Arklow Bank Wind Park 2

Environmental Impact Assessment Report

Volume III, Appendix 25.2: Marine Mammal Mitigation Plan (Revised March 2026)

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Arklow Bank Wind Park 2: Marine Mammal Mitigation Plan (Revised March 2026)

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Phoebe Meredith, Tierney Carter, Hannah Snead, Ross Culloch, Ophelie Humphrey-Walsh, & Sarah Brouder

COMMERCIAL IN CONFIDENCE

Client: Sure Partners Limited

Address: Inveralmond House

200 Dunkeld Road

Perth

PH1 3AQ

Project reference: P14099 Arklow Bank Wind Park 2

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Project Director: Dr. Ross Culloch, Ophelie Humphrey-Walsh

Project Manager: Phoebe Meredith, Sarah Brouder

Other: Hannah Snead, Tierney Carter, Danielle Neale

APEM Ltd
Riverview
A17 Embankment Business Park
Heaton Mersey
Stockport
SK4 3GN

Tel: 0161 442 8938
Fax: 0161 432 6083

Registered in England No. 02530851

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1.0	16/05/2024	Final (External)	APEM Ltd	GoBe Consultants	Sure Partners Limited
2.0	13/01/2026	Final External (Revised March 2026)	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

Experts	Qualifications	Relevant Experience
		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 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,

Experts	Qualifications	Relevant Experience
		primarily in relation to conservation and management, and anthropogenic impacts including fisheries interactions, collision risk and underwater noise.
Sarah Brouder	M.Sc. Water and Coastal Management, University of Bologna. BSc. (Hons) Zoology, University College Cork.	Sarah is a Senior Marine Mammal Consultant at APEM with experience in environmental consultancy, marine mammal research and field work. Throughout her career, Sarah has worked on a number of marine mammal assessments for offshore projects across the Ireland and the UK, and has a practical understanding of legislation and policy governing marine mammals at a national and international level. Sarah has considerable experience collecting and interpreting baseline data, including from Passive Acoustic Monitoring (PAM), boat-based visual surveys and vantage point surveys.
Ophelie Humphrey-Walsh	M.Sci. Marine Biology, University of Southampton.	Ophelie is a Principal Marine Mammal Consultant and technical co-lead of the marine mammal team at APEM. Ophelie joined APEM in 2024 having gained over 8 years of experience across Natural England and marine consultancy, bringing with her a wealth of experience of marine mammal technical reporting to support consents of marine industries in the UK. Since joining APEM Ophelie has worked on a range of projects in Ireland, providing document audit across EIA and HRA documentation.

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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.
Environmental Impact Assessment (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

Units

Unit	Meaning
%	Percentage
<	Less than
cm	Centimetre (distance)
dB	Decibel (sound pressure)
kJ	Kilojoules (energy)
km	Kilometre (distance)
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)

Acronyms

Term	Meaning
ABWP1	Arklow Bank Wind Park 1
ABWP2	Arklow Bank Wind Park 2
ADD	Acoustic Deterrent Device
C	Central
CMS	Convention on Migratory Species
CPT	Cone Penetration Test
CS	Celtic Sea
cum	Cumulative
DAHG	Department of Arts, Heritage and the Gaeltacht
DAS	Digital Aerial Survey
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
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
MMOA	Marine Mammal Observers Association
N	North
NPWS	National Parks and Wildlife Service
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

Term	Meaning
PAM	Passive Acoustic Monitoring
PCW	Phocid Carnivore in Water
PTS	Permanent Threshold Shift
RIB	Rigid Inflatable Boat
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

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 (Revised March 2026)** 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 (Revised March 2026)** and **Volume II, Chapter 11: Marine Mammals (Revised March 2026)**) 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;
- Unexploded Ordnance (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, referred to as an auditory injury, of marine mammals, and to reduce the risk of injurious effects to basking sharks and sea turtles. The MMMP is intended to reduce the risk of auditory injury to a negligible level. This MMMP has been developed in consideration of the '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). The mitigation measures outlined for geophysical and geotechnical surveys and UXO clearance are fully compliant with the DAHG (2014) guidance. The mitigation measures for pile driving comply with most measures in the DAHG (2014) guidance, however there are a few points of deviation (see **Section 6** for more detail).

