Arklow Bank Wind Park 2

Environmental Impact Assessment Report

Volume III, Appendix 25.2: Marine Mammal Mitigation Plan

Arklow Bank Wind Park 2: Marine Mammal Mitigation Plan

Volume III, Chapter, 25.2: Marine Mammal Mitigation Plan

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1.0	16/05/2024	Final (External)	APEM Ltd	GoBe Consultants	Sure Partners Limited

Statement of Authority

Experts	Qualifications	Relevant Experience
Tierney Carter	M.Sc. Marine Mammal Science, University of St. Andrews B.Sc. (Hons) Marine Biology, University of Aberdeen	Tierney is a Senior Marine Mammal consultant at APEM with over five years of experience of monitoring and mitigating effects of anthropogenic noise on marine mammals during pile driving, seismic surveys, and harbour construction campaigns. She is a skilled marine mammal specialist with a broad environmental knowledge base and extensive experience in the field with over 350 commercial days at sea. Tierney's duties at sea include visual observations, setting up, deploying, and analysing various static and towed passive acoustic monitoring systems, operating acoustic deterrent devices, and managing projects and teams offshore. In the office, her key duties include desk-based reviews, analysing acoustic data, and conducting assessments for EIA, HRA, and associated technical annexes. In a previous role she led JNCC approved marine mammal observer training courses.
Hannah Snead	M.Sc. Marine Conservation, University of Aberdeen B.Sc. (Hons) Ocean Science and Marine Conservation, University of Plymouth	Hannah is a Marine Mammal Consultant at APEM where she has two years' experience in supporting and carrying out marine mammal consultancy services to a high standard. In her day-to-day role, Hannah applies her knowledge of guidance and policy, and marine mammal ecology to EIA reporting, desk-based research tasks and acoustic data analysis. Hannah has a background in carrying out marine mammal

Experts	Qualifications	Relevant Experience
		surveys in the UK and abroad and has led on vantage point and at-sea surveys including visual observations, photo-identification studies and passive acoustic monitoring.
Phoebe Meredith	M.Sc. Volcanology, University of Bristol B.Sc. (Hons) Geography, University of Exeter	Phoebe is an experienced consultant with a background in consenting of offshore wind developments. She joined APEM in 2021 as a Senior Marine Mammal Consultant where she managed multi-million-pound digital aerial survey programmes, working collaboratively with a range of team members such as aerial technicians, data operators, and image analysts, to collect baseline marine mammal (cetacean and pinniped) data for offshore wind developments off the UK and Irish coasts. Since joining APEM's Marine Mammal Consultancy team, Phoebe has contributed to several projects that demonstrate her understanding of cetacean ecology and potential threats posed to them through several desk-based studies, technical baseline reports, and reports to inform appropriate assessment, as well as providing advice to clients regarding visual and acoustic monitoring options for baseline data collection.
Dr Ross Culloch	Ph.D. Behavioural Ecology and Ecological Modelling, Durham University M.Sc. Marine Mammal Science, Bangor University B.Sc. (Hons) Aquatic Bioscience, University of Glasgow	Ross is an Associate Director and head of the Marine Mammal Consultancy team at APEM. Ross joined APEM in February 2022 from Marine Scotland Science (now Marine Directorate), bringing a wealth of expertise in the field of marine mammal ecology, conservation and management, and a practical understanding of the legislation and policy relating to marine mammals and the consenting of major marine infrastructure projects. Ross has 20 years of experience working on marine mammals, primarily in relation to conservation and management, and anthropogenic impacts including fisheries interactions, collision risk and underwater noise.

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Glossary

Term	Meaning
Arklow Bank Wind Park 1 (ABWP1)	Arklow Bank Wind Park 1 consists of seven wind turbines, offshore export cable and inter-array cables. Arklow Bank Wind Park 1 has a capacity of 25.2 MW. Arklow Bank Wind Park 1 was constructed in 2003/04 and is owned and operated by Arklow Energy Limited. It remains the first and only operational offshore wind farm in Ireland.
Arklow Bank Wind Park 2 (ABWP2) (the Project)	Arklow Bank Wind Park 2 (ABWP2) (The Project) is the onshore and offshore infrastructure. This EIAR is being prepared for the Offshore Infrastructure. Consents for the Onshore Grid Infrastructure (Planning Reference 310090) and Operations Maintenance Facility (Planning Reference 211316) has been granted on 26th May 2022 and 20th July 2022, respectively. • Arklow Bank Wind Park 2 Offshore Infrastructure: This includes all elements to be consented in accordance with the Maritime Area Consent. This is the subject of this EIAR and will be referred to as 'the Proposed Development' in the EIAR. • Arklow Bank Wind Park 2 Onshore Grid Infrastructure: This relates to the onshore grid infrastructure for which planning permission has been granted. • Arklow Bank Wind Park 2 Operations and Maintenance Facility (OMF): This includes the onshore and nearshore infrastructure at the OMF, for which planning permission has been granted. • Arklow Bank Wind Park 2 EirGrid Upgrade Works: any non-contestable grid upgrade works, consent to be sought and works to be completed by EirGrid.
Arklow Bank Wind Park 2 – Offshore Infrastructure	"The Proposed Development", Arklow Bank Wind Park 2 Offshore Infrastructure: This includes all elements under the existing Maritime Area Consent.
Array Area	The Array Area is the area within which the Wind Turbine Generators (WTGs), the Offshore Substation Platforms (OSPs), and associated cables (export, inter- array and interconnector cabling) and foundations will be installed.

Term	Meaning
Availability bias	where an animal is underwater and is therefore not available for visual detection, or when an animal does not vocalise within audibility of hydrophones.
Bathymetry	The measurement of water depth in oceans, seas and lakes.
Cable Corridor and Working Area	The Cable Corridor and Working Area is the area where the export, inter array and interconnector cabling will be installed. This area will also facilitate vessel jacking operations associated with installation of WTG structures and associated foundations within the Array Area.
Cetacean	Aquatic mammals constituting the infraorder *Cetacea* (whales, dolphins, porpoises).
Demersal zone	Part of the water column near to (and significantly affected by) the seabed.
Eirgrid	State-owned electric power transmission system operator (TSO) in Ireland and Transmission Asset Owner (TAO) for the Project's transmission assets.
EIA	An Environmental Impact Assessment (EIA) is a statutory process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information, which fulfils the assessment requirements of the Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment as amended by Directive 2014/52/EU of the European Parliament and of the Council (EIA Directive) and the regulations transposing the EIA Directive (EIA Regulations).
Environmental Impact Assessment Report (EIAR)	An Environmental Impact Assessment Report (EIAR) is a report of the effects, if any, which the proposed project, if carried out, would have on the environment. It is prepared by the developer to inform the EIA process.
Foreshore	The bed and shore, below the line of high water of ordinary or medium tides, of the sea and of every tidal river and tidal estuary and of every channel, creek, and bay of the sea or of any such river or estuary including the subsoil below, and the water column above the bed and shore and extending to the 12 nautical mile limit.
Foundation	The load carrying support structure for the wind turbine generator tower or offshore substation platform topside. The foundation is the part of the structure from the interfacing flange with the turbine tower or topside-foundation interface, down to below seabed. This includes any secondary steel items associated with the structure.

Term	Meaning
	For the purposes of the EIAR the term ‘foundation’ includes the structure from the WTG tower or topside interface down to the lower end of the monopile commonly known as the ‘substructure’ and encompasses monopiles and transition pieces.
Functional hearing group	Categories of marine taxa with similar measured or estimated hearing capabilities and sensitivities.
Habitats Directive	Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (Habitats Directive).
Haul-out	a coastal site where seals choose to rest on land. These sites are important during life-history stages such as moulting or breeding.
Landfall	The area in which the offshore export cables make landfall and is the transitional area between the offshore cabling and the onshore cabling.
Lanugo	white natal coat of grey seal pups.
Maritime Area Consent (MAC)	A consent to occupy a specific part of the maritime area on a non-exclusive basis for the purpose of carrying out a Permitted Maritime Usage strictly in accordance with the conditions attached to the MAC granted on 22nd December 2022 with reference number 2022-MAC-002.
Pelagic	Area of the water column which is neither close to the bottom of the seafloor nor near the water surface.
Perception bias	where an animal is at the surface (or vocalising), but the detection is missed
Pinniped	aquatic mammals constituting the clade *Pinnipedia* (true seals, eared seals and walrus)
The Developer	Sure Partners Limited
Trackline	the line taken by the vessel during a survey

Acronyms

Term	Meaning
ABWP1	Arklow Bank Wind Park 1
ABWP2	Arklow Bank Wind Park 2
ADD	Acoustic Deterrent Device
ASL	Above Sea Level
C	Centre
CI	Confidence Interval
CMS	Convention on Migratory Species
CPT	Cone Penetration Test
CS	Celtic Sea
cum	Cumulative
CV	Coefficient of Variation
DAHG	Department of Arts, Heritage and the Gaeltacht
DAS	Digital Aerial Surveys
DAQ	Data acquisition unit
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
EEZ	Exclusive Economic Zone
EPS	European protected species
HF	High Frequency
FHG	Functional Hearing Group
IAMMWG	Inter-agency Marine Mammal Working Group
ISO	International Organisation for Standardisation
IWDG	Irish Whale and Dolphin Group
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
LF	Low Frequency
MAC	Maritime Area Consent
MARA	Maritime Area Regulatory Authority
MBES	MultiBeam Echosounder
MMMP	Marine Mammal Mitigation Plan
MMMZ	Marine Mammal Mitigation Zone
MMO	Marine Mammal Observer
MU	Management Unit
N	North
NBDC	National Biodiversity Data Centre
NIS	Natura Impact Statement

Term	Meaning
NPWS	National Parks and Wildlife Service
NW	Northwest
OMF	Operations and Maintenance Facility
OSP	Offshore Substation Platform
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
OWF	Offshore Windfarm
PAM	Passive Acoustic Monitoring
PCW	Phocid Carnivore in Water
PPM	Porpoise Positive Minutes
PTS	Permanent Threshold Shift
RIB	Rigid Inflatable Boat
RoI	Republic of Ireland
S	south
SAC	Special Area of Conservation
SBP	Sub-Bottom Profiler
SCANS	Small Cetacean Abundance in the North Sea
SCOS	Special Committee on Seals
SEL	Sound exposure level
SPL	Sound pressure level
SSS	Side Scan Sonar
SW	southwest
TAO	Transmission asset owner
TI	Titanium
TSO	Transmission system operator
TTS	Temporary threshold shift
UK	United Kingdom
UNCLOS	United Nations Convention of the Law of the Sea
USBL	Ultra-Short Baseline
UXO	Unexploded Ordnance
VHF	very high frequency
WTG	Wind Turbine Generator

Units

Unit	Meaning
%	Percentage
<	Less than
>	More than
cm	Centimetre (distance)
dB	Decibel (sound pressure)
Hz	Hertz (frequency)
kHz	Kilohertz (frequency)
kJ	Kilojoules (energy)
km	Kilometre (distance)
km^2	Square kilometre (area)
m	Metre (distance)
min	Minute (time)
ms^{-1}	Metres per second (unit of speed, e.g. wind, animal)
MW	Megawatt (power; equal to one million watts)
Pa	Pascal (pressure)
Pa^2s	Pascal squared seconds (acoustic energy)
s	Seconds (time)
µPa	Micropascal (pressure)

1. Introduction

1.1 Project background

Sure Partners Ltd hereafter referred to as the Developer is proposing to develop Arklow Bank Wind Park 2 (ABWP2) offshore windfarm (hereafter referred to as 'the Proposed Development'). The Proposed Development will be located on and around Arklow Bank in the Irish Sea, approximately 6 to 15 km off the coast of Arklow in County Wicklow (**Figure 25.2.1**). The Proposed Development will include the ABWP2 offshore infrastructure including offshore wind turbine generators (WTGs), WTG foundations, inter-array cables, offshore substation platforms (OSPs), OSP foundations and export cables to the Landfall to be consented in accordance with the Maritime Area Consent (MAC); see **Volume II, Chapter 4: Description of Development** for further details.

