in relation to the MMMP include:

- Quality assurance of this MMMP;
- Providing advice on compliance with the MMMP;
- Monitoring compliance with the MMMP;
- Reporting on compliance with the MMMP to the Department of Housing, Local Government and Heritage (DHLGH);
- Ensuring that the Contractor is providing appropriate training in relation to construction-related environmental measures and consents compliance; and
- Ensuring that the Contractor is also delivering toolbox talks (e.g. outlining soft start and mitigation procedures as required by the MMMP; see section 1.6) as appropriate.

Contractors

Contractors and their subcontractors are responsible for installing the Project infrastructure in compliance with this MMMP, as required by their contract with the Applicant, and for appropriate liaison with the MMOs and PAM and ADD operators (see below) and the Contractors Environmental Manager.

1.8 Reporting

Full reporting on MMO operations and mitigation undertaken must be provided to the Regulatory Authority. The Works Superintendent and MMO/PAM Operator tasked with monitoring the implementation of the mitigation plan and with conducting survey effort for marine mammals in accordance with this guidance, will submit a report to the Regulatory Authority within 30 days of completion of the relevant piling and/or geophysical survey activity. This will include a daily log concerning the testing and operation of all relevant sound-producing equipment/activities, including ADDs and a record of all marine mammal detections.

Reporting will be provided in line with the Operations Report and Marine Mammal Observer Report contents outlined in NPWS (2014) and details are provided in NPWS (2014). The reports also provide information on any problems encountered during the survey activity or mitigation procedure (compliance reporting).

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