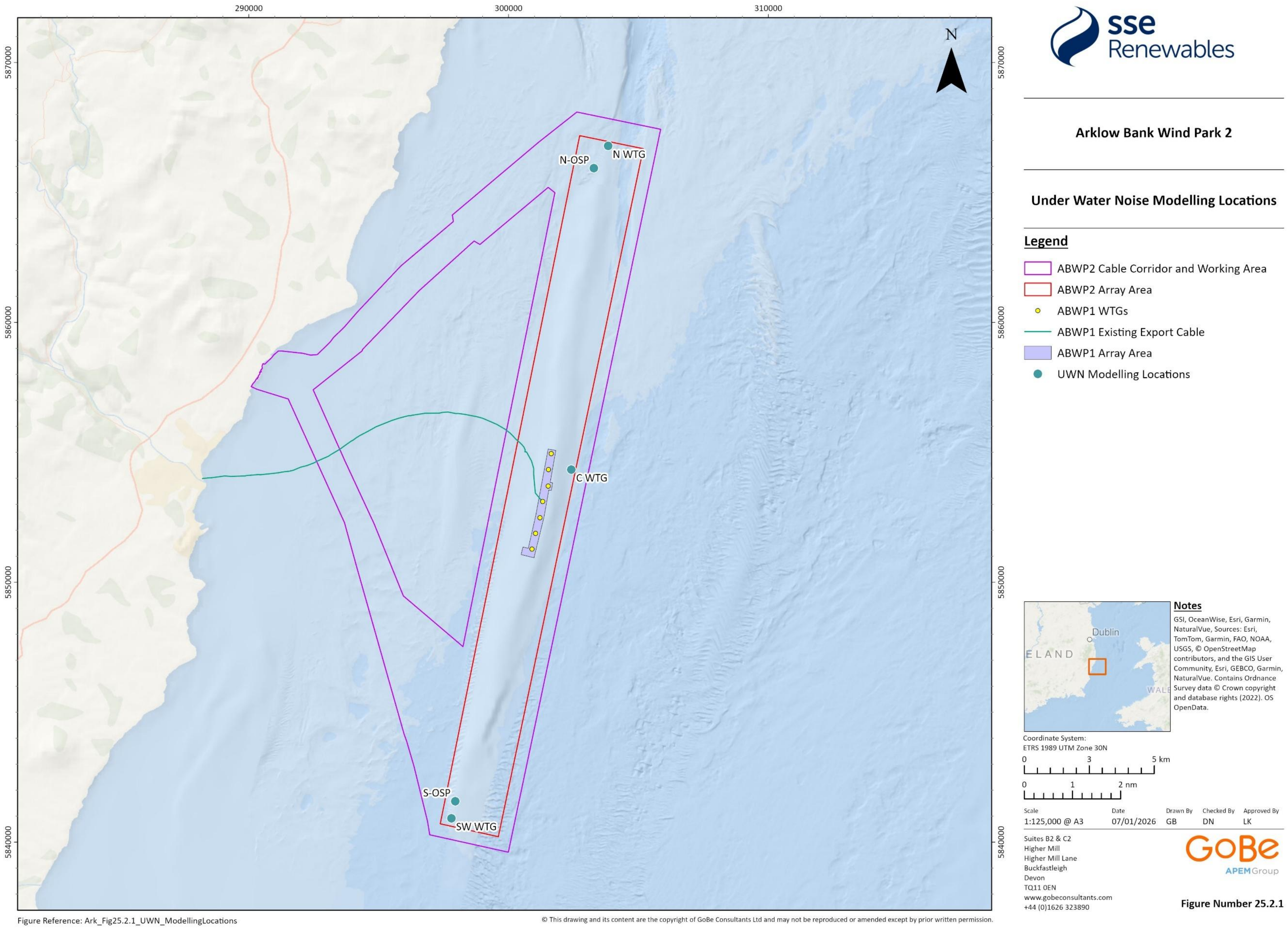

Figure 25.2.1 Underwater Noise Modelling Locations

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, basking shark and turtles 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 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 53 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 25.2.2-1** for WTGs and **Table 25.2.2-2** for OSPs.