1.2 Purpose of the Marine Mammal Mitigation Plan (MMMP)

This Marine Mammal Mitigation Plan (MMMP) has been prepared for the Developer to support the Environmental Impact Assessment Report (EIAR) for the Proposed Development.

As highlighted in the EIAR chapters (**Volume II, Chapter 10: Fish, Shellfish and Sea Turtle Ecology** and **Volume II, Chapter 11: Marine Mammals**) the Proposed Development identified potential risks that could impact marine mammals (e.g. cetaceans and seals), basking sharks (*Cetorhinus maximus*) and sea turtles. Based on the assessments presented in the relevant EIAR chapters, the purpose of the MMMP is to present mitigation measures to minimise the effects of underwater noise and vibration resulting from activities relating to the Proposed Development. The activities identified as requiring mitigation measures, and as such are presented herein are:

- Confirmatory geophysical and geotechnical surveys;
- UXO clearance; and
- Impact pile driving.

The primary aim of this MMMP is to detail measures which are committed to by the Developer to reduce the risk of a permanent threshold shift (PTS) in hearing of marine mammals, basking sharks and sea turtles. The MMMP is intended to reduce the risk of injury to a negligible level. This MMMP complies with 'Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters' provided by the Department of Arts, Heritage and the Gaeltacht (DAHG, 2014).

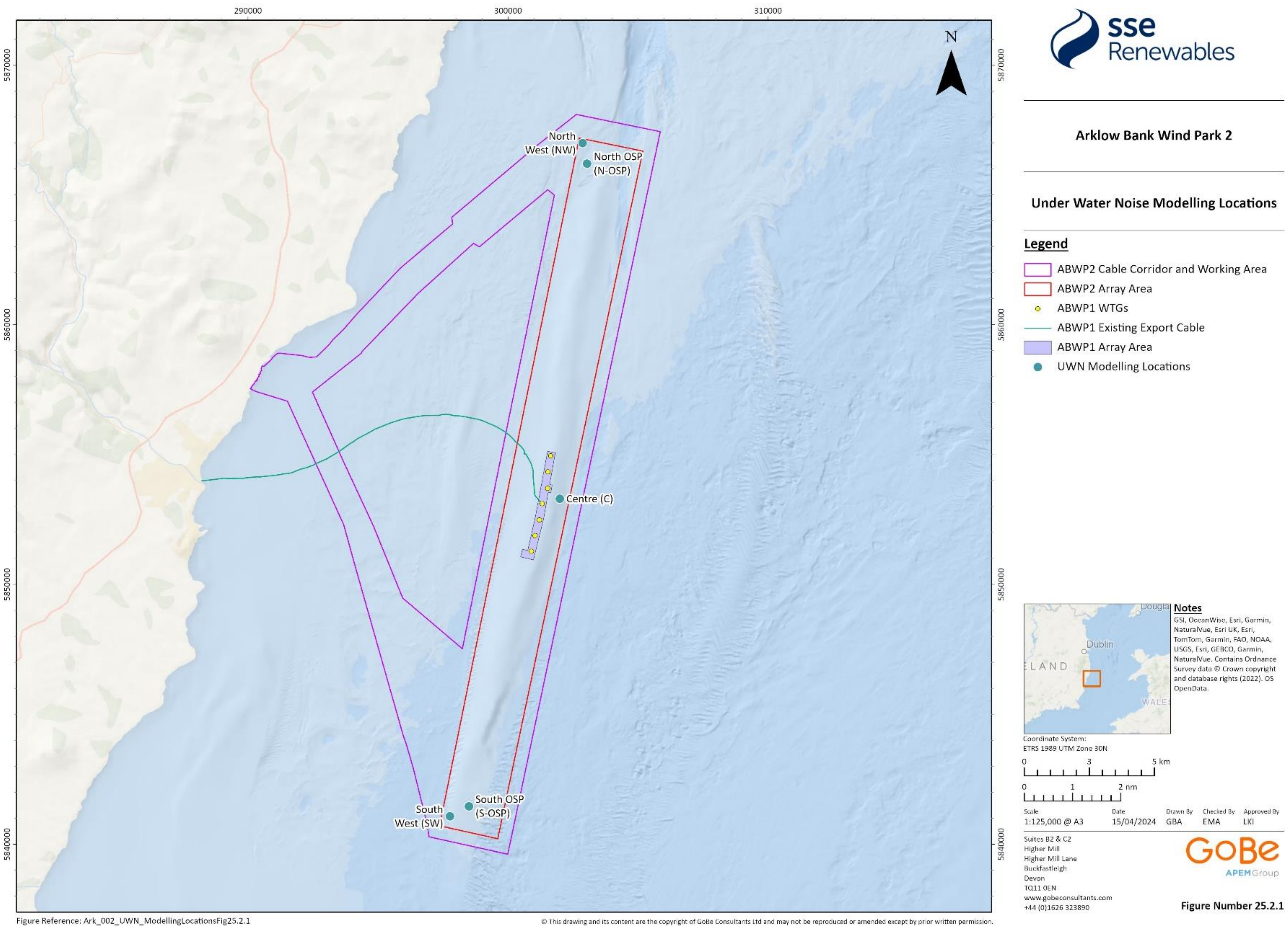

Figure 25.2.1 Underwater Noise Modelling Locations

The EIAR for the Proposed Development, and impact assessment within it, considers both Project Design Options 1 and 2 (as set out in **Section 2.1**) and the associated elevations in subsea noise and vibration. The impact assessment for each Project Design Option provides precautionary injury ranges for marine mammals, and the measures outlined within this MMMP consider those. Therefore, this MMMP is applicable to both Project Design Options.

2. Project description

2.1 Confirmatory geophysical surveys, geotechnical surveys and UXO clearance

The specific equipment to be deployed during the confirmatory geophysical and geotechnical surveys are yet to be confirmed; therefore, examples of different survey equipment and typical ranges of source levels and operating frequencies, where relevant, have been used to inform the assessment of injury and/or disturbance to marine mammals from underwater noise. Equipment likely to be used on these surveys have all been assessed. For geophysical surveys these are MultiBeam Echosounder (MBES), Side Scan Sonar (SSS), Ultra-Short Baseline (USBL), and Sub-Bottom Profiler (SBP), and for geotechnical surveys these are seismic cone penetration test (CPT), vibrocore, boreholes, and grab sampling. Relevant mitigation measures are presented in **Section 4**.

As part of the survey works, surveying will be completed in the proximity of the Proposed Development to identify if there are any UXO's (recording location and size) which need to be cleared prior to construction. Relevant mitigation measures are presented in **Section 5**.

2.2 Project Design Options and impact pile driving

There are two discrete Project Design Options and associated layouts for the Proposed Development. Project Design Option 1 includes the installation of 56 monopile WTG foundations and Project Design Option 2 includes the installation of 47 monopile WTG foundations. Both Project Design Options will include two OSPs installed on monopile foundations. A summary of the relevant parameters assessed for both design options are presented in **Table 25.2.1**.

The Proposed Development will only install monopiles, therefore only this foundation type has been assessed in the EIAR (see **Volume II, Chapter 11: Marine Mammals**). Monopiles will be installed using either pile driving or drilling methodologies. Full details of the monopile installation methodology are provided in **Volume II, Chapter 4: Description of Development** of the EIAR.

No simultaneous piling or drilling events will occur as a maximum of one monopile foundation will be installed at any one time (within any 24-hour period). It is estimated that most WTG foundation monopiles for both project designs will require a hammer energy up to 4,000 kJ, but some pile locations may require a maximum hammer energy up to 6,600 kJ for installation (as dictated by ground conditions at the piling location). OSP foundation monopiles for both project designs may require a maximum hammer energy up to 6,600 kJ for installation. To account for the variety of piling locations and precautionary scenarios in terms of underwater noise and vibration, piling activities were modelled for WTG monopiles at three locations: the northwest (NW), centre (C), and southwest (SW). In addition, two locations were modelled for OSP monopiles: north (N-OSP), and south (S-OSP). Full details of the piling parameters assessed are provided in **Volume III, Appendix 11.1: Underwater Noise Assessment.**

The construction programme comprises the installation of monopile foundation structures over a period of 18 months starting in 2028, subject to grant of consent.

Both project designs will require two OSPs which will be installed using monopile foundations. A summary of the relevant parameters assessed are presented in **Table 25.2.2**.

Table 25.2.1 Overview of Project Design Options

Parameter	Project Design Option 1		Project Design Option 2	
Number of WTG foundations to be installed	56		47	
Foundation type	monopile		monopile	
Maximum hammer energy (kJ)	4,000	6,600	4,000	6,600
Maximum pile diameter (m)	7	11	7	11
Maximum seabed penetration (m)	37		37	
Soft start duration	30 minutes		30 minutes	
Maximum soft start hammer energy (kJ)	825		825	
Ramp up duration (minutes)	70 minutes	146 minutes, 40 seconds	70 minutes	146 minutes, 40 seconds
Maximum piling time per foundation	3 hours 30 minutes	5 hours, 10 minutes	3 hours 30 minutes	5 hours, 10 minutes
Maximum number of piles per 24 hours	1		1	
Maximum total piling time	280 hours		235 hours	

Table 25.2.2 OSP maximum design parameters

Parameter	Project Design Option 1		Project Design Option 2	
Number of foundations to be installed	2		2	
Foundation type	monopile		monopile	
Maximum hammer energy (kJ)	4,000	6,600	4,000	6,600
Maximum pile diameter (m)	7	14	7	14
Maximum seabed penetration (m)	45		45	
Soft start duration	30 minutes		30 minutes	
Maximum soft start hammer energy (kJ)	825		825	
Ramp up duration (minutes)	70 minutes	146 minutes, 40 seconds	70 minutes	146 minutes, 40 seconds
Maximum piling time per foundation	3 hours 30 minutes	5 hours, 10 minutes	3 hours 30 minutes	5 hours, 10 minutes

3. Summary of Relevant Species and Potential Impacts

3.1 Introduction

This section sets out the key marine mammal, basking shark, and sea turtle species that are sensitive to underwater noise based on the information and associated assessments described in the following EIAR chapters:

Volume II, Chapter 10: Fish, Shellfish and Sea Turtle Ecology;

Volume II, Chapter 11: Marine Mammals;

Volume III, Appendix 10.1: Fish, Shellfish and Sea Turtle Ecology Technical Report; and

Volume III, Appendix 11.2: Marine Mammals Technical Report.

As per the approach set out in **Volume II, Chapter 11: Marine Mammals**, harbour porpoise (*Phocoena phocoena*), bottlenose dolphin (*Tursiops truncatus*), Risso's dolphin (*Grampus griseus*), short-beaked common dolphin (*Delphinus delphis;* hereafter termed 'common dolphin'), minke whale (*Balaenoptera acutorostrata*), grey seal (*Halichoerus grypus*), and harbour seal (*Phoca vitulina*) have been assessed in this MMMP. As set out in **Volume II, Chapter 10: Fish, Shellfish and Sea Turtle Ecology,** basking shark and leatherback turtle (*Dermochelys coriacea*) have also been assessed in this MMMP.

Data from site-specific digital aerial survey (DAS) carried out between 2018 and 2020 are included within species accounts. The DAS Study Area surveyed includes the Array Area, Cable Corridor and Working Area of the Proposed Development plus a 4-kilometre (km) buffer extending around the Array Area and covering the area west of the Array Area to the coast.

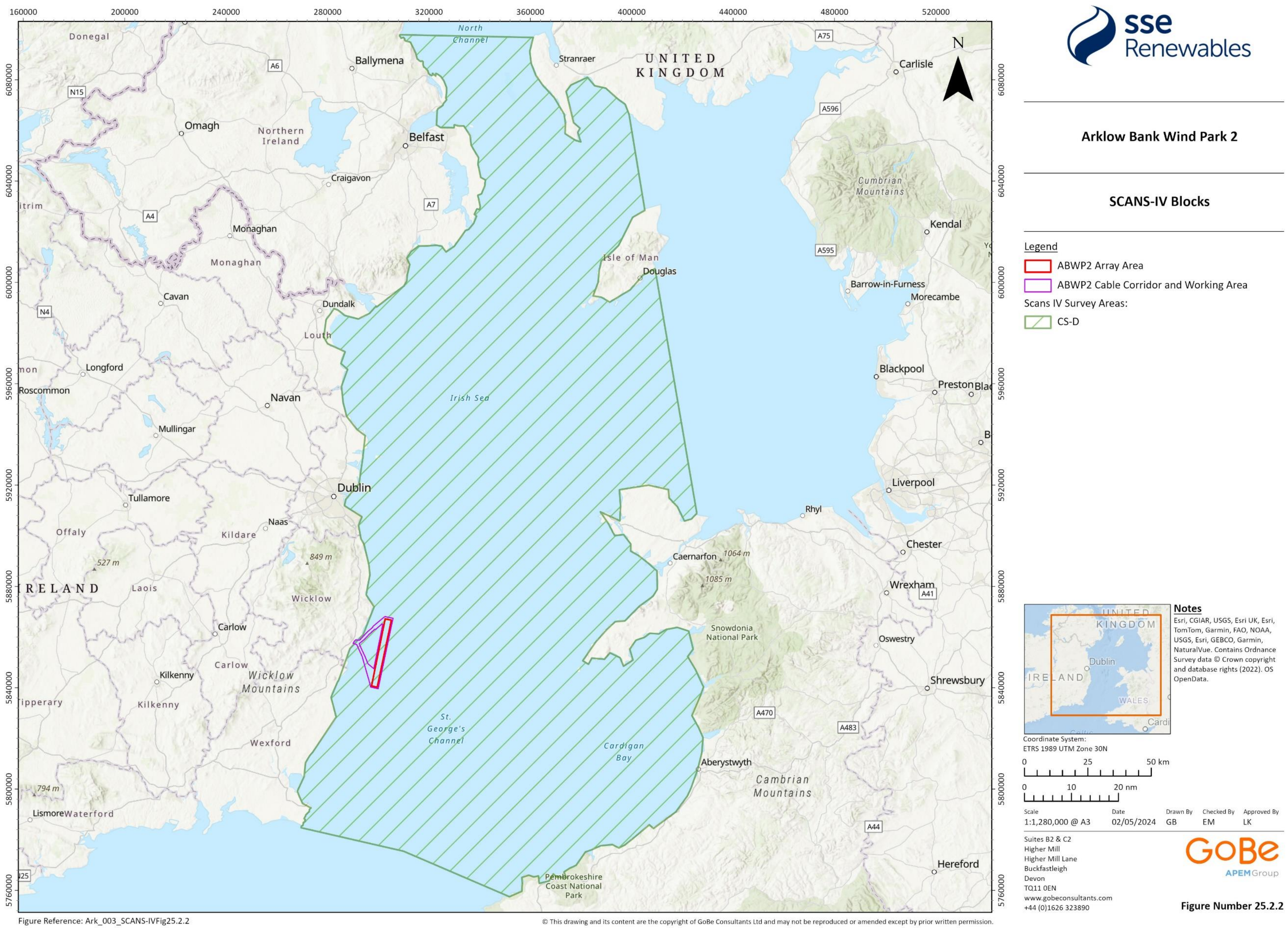

Figure 25.2.2 The marine mammal study area and relevant SCANS-IV survey block.

3.1.1 *Harbour porpoise*

Harbour porpoises are listed under Annex IV of the Habitats Directive as a European Protected Species (EPS), which is afforded strict protection from injury and disturbance. They were the most frequently recorded marine mammal species during site-specific DAS, resulting in a mean corrected density estimate of 0.38 animals/km^2. Site-specific DAS confirmed the presence of harbour porpoise within the Study Area year-round, although abundance and density was higher in summer months (HiDef, 2020a), which has been confirmed by several other studies in this region (Berrow *et al.,* 2008; Rogan *et al*., 2018). The most recent large-scale surveys conducted were SCANS-IV in 2022 which estimate an abundance of 9,773 animals and a density of 0.2803 animals/km^2 within block CS-D which encompasses the Irish Sea (within which the Study Area is located; **Figure 25.2.2**; Gilles *et al*., 2023).

3.1.2 *Bottlenose dolphin*

Bottlenose dolphins are an EPS that are widespread and abundant in Irish waters (Berrow *et al*., 2010; Wall *et al*., 2013). One group of bottlenose dolphins were recorded during site-specific DAS, confirming their presence within the Marine Mammal Study Area (HiDef, 2020a). However, it was not possible to provide an abundance and/or density estimate for bottlenose dolphin from the site-specific DAS due to the low number of sightings across the survey period. Recent large-scale surveys include ObSERVE and SCANS-IV which have provided contrasting abundance and density estimates, with the ObSERVE surveys providing an abundance of 223 animals and a density estimate of 0.0201 animals/km^2 within stratum 5 (**Figure 25.2.2**; Rogan *et al*., 2018) and SCANS-IV providing an estimated abundance of 8,199 animals and a density of 0.2352 animals/km^2 within block CS-D (Gilles *et al*., 2023).

3.1.3 *Risso's dolphin*

Risso's dolphins are an EPS that are frequently recorded in Irish waters in both deep offshore shelf and slopes waters and in coastal areas (Berrow *et al.,* 2010; Rogan *et al.,* 2018). They were not recorded during site-specific DAS (HiDef, 2020a), although six sightings of between one and eight individuals have been previously recorded during historic site-specific boat-based surveys carried out from 2000 to 2008 (Cork Ecology, 2007; 2009; 2010; CWC, 2003; 2004; 2005; Fulmar Ecological Services, 2006), confirming their presence within the Study Area. Sightings of Risso's dolphins have also been recorded during the recent ObSERVE and SCANS-IV surveys of the wider area (Gilles *et al*., 2023; Rogan *et al.,* 2018). However, only one individual was recorded in stratum 5 during the ObSERVE surveys (Rogan *et al*., 2018). SCANS-IV estimated an abundance of 75 animals and a density of 0.0022 animals/km^2 in block CS-D which is lower than estimates from the previous SCANS-III survey which estimated an abundance of 1,090 animals and a density of 0.031 animals/km^2 in block E (**Figure 25.2.2**; Hammond *et al.,* 2021).

3.1.4 *Common dolphin*

Common dolphins are an EPS and are the most frequently recorded dolphin species in Irish waters (Berrow *et al*., 2010). They were recorded on two occasions during site-specific DAS with a total of 22 individuals sighted, confirming their presence within the Marine Mammal Study Area (HiDef, 2020a). SCANS-IV estimated an abundance of 949 animals and a density of 0.0272 animals/km^2 in block CS-D (**Figure 25.2.2;** Gilles *et al*., 2023).

3.1.5 Minke whale

Minke whales are an EPS and are the most abundant species of baleen whale in Irish waters (Reid *et al*., 2003; Rogan *et al*., 2018). They were not recorded during the site-specific DAS (HiDef, 2020a), although sightings have been recorded during the recent ObSERVE and SCANS-IV surveys, which cover the wider area (Gilles *et al*., 2023; Rogan *et al*., 2018). Furthermore, the ObSERVE surveys confirmed a higher presence of minke whale during the spring and summer months, whilst the species is expected to be largely absent in autumn and winter due to offshore movements during these months (Rogan *et al*., 2018). The ObSERVE surveys estimated an abundance of 495 animals and a density of 0.045 animals/km^2 in stratum 5 (**Figure 25.2.2;** Rogan *et al*., 2018). SCANS-IV estimated an abundance of 477 animals and a density of 0.0137 animals/km^2 in block CS-D, which is lower than estimates from the previous SCANS-III survey which estimated an abundance of 603 animals and a density of 0.017 animals/km^2 in block E (Hammond *et al.,* 2021).

3.1.6 Seals

Two seal species are considered resident in Irish and UK waters, grey seal and harbour seal. Although they are not EPS, there are various legislation protecting seals from mortality, injury and disturbance (e.g. Wildlife Act, 1976 (as amended); Annex II of the Habitats Directive). Both species are present along the east coast of Ireland and have been recorded during site-specific DAS within the Study Area (**Figure 25.2.2;** HiDef, 2020a; Morris and Duck, 2019).

3.1.7 Grey seal

Grey seals have a wide distribution and occur around the coast of Ireland year-round (Morris and Duck, 2019; O'Cadhla *et al*., 2007). Along the east of Ireland, the population has been scaled to an estimate of 1,662 individuals and the average density across the Study Area is 0.07 animals/km^2 (**Figure 25.2.2;** extracted from Carter *et al*. (2020)). The closest haul-out to the Proposed Development is on the coast at Arklow, co. Wicklow, grey seals also haul-out at Lambay Island, to the north of the Proposed Development, and at Wexford Harbour to the south of the Proposed Development (Duck and Morris, 2013; Morris and Duck, 2019). Telemetry studies showed that, whilst grey seals can forage up to 448 km from haul out sites, the typical foraging distance is approximately 100 km (Carter *et al.,* 2022; SCOS, 2023).

3.1.8 Harbour seal

The population of harbour seals along the east of Ireland has been scaled to an estimate of 182 individuals (Morris and Duck, 2019) and the average density across grid cells within the Study Area is 0.0003 animals/km^2 (**Figure 25.2.2;** extracted from Carter *et al*. (2020)). The closest haul-out to the Proposed Development is on the coast at North Bull Island to the south of Dublin Bay, although harbour seals also haul-out at Lambay Island to the north of the Proposed Development and at Wexford Harbour to the south of the Proposed Development (Duck and Morris, 2013; Morris and Duck, 2019). Telemetry studies showed that, whilst harbour seals can forage up to 273 km from haul out sites, the typical foraging distance is approximately 50 km (Carter *et al.,* 2022; SCOS, 2022; 2023).

3.1.9 Basking shark

Basking sharks are not a EPS, but they are listed on the OSPAR list of threatened/declining species including in Region III (Celtic Seas; OSPAR Commission, 2015), on the International Union for Conservation of Nature (IUCN) Red List as Globally Endangered (Rigby *et al.,* 2021) protected under the Wildlife Act 1976 (as amended in 2022) and on Ireland's Red list as endangered (Clarke *et al.,* 2016). In addition, as a highly migratory species, basking shark is protected under various international conventions including Convention on the Conservation of Migratory Species (CMS; Bonn Convention) and the United Nations Convention of the Law of the Sea (UNCLOS).

Basking shark is a large, filter-feeding species that is predominately solitary but may also occur in aggregations where there is dense zooplankton abundance (Speedie, 1999). Basking sharks migrate through the Irish Sea during spring and summer, with migration routes covering large distances from the north of Scotland to North Africa, and occasionally between the UK and America (Johnston *et al*., 2019). A tagging study of basking sharks found that half of the tagged individuals entered the Exclusive Economic Zone (EEZ) of Ireland, including the Irish Sea, indicating the importance of this area for overwintering and migration (Doherty *et al.,* 2017).