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 (Revised March 2026)** and **Volume II, Chapter 10: Fish, Shellfish and Sea Turtle Ecology(Revised March 2026)**). 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 (Revised March 2026)** 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). The WTG and OSP foundation monopiles for both project designs will require a hammer energy of up to 3,500 kJ. To account for the variety of piling locations and scenarios in terms of underwater noise and vibration, piling activities were modelled for WTG monopiles at three locations: the north (N), central (C), and southwest (SW) (**Figure 25.2.1**). 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.**

Furthermore, the Applicant has committed to additional mitigation to reduce underwater noise generated during piling and associated impacts to sensitive marine receptors. Under this extended ramp-up mitigation scenario, the start of the ramp-up (soft-start) will commence at 400 kJ and the ramp-up duration will be extended (see Section 6.7 for further details).

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** and **Table 25.2.2-2**.

Table 25.2.2-1 Overview of Project Design Options (WTGs)

Parameter	Project Design Option 1	Project Design Option 2
Number of WTG foundations to be installed	53	47
Foundation type	monopile	monopile
Maximum hammer energy (kJ)	3,500	3,500
Maximum pile diameter (m)	11	11
Maximum seabed penetration (m)	37	37
Soft start duration	60 minutes	60 minutes
Maximum soft start hammer energy (kJ)	400	400
Ramp-up duration (minutes)	120 minutes	120 minutes
Maximum piling time per foundation	4 hours	4 hours
Maximum number of piles per 24 hours	1	1

Table 25.2.2-2 Overview of Project Design Options (OSPs)

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)	3,500	3,500
Maximum pile diameter (m)	14	14
Maximum seabed penetration (m)	45	45
Soft start duration	60 minutes	60 minutes
Maximum soft start hammer energy (kJ)	400	400
Ramp-up duration (minutes)	120 minutes	120 minutes
Maximum piling time per foundation	4 hours	4 hours

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 (Revised March 2026)**;
- **Volume II, Chapter 11: Marine Mammals (Revised March 2026)**;
- **Volume III, Appendix 10.1: Fish, Shellfish and Sea Turtle Ecology Technical Report (Revised March 2026)**; and
- **Volume III, Appendix 11.2: Marine Mammals Technical Report (Revised March 2026)**.

As per the approach set out in **Volume II, Chapter 11: Marine Mammals (Revised March 2026)**, 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 (Revised March 2026),** basking shark and leatherback turtle (*Dermochelys coriacea*) have also been assessed in this MMMP.

Data from site-specific Digital Aerial Surveys (DAS) carried out between 2018 and 2020, 2023 and 2024, and 2025, are included within species accounts. The Marine Mammal Study Area surveyed includes the Array Area, Cable Corridor and Working Area of the Proposed Development plus a 4 km buffer extending around the Array Area and covering the area west of the Array Area to the coast. In May to July of the 2025 site-specific DAS, an Extended Marine Mammal Study Area was surveyed in addition to the Marine Mammal Study Area. This Extended Marine Mammal Study Area encompasses the Proposed Development plus a 10 km buffer zone extending around the Array Area and covering from the west of the Array Area to the coast.