Whilst their distribution patterns are relatively well studied around Ireland and the UK, there are no density or abundance estimates for populations of basking sharks anywhere in the world (Sims, 2008). During the two-year site-specific DAS, a single basking shark was recorded, confirming their presence within the Study Area (**Figure 25.2.2;** HiDEF, 2020a). An individual basking shark was also recorded off the east coast of Ireland during the ObSERVE surveys (Rogan *et al*., 2018) and one individual has been recorded off County Dublin on the east coast during the last 12 months (since January 2024), which was reported on the Irish Whale and Dolphin Group (IWDG) sightings app (IWDG, 2019).

3.1.10 Sea turtles

All species of marine turtles are listed under Annex IV of the Habitats Directive as an EPS, which is afforded strict protection from injury and disturbance. Five species of marine turtles have been recorded in Irish waters including leatherback turtle, loggerhead turtle (*Caretta caretta*), Kemp's Ridley turtle (*Lepidochelys kempii*), green turtle (*Chelonia mydas*) and hawksbill turtle (*Eretmochelys imbricata*; King and Berrow, 2009; Botterell *et al*., 2020). Of these, leatherback turtles are the most regularly reported around the coast of Ireland (King and Berrow, 2009; Botterell *et al*., 2020). Only a few records have been found of hawksbill turtle and green turtle, both on the south coast of Ireland, and these are thought to be rare vagrants to Irish waters (King and Berrow, 2009).

The majority of leatherback turtle sightings have been recorded along the south and west coasts of Ireland, although there are records of leatherback turtles along the east coast of Ireland suggesting that this species may occur within the Irish Sea. This species has a strong seasonal distribution with most sightings in the Irish Sea in the summer months; most likely driven by an increase in the abundance of jellyfish, as their key prey resource (Houghton *et al*., 2006). No leatherback turtles were recorded during the site-specific digital aerial surveys. However, a leatherback turtle was recorded in August 2020 by a Marine Mammal Observer (MMO) during a programme of site investigation activities within the Study Area (Gavin and Doherty Geosolutions Ltd, 2020a; 2020b; HiDef, 2020a; 2020b).

3.2 Noise and vibration impacts

Installation of offshore windfarms (OWFs) involve multiple activities that can have direct and indirect impacts on marine fauna. Impacts typically assessed are a permanent threshold shift (PTS) in hearing, where the hearing sensitivity is reduced after noise exposure, with no hearing recovery in the impacted frequencies and disturbance to marine mammals, including a temporary threshold shift (TTS) in hearing, where an animal experiences a reduced hearing sensitivity for a period of time before hearing returns to the animal's baseline. PTS and TTS can occur instantaneously or cumulatively (i.e. exposed to the sound source over an extended period). With respect to PTS, the level of injury depends on the duration, frequency and intensity of the sound source and received level. Whilst PTS is considered a permanent effect, the most likely response of an animal exposed to noise levels that could induce PTS is to flee the ensonified area. Therefore, animals exposed to these noise levels are likely to actively avoid hearing damage by moving away from the area.

Noise exposure criteria are typically represented by dual exposure metrics, including the frequency-weighted sound exposure level (SEL; expressed in decibels (dB) re. 1 μPa^2–s or $\mu Pa^2 s$) and the unweighted sound pressure level (SPL; expressed in units relative to 1 µPa in water; ISO 18405, 2017; Juretzek *et al.,* 2021). Results are expressed further by SEL_{cum} (SEL cumulative; the frequency weighted SEL where both the received level and duration of exposure are accounted for) and SPL_{peak} (the unweighted zero to peak SPL as a measure of characterising the amplitude of a sound). The ranges relating to SPL_{peak} indicate the distance from the sound source to which an animal can experience instantaneous injury.

Based on the assessments presented in the relevant EIAR chapters, underwater noise and vibration resulting from the following activities are considered here:

- Confirmatory geophysical and geotechnical surveys;
- UXO clearance; and
- Impact pile driving.

Sound waves can propagate in various manners depending on the nature of the sound, where the sound source is in relation to the water column and bathymetry, and seawater properties. Sound from pile driving propagates in a conical Mach wave (angled wavefront between the water surface and seafloor), sound in deep water propagates in a spherical nature and sound within shallow water environments propagate by cylindrical spreading (Wood, Ainslie and Burns, 2023). As sound travels through water, it experiences sound attenuation (where sound waves lose amplitude and intensity due to energy loss through a medium). This phenomenon affects high frequency sounds to a greater degree than lower frequencies. Therefore, the risk of auditory injury or disturbance is reduced with increasing distance from the source. SEL_{cum} distances are typically greater than SPL_{peak} as the former criteria considers an accumulation of sound exposure across a period of 24-hours.

3.2.1 Confirmatory geophysical and geotechnical surveys: Scope of works and assessment approach

Geophysical survey equipment emits high-energy sound sources with a downwards projection through the water column to the seabed with the aim of mapping the geology of the topography. Although highly directional in nature, the impulsive, high-energy sound emitted from airguns and SBPs have been shown to elicit behavioural and physiological responses in many species of marine mammal (Blackwell *et al*., 2015; Erbe *et al*., 2018; Gordon *et al*., 2003; Romano *et al*., 2004; Southall *et al.,* 2019).

Confirmatory surveys of relevance to this MMMP are those that produce underwater noise, primarily geophysical and geotechnical surveys. Geophysical surveys such as MBES and SSS typically produce sound sources that are sonar-based or impulsive. Geotechnical surveys including seismic cone penetration test (CPT), vibrocore, borehole drilling, and grab sampling typically produce sound sources that are non-impulsive and operate outside the hearing sensitivities of HF and VHF cetaceans. LF cetaceans hearing range overlaps with the noise generated from geotechnical survey works, but it is not within their range of peak sensitivity. Only noise from vibrocoring is within the hearing range of seals in water, but it is not within their peak sensitivity range. Noise levels generated from confirmatory surveys (geophysical and geotechnical) were predicted by Seiche Ltd (2022). The report details the underwater noise modelling methodology, assumptions, and resulting impact ranges. The relevant findings of the report are presented in **Section 4.2**, along with the proposed mitigation measures.

3.2.2 UXO clearance: Scope of works and assessment approach

Clearance of UXOs often requires the detonation of explosive material, either by detonating a donor charge or the UXO itself. Preferred approaches include relocation, wet storage or low order clearance techniques such as deflagration, as this is considered a low-noise option; however, in some cases high order clearance is required to detonate any live explosive material left in the device. Explosions underwater produces high-intensity noise and high-velocity spherical waves which have led to mortality (Broner and Huber, 2012), physical injuries (Ketten, 1995; Koschinski, 2011) auditory injury (Koschinski, 2011) and behavioural responses (Gomez *et al.,* 2016) in marine mammals.

Once the UXO identification surveys are complete, details of the anticipated number, location and type of UXO that may require clearance will be known. In the interim, a range of UXO sizes and donor charges have been assessed and have been presented alongside possible mitigation measures including avoiding UXO, ADD use, low order clearance and high order clearance, which is presented in **Section 5.2**.

3.2.3 Impact pile driving: Scope of works and assessment approach

Impact pile-driving (piling) is currently the most common approach for installing foundations for OWFs. However, piling has the potential to produce underwater noise levels capable of causing injury (e.g. PTS).

Noise modelling has been undertaken by Subacoustech Environmental, to assess the potential impacts on marine mammals, basking sharks (as fish category without swim bladders) and sea turtles, as a result of pile-driving within the Array Area (**Volume III, Appendix 11.1: Underwater Noise Assessment).**

Modelling for WTG and OSP foundation impact piling considered effects across five representative locations within the Array Area, ranging from water depths between 24.4–35.6 m. Two monopile diameter scenarios were modelled with estimated maximum hammer energies depending on the engineering estimates relevant to each piling location.

4. Geophysical and Geotechnical Survey Mitigation Methodology

4.1 Introduction

The MMMP is focused on minimising risk of instantaneous PTS or disturbance, primarily from the sparker and seismic equipment, non-impulsive geophysical and geotechnical survey sound sources (e.g. borehole drilling) are excluded from the requirements.

The Factored In Measures (see **Table 11.15** within **Volume II, Chapter 11: Marine Mammals**) includes the implementation of a project-specific mitigation protocol during the geophysical and geotechnical surveys to minimise the risk of PTS, as presented herein, adhering to international best practice, including DAHG (2014) guidance.

4.2 Assessment Outcomes and Mitigation Procedures

The Subsea Noise Assessment (Seiche Ltd, 2022) has concluded that for impulsive geophysical survey sound sources (seismic refraction and sparker) injury in the form of instantaneous PTS could occur up to 22 m from the source (Seiche Ltd, 2022). It should be noted that sonar-based systems (e.g. MBES, SSS, SBP) have very strong directivity which means that an individual would need to be within the beam of the sound source for injury to occur. For the sonar-based systems, the MBES, SSS nor SBP were predicted to cause instantaneous injury for any functional hearing groups (FHGs; groupings of marine mammals based on their hearing capabilities and sensitivities as assessed in Southall *et al.* (2007, 2019)). The greatest predicted impact range for cumulative PTS is 517 m, for harbour porpoise from a pinger, chirp or SBP survey type (Seiche Ltd, 2022). Maximum impact ranges from MBES and SSS survey types for cumulative PTS is 25 m for harbour porpoise. Basking shark and sea turtle impact ranges were not predicted for sonar-based surveys due to the high frequency nature of the equipment being outside of the receptor species hearing thresholds.

For sparker surveys, the greatest predicted impact range for instantaneous PTS is 22 m, for harbour porpoise from a TI sleeve (10 cubic inch (cu in); Seiche Ltd, 2022). Sparkers are predicted to not be able to cause instantaneous PTS to any individual across the FHGs. Cumulative PTS is estimated to occur within 130 m of the TI Sleeve (10 cu in) and within 14 m of a sparker. Basking sharks were predicted to be at risk of mortality or potential mortal injury within 5 m of a TI Sleeve and 3 m from a sparker. Sea turtles were predicted to be at risk of mortality or potential mortal injury within 9 m of a TI Sleeve and 7 m from a sparker.

The Subsea Noise Assessment (Seiche Ltd, 2022) has concluded that for geotechnical surveys (seismic CPT and vibrocore sampling) injury in the form of instantaneous PTS could occur up to 15 m from the source and cumulative PTS could occur up to 62 m from the seismic CPT sound source for harbour porpoise (Seiche Ltd, 2022). Basking sharks were predicted to be at risk of mortality or potential mortal injury within 4 m of a seismic CPT. Sea turtles were predicted to be at risk of mortality or potential mortal injury within 8 m of a seismic CPT.

For vibrocore sampling, cumulative PTS only occurs for VHF cetaceans (harbour porpoise) and is predicted to occur within 2 m of the source (Seiche Ltd, 2022). No effect is predicted to occur for basking shark or sea turtles from non-impulsive sound sources.

For impulsive sound sources, disturbance could occur out to the following distances for all FHGs (Seiche Ltd., 2022); MBES 492 m, SSS 319 m, SBP 4,950 m, TI Sleeve (10 cu in) 1,324 m and Sparker 700 m.

A summary of mitigation measures to be used specifically during the project geophysical surveys are listed in **Table 25.2.3** below. The Marine Mammal Mitigation Zone (MMMZ) is much larger than predicted impact ranges for instantaneous PTS; however, the MMMZ will remain precautionary at 500 m following DAHG (2014) guidance.

Given the above and the information assessed within **Volume II, Chapter 11: Marine Mammals**, the risk of injury from underwater noise as a result of confirmatory surveys will be Negligible adverse for all marine mammal species. For all marine mammal species, the impact of behavioural disturbance from underwater noise during confirmatory surveys has been assessed as **Low adverse.** Given the above and the information assessed within **Volume II, Chapter 10: Fish, Shellfish and Sea Turtle Ecology,** the risk of injury from underwater noise as a result of confirmatory surveys will be Slight adverse for basking shark and sea turtles. Any disturbance effects would be short-term due to the limited time estimated to conduct confirmatory surveys.

Table 25.2.3 Summary of mitigation measures to be used during geophysical and geotechnical surveys

SUMMARY	
Mitigation Zone	500 m
Predicted maximum instantaneous PTS onset impact ranges **Sparker based surveys** **Geotechnical surveys**	 22 m 15 m
Predicted cumulative PTS impact ranges **Sparker based surveys** **Seismic surveys** **Geotechnical surveys**	 130 m 517 m 62 m
Pre-watch period	30 mins
Soft start length	Min. 20 to Max. 40 mins
Soft start delays	30 minutes
Shut down during acquisition	n/a
Species covered	Marine mammals, basking sharks and sea turtles
No. of MMOs	1-2
Special requirements	n/a

4.3 Mitigation zone

The mitigation zone is dependent on the specification/type of equipment and impact range of injury for the most sensitive marine mammal. Based on the assessment, the maximum range for instantaneous injury (PTS onset) is 22 m and 517 m for cumulative PTS onset. The Subsea Noise Assessment (Seiche Ltd, 2022) indicates that instantaneous injury could occur within more restricted impact ranges than the advised distance of 1,000 m mitigation zone in the absence of a site specific assessment as stated within DAHG (2014) guidance. Consequently, the Proposed Development will use a mitigation zone of 500 m from the sound source where the following equipment are used: TI sleeve, sparker, seismic CPT, MBES, SSS and SBP. Although this mitigation zone is less than the maximum cumulative impact range, it is considered appropriate as it is greater than the maximum instantaneous injury impact range. This means that any animal out with the 500 m mitigation zone will be able to flee the area to not be exposed to the injurious noise levels across the period of operations. This will also reduce the dose of noise received cumulatively, as the modelling considers an animal starting at source; therefore, where the proposed mitigation is applied an animal will be at least 500 m from source at the point it starts to accumulate the dose (i.e. is subjected to the noise).

Depending on daylength, one or two trained and dedicated (personnel with no other role onboard the vessel) MMOs will be present on board the vessel throughout the survey. Two MMOs will be required if operations occur over a time period greater than 12 hours. The MMO will carry out dedicated watches for marine animals during survey operations during daylight hours.

The MMOs monitor the area with the naked eye and 10 x 50, 7 x 50 or 7 x 30 reticule binoculars checking for visual cues such as feeding seabirds, splashes, blows and sea surface disturbance. When marine mammals are observed, the distance and bearing to the sighting will be recorded along with the species identification, time of sighting, vessel position and other data required for the completion of the sighting form. Species identification can be aided, by photographic records of sightings, taken using digital cameras or reference to a field guide (e.g. Shirihai and Jarrett, 2006).

Observations are carried out from the same vessels as the operations. Observation points should provide unobstructed 360-degree views of the mitigation zone, preferably from the bridge wings.

Distances to sightings are estimated using reticule binoculars or range finder sticks and by reference to the known distances of, for example, acoustic gear.

Information on operations (e.g. survey type, start/end of sound output, vessel location, time of day and any mitigation actions), survey effort (including the vessel's location and weather conditions) and sightings will be recorded using standardised data forms (DAHG, 2014). Communication with survey and the MMOs are maintained by handheld VHF radio with the surveyors in the instrument room informing the MMO of all planned activities and any change in source activity.

4.4 Pre-watch monitoring

Pre-watch monitoring by MMO's will be carried out for 30 minutes prior to the start of any testing or survey operations. The watch is carried out visually using the naked eye and reticule binoculars (10 x 50, 7 x 50 or 7 x 30).

4.5 Delay of operations

The start of the acoustic equipment will be delayed if marine mammals are detected within the MMMZ during the pre-watch, allowing the animals time to move away from the acoustic source. The start of the source will be delayed for at least 30 minutes following the last sighting within the MMMZ.

4.6 Soft start

Sound-producing activities will only commence during daylight hours where effective visual monitoring can be achieved.

Survey equipment with a source SPL above 170 dB re 1µPa shall commence from a lower energy start-up (e.g. a single seismic device/airgun or electric discharge, starting from the lowest sound energy level possible and incrementally adding more until the full complement is achieved) and increase gradually over a period of 40 minutes. After the 40 minutes of ramp-up is concluded, there is no requirement to halt activities even if visibility worsens or if marine mammals enter the MMMZ.

Where MBES, SSS and/or SBP equipment are used, where the operational parameters of the equipment allow, start-up energy will commence from the lowest possible energy and thereafter increase incrementally to operational power over a period of 20 minutes. If the equipment is unable to change the energy levels, the survey team will switch the equipment on and off over the period of 20 minutes, where the portion of time that the equipment is switch on increases gradually. After the 20 minutes of ramp-up is concluded, there is no requirement to halt activities even if visibility worsens or if marine mammals enter the MMMZ.

4.7 Line Changes

For line changes taking longer than 40 minutes, the source will be stopped, then a pre-watch of 30 minutes followed by a soft-start will be required to resume operations.

4.8 Breaks in Operations

For any breaks in operation of the equipment of between 5 and 10 minutes the MMOs will undertake dedicated monitoring to check no marine mammals are present within the mitigation zone prior to the source restarting.

If a marine mammal is sighted within the mitigation zone during a break in operation, the equipment will recommence firing with a full soft start once the mitigation zone has been clear for 30 minutes from the last sighting.

For any breaks in operations of more than 10 minutes the equipment will only recommence following a full 30 minutes of dedicated pre-start monitoring and a soft start. If the MMO has been monitoring prior to and throughout the break, this time contributes to the pre-start monitoring time. The source is only started once the mitigation zone is clear of marine mammals for 30 minutes.

For any breaks in operation of more than 30 minutes the equipment will recommence operation following 30 minutes of dedicated pre-start monitoring and a soft start. If the

MMO has been monitoring during the break this time contributes to the pre-start monitoring time.

Should marine mammals be sighted within the mitigation zone during this period the start of the equipment will be delayed for at least 30 minutes from the last sighting within the mitigation zone.

4.9 Data Collection and Recording Forms

The MMOs will compile data throughout the survey into three main data sheets: 1) Effort, 2) Operations, and 3) Sightings, in line with Appendix 6 of the 'Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters' (DAHG, 2014).

4.10 Communication

A pre-survey kick-off meeting is recommended to confirm the marine mammal mitigation requirements and further meetings on board the vessel, between the vessel surveyors and engineers, and the MMOs to agree on mitigation procedures as set out in the MMMP and consent.

All communication to follow the agreed protocol. Notice for commencement of the pre-line search is to be given to the MMOs by VHF radio, at least one hour before any source operation. All soft starts and tests to be cleared with the MMOs prior to source activation. In the case of a mitigation action, the MMOs would communicate with the surveyors directly, who would then advise all parties.

5. UXO Mitigation Methodology

5.1 Introduction

This section of the MMMP has been developed for the purpose of mitigating the risk of physical trauma and auditory injury (PTS) to marine mammals by the proposed UXO clearance activities. The MMMP presented here can be considered a proposed list of measures and procedures, which can be modified in accordance with advice received from the regulator and their specialist UXO advisors as appropriate prior to UXO clearance activities commencing. Specifically, once UXO identification surveys are complete, further details of the anticipated number, location and type of UXO that may require clearance will be known. The Department of Art, Heritage and the Gaeltacht guidance to manage the risk to marine mammals from man-made sound sources in Irish waters (DAHG, 2014) does not specifically cover UXO; however, it does provide guidance on blasting. Reference is also made to the JNCC guidelines for minimising the risk of disturbance and injury to marine mammals whilst using explosives (JNCC, 2010; 2021).

Where appropriate, mitigation may take the form of avoiding the need for the use of explosives, either by leaving the confirmed UXO in situ and micro-siting construction work and infrastructure around it, relocating the UXO to a safe place and leaving in situ, or the explosives is removed via low order deflagration. However, avoidance, relocation or low order methodologies may not be possible for some UXO and, therefore, as a worst-case scenario high order detonation may be required.

High-order disposal of UXO, where an attempt is made to fully detonate the contents of the UXO, represents the highest potential for impacts to marine mammals, as assessed in **Section 11.7.5** of **Volume II, Chapter 11: Marine Mammals.** Alternative methods of detonation such as low-yield and low-order disposal where practicable can be used as embedded mitigation. The donor charge sizes for low-order disposal are very small in comparison of all disposal approaches and therefore, where successful, low-order disposal represents the lowest potential impact and preferred method. The potential for physical trauma, PTS or behavioural disturbance is much reduced for low-yield disposal, corresponding only to the size of the donor charges to be used.

5.2 Assessment Outcomes and Mitigation Procedures

Table 25.2.4 summarises the impact ranges for the various FHGs against various charge weights. Whilst the significance of effect from injury and/or disturbance to marine mammals from underwater noise during UXO clearance is not significant in EIA terms, it is important to note that all cetaceans are EPS and under EPS legislation it is an offence to injure a single individual (this includes PTS auditory injury). Therefore, the Developer has committed to a UXO MMMP to further reduce the risk of physical trauma or PTS-onset. Any charge with PTS-onset impact ranges greater than 1,000 m would be required to implement noise abatement to reduce risk of injury to mitigatable ranges.

To deter marine mammals from potential injury zones, ADDs will be deployed during pre-watch periods. Details of ADD use and soft-start charges will need to be tailored to the anticipated UXO sizes requiring clearance at the site and the different methods of UXO disposal which may be applied.

Table 25.2.4 shows the potential impact radius of up to 14 km for unmitigated detonations up to a maximum of 800 kg. It has been assumed that avoidance and alternatives, such as low order detonation will be considered for the UXO inventory for the Proposed Development where appropriate.

Given the above and the information assessed within **Volume II, Chapter 11: Marine Mammals**, the risk of injury from underwater noise as a result of UXO clearance will be Low adverse for harbour porpoise, minke whale and grey seal, and Negligible adverse for dolphin and harbour seal. Given the above and the information assessed within **Volume II, Chapter 10: Fish, Shellfish and Sea Turtle Ecology,** the risk of injury from underwater noise as a result of UXO clearance will be Slight adverse for basking shark and sea turtles. Any disturbance effects would be short-term due to the limited time estimated to clear any UXO.

Table 25.2.4 Summary of auditory injury (PTS-onset) impact ranges for UXO detonation using the impulsive noise criteria from Southall *et al.* (2019) for marine mammals.