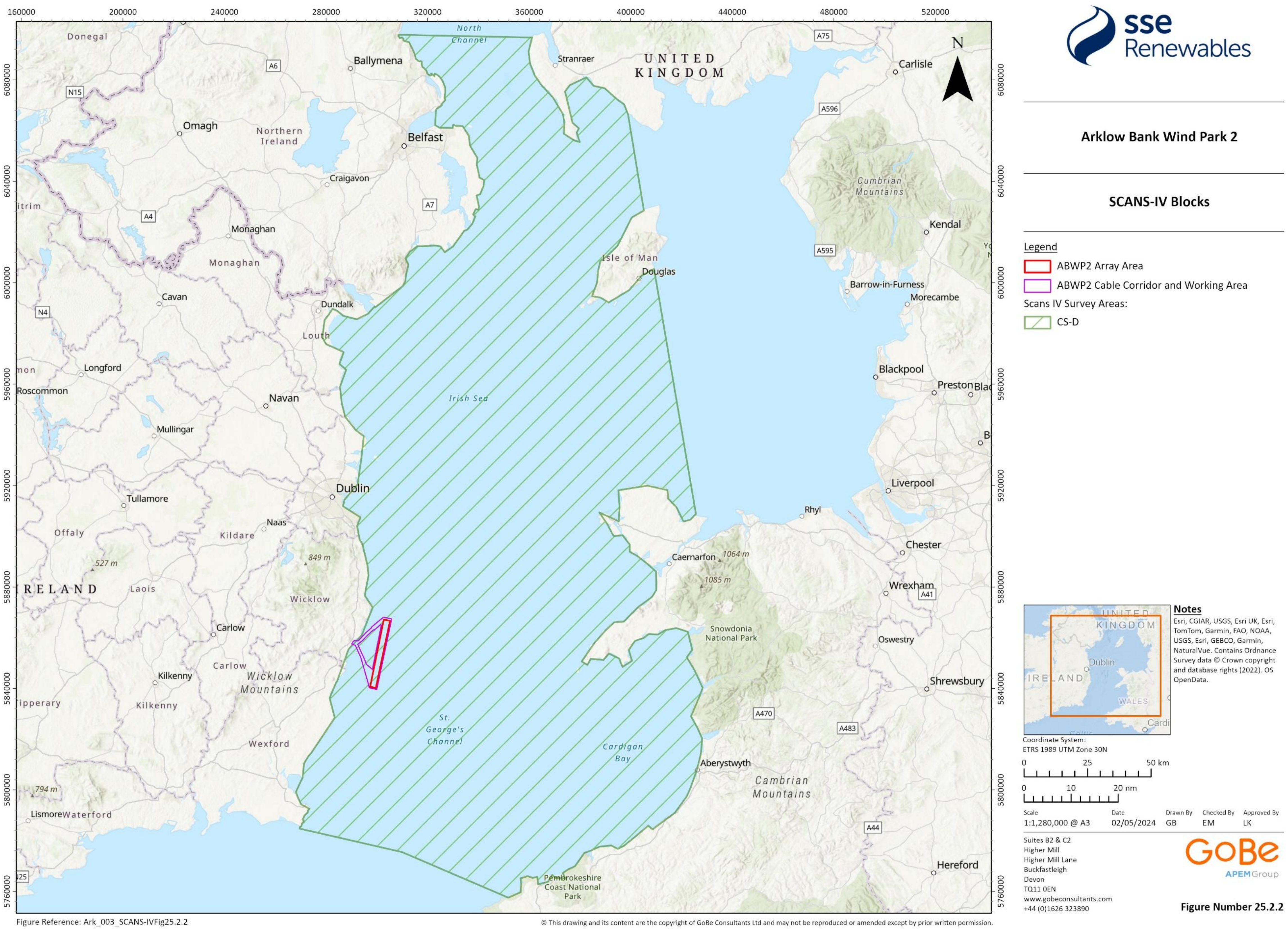

Figure 25.2.2 The Proposed Development area and relevant SCANS-IV survey block.

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. The highest mean corrected density estimate was from the 2018-2020 DAS, and comprised 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; **Volume III, Appendix 11.2 Marine Mammals Technical Report (Revised March 2026)**), 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 Small Cetacean Abundance in the North Sea IV (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 the site-specific DAS, confirming their presence within the Marine Mammal Study Area (HiDef, 2020a; **Volume III, Appendix 11.2 Marine Mammals Technical Report (Revised March 2026)**). 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 (only one sighting, in the 2018-2020 DAS; no further sightings in the 2023-2025 DAS; **Volume III, Appendix 11.2 Marine Mammals Technical Report (Revised March 2026)**). 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; **Volume III, Appendix 11.2 Marine Mammals Technical Report (Revised March 2026)**), 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 during the site-specific DAS, confirming their presence within the Marine Mammal Study Area (HiDef, 2020a; **Volume III, Appendix 11.2: Marine Mammals Technical Report (Revised March 2026)**). No density estimate could be calculated for common dolphin from the 2018-2020 DAS, however a mean density estimate of 0.03 animals/km^2 was calculated from 2023-2024 DAS. 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 2018-2020 or 2023-2024 site-specific DAS (HiDef, 2020a) however, a single individual was recorded in the Marine Mammal Study Area, but outside of the Array Area and 2km buffer, on one occasion during the 2025 site-specific DAS in July 2025. Sightings have also 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 United Kingdom (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 Marine Mammal Study Area and Extended Marine Mammal Study Area (HiDef, 2020a; Morris and Duck, 2019). In addition, seal Vantage Point (VP) surveys were undertaken monthly from June to November 2025, and identified grey seal presence in the Landfall plus 500 m buffer area but no harbour seals.