Charge weight (kg)	**PTS-onset (unweighted SPL_{peak})**				**PTS-onset (weighted SEL_{ss})**			
	VHF cetacean	HF cetacean	LF cetacean	PCW	VHF cetacean	HF cetacean	LF cetacean	PCW
0.5 (low order)	1.2 km	70 m	220 m	240 m	110 m	<50 m	320 m	60 m
25 + donor	4.6 km	260 m	820 m	910 m	570 m	<50 m	2.2 km	390 m
55 + donor	6.0 km	340 m	1.0 km	1.1 km	740 m	<50 m	3.2 km	570 m
120 + donor	7.8 km	450 m	1.3 km	1.5 km	950 m	<50 m	4.7 km	830 m
240 + donor	9.8 km	560 m	1.7 km	1.9 km	1.1 km	<50 m	6.5 km	1.1 km
525 + donor	12.0 km	730 m	2.2 km	2.5 km	1.4 km	50 m	9.5 km	1.6 km
700 + donor	14.0 km	810 m	2.4 km	2.7 km	1.5 km	60 m	10.0 km	1.9 km
800 + donor	14.0 km	840 m	2.6 km	2.8 km	1.6 km	60 m	11.0 km	2.0 km

5.3 Mitigation zone and pre-detonation watch

If detonation is deemed required, a mitigation zone of 1,000 m from the detonation location will be established, within which it will be ensured, through visual observations (trained and experienced MMOs), ADD (refer to Section 5.4) and PAM where required, that no marine mammals are present prior to the detonation event. Visual monitoring will be conducted in accordance with DAHG (2014) guidance and PAM will be conducted following JNCC (2010) guidance (new guidance is due to be released in 2024 which will be followed if published prior to the Proposed Development's activities). The pre-detonation monitoring should be conducted for a minimum of 30 minutes. Should a marine mammal be detected within the mitigation zone during this time, the monitoring period should be extended by a further 30 minutes. Once 30 minutes has elapsed since the last marine mammal detection, detonation operations may proceed. This pre-detonation procedure is appropriate to the conditions at this site which is applicable in locations of up to 200 m water depth.

In accordance with DAHG, detonations will only occur during daylight and with a strong preference for calm sea conditions. It is advised that, where possible, detonations be scheduled for early in the day to allow a buffer should marine mammal detections warrant delays. This will reduce the risk of operations having to cease due to nightfall. Ensuring that no marine mammals are present in the mitigation zone prior to detonation will reduce the risk of physical trauma to any species of marine mammal to negligible.

Due to the potential volatile nature of UXO clearance, two MMOs are required to monitor the mitigation zone. Typically, one or two vessels survey around the 1,000 m MMMZ border on vessels with an observation platform that covers the MMMZ. One MMO is typically deployed on a smaller vessel that can vacate the explosive area quickly. This vessel, normally a rigid inflatable boat (RIB), will be stationed near the detonation location during the pre-watch and then vacates the explosive zone prior to detonation.

5.4 Acoustic Deterrence Device (ADD)

For all methods of UXO disposal that may be used and UXO/charge sizes that may be detonated, PTS impact ranges for harbour porpoise may exceed the 1,000 m mitigation zone thus there is a residual risk of auditory injury to marine mammals at a greater range than can be mitigated by monitoring of the 1,000 m MMMZ alone. Therefore, an ADD will be operated for a pre-determined length of time, concurrent to the pre-detonation search, to deter marine mammals to a greater distance prior to any detonation. For the site specific UXO clearance activities, it will be necessary to operate the ADD for different durations according to the UXO disposal method used, UXO/charge size, and associated predicted impact ranges.

For example, for low-yield disposal and low-order or high-order disposal of UXOs with a combined UXO and donor charge size of up to 50 kg, the use of pre-detonation search and ADD measures may be considered to reduce the risk of auditory injury (PTS) to negligible for all marine mammal species.

5.5 Soft-start charges

While the effectiveness of soft-start charges for displacement of marine mammals is currently unknown, it is assumed that a series of small detonations of increasing size will induce avoidance behaviour and provide additional time for animals to move away prior to the main detonation. For combined UXO/charge sizes > 50 kg and up to 300 kg, to reduce the risk of PTS to negligible, there is less evidence that ADDs will be able to exclude marine mammals to the greater distance necessary to avoid risk of an injury. Therefore, for low-order or high-order disposal of UXO/charge sizes > 50 kg and up to 300 kg, following ADD use, additional mitigation in the form of soft-start detonations should be undertaken.

This practice has been widely adopted in recent UXO clearance operations. Depending on the size of the UXO/charge, it is proposed to use between 2-4 soft-start charges between 50- 200 g each, spaced at 5-minute intervals. For all species, the maximum predicted impact range for PTS from the soft-start charges is <1 km therefore, these detonations, following ongoing ADD use and pre-detonation search, do not themselves pose a risk of injury.

5.6 Post-detonation search

It is recommended for the MMO on the vessel to undertake a post-detonation search of the mitigation zone for at least 15 minutes after the final detonation, to look for evidence of injury to marine life, including any fish kills. Any other unusual observations will be noted in the post-activity report.

5.7 Reporting

A detailed record of UXO clearance operations, mitigation procedures and marine mammal sightings will be prepared and submitted in compliance with consent conditions and will include completion and submission of standardised forms in line with the 'Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters' (DAHG, 2014).

Reporting will include a record of:

- All confirmed UXO identified, including estimated size, type, location and water depth;
- The approach taken for each confirmed UXO, including the dates, times, disposal method attempted, size, type and number of donor charge(s) used;
- Vessel presence, location and activity during UXO clearance operations;
- The outcome of each UXO disposal, including evidence of high-order detonation, any clearing charges required and method of debris and residue recovery;

- The mitigation procedures followed for each UXO disposal, including details of visual observations, ADD duration and size and timing of soft-start charges where required;
- All marine mammal sightings and completed marine mammal recording forms; and
- Any problems encountered and instances of non-compliance with the JNCC (2010)/DAHG (2014) guidelines, MMMP and variations from agreed procedures.

Reports will be collated and provided to MARA for information once the works are complete, alongside a summary report of the numbers of marine mammals recorded (visually or acoustically) and any mitigation required during UXO clearance. The report will also discuss the protocols followed, and put forward any recommendations based on project experience, that could benefit future OWF construction projects.

6. Impact Hammer Piling Mitigation Methodology

6.1 Introduction

To minimise the risk of any auditory injury to marine mammals and sea turtles from underwater noise during pile driving, the Developer will implement a number of Factored In Measures (see **Table 11.15** within **Volume II, Chapter 11: Marine Mammals**) including:

- Marine mammal observation of a 1,000 m MMMZ;
- Passive acoustic monitoring (PAM); and
- Soft-start procedure; and
- Pre-piling deployment of ADD.

Details of each of the mitigation measures listed above, are detailed in their relevant sections below.

6.2 Assessment Outcomes and Mitigation Procedures

6.2.1 Instantaneous and cumulative PTS-onset

Impact ranges for marine mammals were calculated using the Southall *et al.* (2019) impulsive criteria. **Table 25.2.5** presents modelled PTS onset impact ranges for marine mammals within two scenarios of unmitigated pile-driving (i.e. 7 m or 11m pile diameter) with two different maximum hammer energies (e.g. 4,000 kJ or 6,600 kJ). The largest instantaneous PTS-onset impact range (SPL_{peak}) for impact piling is estimated at 750 m for harbour porpoise (installing an 11 m pile with a maximum hammer energy of 6,600 kJ at the SW location). For all other marine mammal receptors, the maximum range was <60 m.

The largest PTS-onset impact range was for the weighted cumulative sound exposure level (SEL_{cum}) for minke whales, which was predicted to be 19 km. For all other marine mammal receptors, the maximum range for SEL_{cum} was 10 km for harbour porpoise, 400 m for seal species, and <100 m for dolphin species (**Table 25.2.5**). The greatest impact ranges correlated with the locations with the deepest water depth.

Impact ranges for fish species were calculated using the Popper *et al.* (2014) pile driving criteria, where species of fish were categorised by whether they possess a swim bladder, and whether it is involved in a fish's hearing function. As basking sharks do not have swim bladders, they are categorised as 'fish: no swim bladder' in Popper *et al.* (2014). For this category, the largest instantaneous PTS-onset impact range for SPL_{peak} was estimated at 130 m (213 dB re 1µPa) from the SW location. Several studies suggest that underwater noise causes little or no damage to fish without swim bladders (Goertner *et al*., 1994; Stephenson *et al.,* 2010; Halvorsen *et al*., 2012). Basking sharks are therefore considered to be at negligible risk of injury from the Proposed Development's activities.

Popper *et al*. (2014) noted that sea turtles can experience mortality and potential mortal injury when exposed to noise levels greater than 210 dB re 1 µPa² s (weighted SELcum) or 207 dB re 1µPa (unweighted SPLpeak). Sea turtles may be affected by pile driving noise both physiologically and behaviourally, but the effects of noise are largely unknown due to a lack of information on hearing capabilities and responses to sound (Dow Piniak *et al*., 2012; Díaz *et al*., 2024). Impact ranges for sea turtles have been modelled in the same category as fish species (**Table 25.2.5**).

If an individual is within the impact ranges of SPLpeak during full power, they risk immediate onset of a permanent or temporary threshold shift (PTS/TTS) in hearing. To limit this risk, the Proposed Development will follow standard DAHG (2014) guidelines, which incorporates a pre-watch and soft-start procedure. Marine mammals typically flee when exposed to loud noises within their hearing ranges. This means that the received level decreases as they increase the distance from the source. However, if an animal remains within the SELcum impact ranges (assessed over a 24-hour period) they can accumulate a dose over that time which can lead to cumulative PTS or TTS.

The largest predicted instantaneous PTS-onset impact range (SPL_{peak}) falls within 750 m, which will be mitigated for with passive mitigation measures (e.g. MMO pre-watch over the recommended 1,000 m mitigation zone (DAHG, 2014) and soft-start procedure). However, the largest cumulative PTS-onset impact ranges (SEL_{cum}) were predicted up to 19 km for minke whales, which would require additional mitigation that is not achievable with current mitigation methods. The MMO pre-watch will ensure no marine mammals are within instantaneous PTS-onset impact range prior to activities commencing and the soft-start procedure will encourage individuals to flee the ensonified area without risk of instantaneous injury. These impact ranges are based on a precautionary scenario for piling parameters. For example, piling is modelled to occur at a maximum hammer energy of 4,000 kJ or 6,600 kJ depending on pile location, but seabed conditions may allow for successful pile installation using less than the maximum hammer energies modelled, which would lessen the impact ranges.

Table 25.2.5 Summary of the modelled PTS onset impact ranges for marine mammals at the various locations within two scenarios of unmitigated pile-driving with two different maximum hammer energies.

Species	Threshold	Monopile (at 4,000 kJ hammer energy) maximum range (m)						Monopile (at 6,600 kJ hammer energy) maximum range (m)			
		NW location 7 m	NW location 11 m	C location 7 m	C location 11 m	N-OSP location 7 m	N-OSP location 14 m	SW location 7 m	SW location 11 m	S-OSP location 7 m	S-OSP location 14 m
Very high frequency (VHF) cetacean (e.g. harbour porpoise)	Unweighted SPL_{peak} 202 dB re 1µPa	490	500	690	700	570	580	680	750	670	680
	Weighted SEL_{cum} 155 dB re 1 µPa² s	4,600	4,600	9,100	9,100	5,400	5,400	10,000	10,000	10,000	10,000
High frequency (HF) cetacean (e.g. bottlenose, common and Risso's dolphin)	Unweighted SPL_{peak} 230 dB re 1µPa	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
	Weighted SEL_{cum} 185 dB re 1 µPa² s	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
Low frequency (LF) cetacean (e.g. minke whale)	Unweighted SPL_{peak} 219 dB re 1µPa	<50	<50	<50	<50	<50	<50	50	50	<50	<50
	Weighted SEL_{cum} 183 dB re 1 µPa² s	7,500	7,600	17,000	17,000	9,400	9,500	18,000	19,000	18,000	18,000
	Unweighted SPL_{peak} 218 dB re 1µPa	<50	<50	50	50	<50	<50	<50	60	60	60

Species	Threshold	Monopile (at 4,000 kJ hammer energy) maximum range (m)						Monopile (at 6,600 kJ hammer energy) maximum range (m)			
		NW location 7 m	NW location 11 m	C location 7 m	C location 11 m	N-OSP location 7 m	N-OSP location 14 m	SW location 7 m	SW location 11 m	S-OSP location 7 m	S-OSP location 14 m
Phocids in water (PCW; e.g. grey and harbour seal)	Weighted SEL_{cum} 185 dB re 1 µPa^2 s	<100	<100	400	500	<100	<100	380	400	200	200
Fish and sea turtles	Unweighted SPL_{peak} 213 dB re 1µPa	90	90	120	120	110	110	130	130	120	120
	Unweighted SPL_{peak} 207 dB re 1µPa	230	230	310	310	270	270	330	340	310	310

Key: NW = northwest (18.7 m water depth), C = centre (35.6 m water depth), SW = southwest (30.3 m water depth), N = north (24.4 m water depth), S = south (26.3 m water depth.

Note: Impact ranges for marine mammals were predicted using thresholds derived from Southall *et al.* (2019) criteria and from Popper *et al.* (2014) for fish and sea turtles. Impact ranges were modelled without use of noise abatement/mitigation systems.

Maintenance activities to support the ongoing operation of the Proposed Development will be spatially and temporally small scale, with any impacts likely to be much less than during construction works. It should be noted that drilling and potential piling activities are only planned for the construction phase and, therefore, potential disturbance to marine mammals during maintenance activities will largely be in relation to vessel presence.

Given the above and the information assessed within **Volume II, Chapter 11: Marine Mammals**, the risk of injury from underwater noise as a result of piling will be Low adverse for harbour porpoise and minke whale, and Negligible adverse for dolphin and seal species. Given the above and the information assessed within **Volume II, Chapter 10: Fish, Shellfish and Sea Turtle Ecology,** the risk of injury from underwater noise as a result of piling will be Slight adverse for basking shark and sea turtles. Any disturbance effects would be short-term due to the limited time estimated to install the WTG foundation piles.

6.3 Mitigation Zone

The mitigation zone is defined as the maximum potential instantaneous PTS onset impact range. The Developer will update the noise modelling, if required, prior to construction once the final project design option(s) is consented. The DAHG (2014) guidance recommends a mitigation zone of 1,000 m for piling, which is greater than the largest impact range for instantaneous PTS onset predicted for the Proposed Development (i.e. 750 m). Therefore, following a precautionary approach, the Proposed Development will use a 1,000 m mitigation zone.

6.4 Marine Mammal Observers (MMO)

The DAHG (2014) guidance recommends a pre-piling search of a minimum period of 30 minutes (in waters less than 200 m) for monopiles. This pre-piling search will be conducted by a trained, experienced and dedicated MMO, who will be stationed on the piling vessel at an appropriate elevation that provides a 360^{o} view of their surroundings. A trained and experienced MMO requires an individual to have passed a Joint Nature Conservation Committee (JNCC) MMO training course, or equivalent, and hold a minimum of six weeks marine mammal survey experience at sea over a period of 3-years in European waters. Required equipment to perform MMO duties includes either reticule binoculars or range stick, to enable range estimation from the observation platform to the sighted individual, and a VHF radio to enable effective communication to the operations and vessel crew.

Passive Acoustic Monitoring (PAM – see **Section 6.5**) can support visual observation in poor weather conditions or visibility (<1 km). This monitoring method has been used routinely since 2002 under jurisdictions following JNCC mitigation guidelines (JNCC, 2023). PAM will be used as a form of mitigation under hours of darkness when an MMO cannot visually observe. This will be necessary if there is a break greater than 10 minutes during darkness or if piling activities commence during darkness, otherwise the operations would need to wait until daylight. The PAM operator will follow the same data forms and communications procedure as the MMO.

The MMO will record all periods of marine mammal observations, including the start and end times of their visual effort, details of the operations, environmental conditions (sea state, weather, visibility, etc.) and any sightings of marine mammals around the piling vessel, using standardised data forms (Appendix 6 in DAHG (2014) guidance).

If a marine mammal or sea turtle is detected within the mitigation zone during the MMO pre-piling watch, the soft-start procedure will be delayed until the MMO has observed, assessed and confirmed that the individual(s) has vacated the MMMZ, and there have been no sightings for at least 20 minutes. If a marine mammal is observed within the mitigation zone during the soft-start, pilling will halt if safe to do so. Alternatively, hammer power does not increase until the animal has vacated the mitigation zone. If a marine mammal is observed within the mitigation zone during full power, pile-driving may continue and the MMO will continue to note marine mammal presence and observations of animal behaviour, where possible.

MMO limitations include a reduced chance of detecting low profile marine mammals, such as harbour porpoise, in a Beaufort sea state greater than two (Gunnlaugsson *et al.,* 1988, as referenced in Teilmann, 2003). Larger cetaceans (*i.e.* dolphins and whales) can generally be sighted at and under a sea state four (Smith *et al.,* 2020). Sea turtles are difficult to detect offshore due to their low profile, where observers typically only see their head in a sea state less than 1, or if observed directly overhead. As sightings are often quick encounters, there is little time for the MMO to capture the individual on camera which makes it difficult, if not impossible, to confirm or review a detection at a later stage. The height of the vantage point used for observation is a principal factor in determining how far an MMO can see. So long as the MMO has good environmental/weather conditions (*i.e.* visibility, sea state and swell), an MMO that is 1.65 cm tall stationed on a platform 5 m from the water's surface could see up to 1,320 m, a platform height of 10 m would increase this viewing distance up to 2,320 m (as calculated through typical trigonometry methods as used by MMOs *e.g.* distance (m) = ((observation height (m)) x 1000/no. of mils in the binocular reticule).

6.5 Passive Acoustic Monitoring (PAM)

PAM is viewed as a complementary method to aid MMOs in low visibility (e.g. fog or heavy precipitation) and a supplementary method in periods of darkness. Projects that follow JNCC guidelines have used PAM as part of their mitigation measures routinely since 2002 (JNCC, 2023). PAM equipment includes a hydrophone array (which is placed over the side of the pile-driving vessel; multiple hydrophones within an array enables the PAM operator to gain a better understanding of bearing and distance to a vocalisation), deck cable, data acquisition units (DAQs) and computer/laptop set up with acoustic analysis software such as PAMGuard (Gillespie *et al.,* 2008). PAMGuard is an open-source software (www.pamguard.org) which has become the industry standard for monitoring, recording and analysing marine mammal vocalisations. As the platform is used by academics and industry scientists, the programming is constantly being updated to allow the integration of a range of additional plug-in modules. These additional modules can be set up to assist in species identification (e.g. detectors and classifiers), improve localisation features (e.g. maps and mapping, and localisers), improve data recording and annotation, for example.

PAM is the best available method of monitoring during low visibility and hours of darkness; in addition, the Developer will also deploy an ADD prior to commencing operations to encourage individuals to move out of the mitigation zone. The use of the ADD as part of the mitigation measures further reduces any risk to marine mammals where PAM may not detect individuals, for example, if they do not vocalise during the pre-watch period.

6.6 Pre-Piling Deployment of ADDs

The Developer will use an ADD to ensure that there are no marine mammals in the MMMZ, prior to the commencement of piling.

The typical ADD used for mitigation is a Lofitech AS Seal Scarer, but other suitable alternatives are available (McGarry *et al.,* 2022); the ADD type to be used will be agreed with MARA and NPWS. The Lofitech AS seal scarer has been used for marine mammal mitigation purposes at a range of European OWF projects during the construction phase, including the C-Power Thornton Bank OWF in Belgium (Haelters *et al.,* 2012), and the Horns Rev II, Nysted and Dan Tysk OWFs in Denmark (Carstensen *et al.,* 2006, Brandt *et al.,* 2009, Brandt *et al.,* 2011, Brandt *et al.,* 2013, Brandt *et al.,* 2016). Within the UK, Lofitech AS seal scarer has been used as mitigation for Dudgeon OWF (Vattenfall, 2017) Beatrice OWF and Race Bank OWF (Seagreen Wind Energy Ltd, 2020).

PAM studies have shown that the Lofitech AS Seal Scarer deters harbour porpoises to a range of 7 km (Graham *et al.,* 2023). Aerial survey studies have shown that ADDs are effective for harbour and grey seals at a range of approximately 1 km (Götz and Janik, 2010; Götz, 2008) and minke whales have been observed to flee to distances greater than 5 km (maximum tracking range noted within the study; Boisseau *et al.,* 2021; McGarry *et al.,* 2017). In the minke whale study, the deterrence effect continued after the ADD was deactivated with the animals continuing to swim away from the ADD location out to up to 5 km (at which point tracking was halted). This suggests that an ADD would deter minke whales further if activated for longer than the duration used in the study (i.e. 15 minutes; McGarry *et al.,*2017).

It is proposed that during pile-driving activities, one ADD will be deployed from the deck of the pilling vessel with enough cable length to allow the transducer to be positioned under the hull. The control unit and power supply will be set up in a suitable, safe position on deck where it can be secured to the vessel and located in an area of easy access for the MMO to deploy and operate during pre-watch. The MMO will be responsible for the coordination of the deployment, maintenance, operation, and recording/reporting of the ADD activity. During nighttime operations, the PAM operator cannot be responsible for the deployment and operation of the ADD whilst monitoring the PAM computers; therefore, during mobilisation the MMO will train a member of the crew that will be positioned on night shift on deployment and retrieval of the ADD and demonstrate how to switch the ADD on and off. This crew member will be given a VHF to allow communication with the PAM operator during operations to ensure the procedures and protocols are followed correctly.

Following the swim speeds used in the underwater noise modelling (**Volume III, Appendix 11.1: Underwater Noise Assessment)** the average swim speed of 1.5 ms^{-1} for harbour porpoises, bottlenose dolphins and seals, and 3.25 ms^{-1} for minke whale, have been used to calculate ADD duration (**Table 25.2.6**). The swim speeds used for bottlenose dolphin and seal species are considered conservative (other citations note greater swim speeds: e.g. bottlenose dolphin: 1.52 ms^{-1}; Bailey and Thompson, (2010), seals: 1.8 ms^{-1}; Thompson, (2015)).

Table 25.2.6 provides the duration for which an active ADD would be required to mitigate the noise impacts for the WTG and OSP foundation installation, as calculated based on the information above.

Table 25.2.6 Modelled PTS onset ranges for SPL_{peak} and SEL_{cum} thresholds based on Southall *et al*. (2019) and the duration an active ADD would be required to ensure marine mammals are outwith their respective impact ranges.

Relevant species	Species PTS onset threshold	Swim speed (ms^{-1})	Max PTS onset range (m)+	ADD duration (minutes)
Minke whale	LF cetacean (219 dB SPL_{peak})	3.25	50	<1
	LF cetacean (183 dB SEL_{cum})	3.25	19,000*	97.44
Dolphins (e.g. bottlenose dolphin)	HF cetacean (230 dB SPL_{peak})	1.5	<50	<1
	HF cetacean (185 dB SEL_{cum})	1.5	<100	1.11
Harbour porpoise	VHF cetacean (202 dB SPL_{peak})	1.5	750	8.33
	VHF cetacean (155 dB SEL_{cum})	1.5	10,000*	111.11
Seals	PCW (218 dB SPL_{peak})	1.5	60	<1
	PCW (185 dB SEL_{cum})	1.5	400	4.44

+ based on a starting distance of 0 m from the pile
*Estimated PTS onset range is greater than studies have shown effective deterrent ranges of ADDs

The ADD durations relating to SPL_{peak} presented in **Table 25.2.6** would likely ensure that the risk of instantaneous injury from piling is reduced to negligible (by allowing all animals time to swim out of any potential instantaneous PTS onset ranges), prior to the first hammer strike. However, reported effective deterrent ranges suggest that an ADD may not deter harbour porpoise further than 7 km away, and in the case of minke whale, monitoring only occurred up to 5 km away, meaning maximum deterrence distances are uncertain. Extended duration of ADD activation for cumulative impact ranges for harbour porpoise and minke whale are highly unlikely to be effective in deterring animals to those distances. Extended durations are more likely to add unnecessary noise into the environment. Therefore, long ADD activation durations are not considered to be a feasible mitigation option. Furthermore, the cumulative impact range is precautionary, and does not include the use of an ADD pre-pile driving, which would further reduce the impact radius. Nonetheless, where ADDs will reduce the impact radii presented in **Table 25.2.7** the risk of cumulative PTS remains a minor risk for these species.

Taking a conservative approach and considering the duration of ADD activation used in studies investigating the effectiveness of ADDs as a tool for mitigation (Boisseau *et al.,* 2021; McGarry *et al.,* 2017), it is proposed that the ADD is deployed for a maximum of 20 minutes before the commencement of the soft-start and will be switched off upon commencement of piling. Based on the calculations used in **Table 25.2.7**, this period of ADD activation will also allow harbour porpoise and minke whale to reach 1.8 km and 3.9 km, respectively, prior to pile driving commencing. This is considered conservative, as the aforementioned studies used an ADD duration of 15 minutes and reported flee distances, of 7 km and 5 km for harbour porpoise and minke whale, respectively (Boisseau *et al.,* 2021; McGarry *et al.,* 2017). The soft-start piling sequence will then continue to ramp up while it is expected that marine mammals will continue moving away from the sound source. **Table 25.2.7** estimates the distances that could potentially be reached by the receptors if the estimated swim speed was maintained and individuals swam in the same direction for the entire duration of ADD activation, followed by the modelled soft-start and ramp up procedure. The specified ramp up is based on a conservative assessment and is not reflective of the actual change in energy for all piles; however, it can be interpreted as an upper limit on the allowable energy at any time during the piling event.

Table 25.2.7 Estimated distances reached by receptor species if the recommended ADD activation, soft-start and ramp-up procedure is implemented consecutively.

Species	Swim speed (ms^{-1})	Total distance reached after 20 minutes ADD activation	Total distance reached after additional 30 minutes soft-start	Total distance reached after additional 70 minutes ramp-up (4,000 kJ scenario)*	Total distance reached after additional 146.67 minutes ramp-up (6,600 kJ scenario)*
Minke whale	3.25	3.9 km	9.75 km	23.4 km	28.6 km
Bottlenose dolphin, harbour porpoise, grey and harbour seals	1.5	1.8 km	4.5 km	10.8 km	13.2 km

*Ramp up distances represent the estimated distance the receptors could reach, if the swim speed remained consistent for the duration stated, for each hammer energy scenario (4,000 or 6,600 kJ) and are therefore independent of each other

The proposed ADD durations, combined with the MMO/PAM pre-piling watch described in **Section 6.4** (or PAM described in **Section 6.6**) and soft-start procedure described in **Section 6.7**, present the best available mitigation measures to reduce the risks by as much as reasonably practicable. These measures increase the probability that marine mammals are outside of the PTS onset range, prior to the start of piling.

It should be noted that the calculations of the required duration for the ADD deployment assumes that the animals are present adjacent to the vessel when the ADD is activated. As noted above, recent studies of impacts from construction at offshore wind farms showed that the presence of vessels alone (prior to the start of any piling activity) contributed to deterrence of harbour porpoises from a very close range (Graham *et al*., 2019) and therefore it is likely that the mammals will be much further away than the minimum distances identified above. Less is known regarding minke whale response to vessels where some studies have recorded little behavioural response to vessels alone (Bland *et al.,* 2023), but individuals have been observed to show aversion to sonar activity (Durbach, *et al.,* 2021). The proposed ADD durations are considered to provide a conservative time period for animals to vacate the impacted area whilst not adding excessive noise into the marine environment.

6.7 Soft-Start Procedure

Following the pre-piling procedures (as identified above, ADD activation and MMO/PAM pre-piling watch), a soft-start procedure for piling will commence (as shown in **Table 25.2.8** and **Table 25.2.9**). The specified ramp up is based on a conservative assessment and is not reflective of the actual change in energy for all piles; however, it can be interpreted as an upper limit on the allowable energy at any time during the piling event.

This will comprise a maximum scenario of 10 minutes slow strike rate of one blow every 10 seconds up to 825 kJ (20% and 12.5% of the respective maximum hammer energies modelled) followed by 20 minutes of 30 blows per minute up to 825 kJ. Once the proposed 30 minutes of soft-start (increasing blow rate at low hammer energy) is complete, the hammer energy will increase over time as a ramp up to the required hammer energy required to reach penetration depth. The specified ramp up is based on a conservative assessment and is not reflective of the actual change in energy for all piles; however, it can be interpreted as an upper limit on the allowable energy at any time during the piling event.

Table 25.2.8 Summary of the soft start and ramp up scenario used for both the 11 m and 7 m monopile foundation modelling at the NW and C WTG locations. Source: Volume III, Appendix 11.1: Underwater Noise Assessment.

	825 kJ		1,550 kJ	2,275 kJ	3,000 kJ	3,300 kJ	3,600 kJ	4,000 kJ
Number of strikes	6	600	400	400	400	450	450	3,300
Duration	10 min	20 min	13 min 20 sec	13 min 20 sec	13 min 20 sec	15 min	15 min	110 min
Strike rate	0.6 blow/min	30 blow/min						
6,006 strikes, 3 hours 30 minutes duration								

Table 25.2.9 Summary of the soft start and ramp up scenario used for the 11 m and 7 m monopile foundation modelling at the SW WTG location. Source: Volume III, Appendix 11.1: Underwater Noise Assessment.

	825 kJ		1,550 kJ	2,275 kJ	3,000 kJ	4,000 kJ	4,450 kJ	6,600 kJ
Number of strikes	6	600	400	400	400	2,750	450	4,000

Duration	10 min	20 min	13 min 20 sec	13 min 20 sec	13 min 20 sec	91 min 40 sec	15 min	133 min 20 sec
Strike rate	0.6 blow/min	30 blow/min						
9,006 strikes, 5 hours 10 minutes duration								

It should be noted that this modelling scenario is based on the upper bounds of the soil conditions and is therefore deemed precautionary. Therefore, whilst piling will adhere to the ramping up process, the hammer energy will not be increased above that which is necessary to complete the piling. For example, if ground conditions are such that a lower hammer energy (<4,000 or 6,600 kJ, respectively) is sufficient to complete installation, then the hammer energy will not unnecessarily be ramped up to the maximum capacity.

6.8 Breaks in Piling Procedure

Standard DAHG (2014) guidance for breaks in piling activity (high output pile driving) will be followed should they occur. If there is a break in piling operations for a period of greater than 10 minutes, then a pre-piling search and soft-start procedure will be repeated prior to piling recommencing, if it is possible to do so. If a watch of the mitigation zone has been continued, the MMO/PAM operator will confirm the presence or absence of marine mammals and it may be possible to commence the soft-start immediately. If there has been no watch, then a pre-piling search will need to be undertaken prior to soft-start commencing.

Under some circumstances, it may not be possible to recommence piling with a soft-start procedure due to technicalities such as ground conditions and equipment limitations. In this case the ADD will be deployed prior to re-commencing piling, following pre-piling search. This will align to DAHG guidance which advises where ramp-up is not possible, alternatives will be implemented whereby the underwater output of acoustic energy is introduced in a consistent, sequential and gradual manner over a period of 20-40 minutes prior to commencement of the full necessary output.

Where possible (i.e. if vessel remains on site), MMO/PAM operator maintain watch throughout any break in piling activities to ensure that no marine mammals are present within the 1,000 m radius.

6.9 Delays in the commencement of piling

There is a risk of animals moving into the mitigation zone when there is no piling activity nor ADD activation. If ADDs are activated for their permitted duration and piling is not ready to commence, the ADD will be switched off. This is to avoid unnecessary noise entering the marine environment. The ADD will not be switched on until the ADD operator is notified that piling is ready to commence and the Developer will follow the procedure as set out in this MMMP (i.e. MMO/PAM pre-watch, ADD activation and soft-start).

6.10 Communications

The MMO, PAM and ADD operator will be appointed either directly or indirectly by the Developer. A communications protocol will be developed between the MMO/ADD operator, the PAM operator and ADD operator (a trained crew member on night shift) and the construction manager and/or appropriate crew members (e.g. hammer operators and Operations Manager). The below section details the personnel, organisations, and responsibilities for the MMMP:

The Developer's Environmental Manager

Overall responsibility for compliance with all environmental monitoring, mitigation and reporting requirements on the Proposed Development. Will ensure that the MMO, PAM/ADD operator, nominated Client Representative for construction activities and installation personnel have received all relevant information, and will consult with them before making decisions affecting the MMMP.

MMO and PAM operator(s) (to be confirmed)

Responsible for advising on, monitoring and recording compliance with this MMMP. Liaises with the nominated Client Representative for construction activities, and Offshore Construction Contractor as appropriate. PAM and MMO responsibilities cannot be shared by one person. The PAM operator is responsible for the PAM equipment (verification and calibration prior to use) in accordance with the MMMP, co-ordination of deployment, maintenance, operation, and recording/reporting.

ADD operator(s)

Responsible for the provision of equipment (verification and calibration prior to use) in accordance with the MMMP, co-ordination of deployment, maintenance, operation and recording/reporting. The ADD operator can work a dual role as the MMO; however, the ADD and PAM operator cannot be the same person. If ADD operation is required during darkness, a crew member on night shift will be trained by the MMO/ADD operator during mobilisation.

Nominated Client Representative for construction activities (the Developer)

Takes offshore responsibility that the requirements of this MMMP are met, responsible for ensuring adequate communication and liaison between MMO/PAM operator and installation personnel as required. The Client Representative (and/or MMO/PAM operator) has the responsibility to delay piling activities if necessary to do so.

Offshore Construction Contractor (to be confirmed)

Responsible for informing MMO/PAM operator about scheduled piling activity and communication as per protocol. Responsible for providing pile driving records to MMO/PAM operator and Client representative.

The communications protocol and flow charts will include but not be limited to procedures:

- To notify the MMO to begin 30-minute pre-watch prior to soft-start commencing;
- For the MMO/PAM operator to give the nominated Offshore Construction Contractor the green light for construction activities and that deployment of ADD and activation for the required time has been successful;
- The nominated Client Representative or Offshore Construction Contractor to notify the MMO/PAM operator that there has been a delay in the onset of the soft-start; and that the MMO/ADD operator should turn off the ADD;
- For the MMO/PAM operator to notify nominated Offshore Construction Contractor or Client Representative for construction activities that a marine mammal has been detected within the mitigation zone and that the soft-start will need to be delayed;
- The client to notify MARA that the piling operations have been successfully completed.

6.11 Reporting

A record of piling operations, MMO/PAM survey effort and sightings will be maintained during piling. These reports include:

- An outline of the marine mammal monitoring methodology and procedures employed;
- A record of all piling operations detailing dates, soft-start duration, piling duration, hammer energy during soft-start and full-power, and any operational issues;
- A record of survey effort including the duration of the MMO/PAM operator's watch, environmental conditions, a description of any marine mammal sightings, passive acoustic recordings and any actions taken A record of any incidental sightings will also be made during the pre-piling watch or operations;
- Details of any problems encountered during the piling process including any instances of non-compliance with the marine licence; and
- Any recommendations for amendment of the protocol.

Reports will be collated and provided to MARA for information once the works are complete, alongside a summary report of the numbers of marine mammals recorded (visually or acoustically) and any mitigation required during construction. The report will also discuss the protocols followed, and put forward any recommendations based on project experience, that could benefit future OWF construction projects.

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