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 0.08 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). The seal VP surveys recorded grey seals, including pups, hauled out within the Landfall, therefore suggesting that the area may serve as a breeding and pupping site for the species. 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)). A single harbour seal was sighted within the Marine Mammal Study Area during the 2023-2024 site specific DAS in April 2024. 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). The seal VP surveys did not record any harbour seals. 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 Convention for the Protection of the Marine Environment of the North-East Atlantic (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 *et al.*, 2009). 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 DAS (conducted in 2018-2020, 2024 and 2025), a single basking shark was recorded in 2019, 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; International Organisation for Standardisation (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 comprising 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 high frequency (HF) and very high frequency (VHF) cetaceans. Low frequency (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 mitigation measures consisting of avoiding UXO, acoustic deterrent device (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 (Revised March 2026)**).

Modelling for WTG and OSP foundation impact piling considered effects across five representative locations (three for WTGs; two for OSPs) within the Array Area, ranging from water depths between 21.1-30.7 m.

The monopile diameter scenarios, for WTGs (outlined in **Table 25.2**) and OSPs (outlined in **Table 25.2**) were modelled at each of the respective WTG and OSP representative locations. This includes the following scenarios:

- 11 m diameter monopiles for WTG foundations, installed with a maximum blow energy of 3,500 kJ;
- 14 m diameter monopiles for OSP foundations, installed with a maximum blow energy of 3,500 kJ.

Additional mitigation has been committed to by the Applicant to reduce underwater noise generated during pilling and associated impacts to sensitive marine receptors for both the

WTG and OSP locations. Under this extended ramp-up mitigation scenario, the start of the ramp-up (soft start) will commence at 400 kJ and the ramp-up duration will be extended. This will be implemented in order to comply with an r_{safe} of 1,000 m, in line with the Danish standard (see **Volume III, Appendix 11.1: Underwater Noise Assessment (Revised March 2026)** for more detail).

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, and other geophysical sources.

Geotechnical survey sound sources (e.g. CPT activities) are excluded from the requirements, as the predicted injury ranges from geotechnical sources are highly localised (maximum of 62 m for harbour porpoise; less than 5 m for other marine mammal species; **Table 25.2**). There is negligible likelihood of a marine mammal being present within these highly localised areas for sufficient duration to accumulate an auditory injury. Furthermore, geotechnical sources are not recommended for mitigation in DAHG (2014) or by JNCC.

The Factored In Measures (see **Table 11.15** within **Volume II, Chapter 11: Marine Mammals (Revised March 2026)**) includes the implementation of a project-specific mitigation protocol during the geophysical and geotechnical surveys to minimise the risk of PTS, as presented herein. The mitigation measures outlined for geophysical and geotechnical surveys are compliant with the measures outlined in the 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 Titanium (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 geophysical 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.

USBLs were not explicitly modelled by Seiche Ltd. (2022), however they are impulsive noise sources, often used during geophysical and geotechnical surveys. The source level of the USBL will be a maximum of 202 dB re 1µPa at1 m (SPL_{peak}), which is lower than the source level of other non-impulsive sonar-based and impulsive surveys / equipment (see **Volume II, Chapter 11: Marine Mammals (Revised March 2026)**, Table 11.81). CSA Ocean Sciences Inc. (2020) estimated that the maximum distance to the weighted Level A threshold (cumulative PTS) is 1.7 m for VHF cetaceans (harbour porpoise). Therefore, the predicted noise impact ranges are less than that for the seismic or sparker sources. Nevertheless, mitigation will also be implemented for the USBL.

A summary of mitigation measures to be used specifically during the project geophysical surveys are listed in **Table 25.2.4-1** below. The Marine Mammal Mitigation Zones (MMMZ) are much larger than predicted impact ranges for instantaneous PTS; however, the MMMZ will remain precautionary and follow DAHG (2014) guidance. Implementing the MMMZ in line with the DAHG (2014) guidance will also provide industry-standard mitigation for marine mammals for the cumulative PTS and TTS onset ranges.

Given the above and the information assessed within **Volume II, Chapter 11: Marine Mammals (Revised March 2026)**, 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 (Revised March 2026),** 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 25.2.4-1 Summary of mitigation measures to be used during geophysical and geotechnical surveys (N/E = threshold not exceeded)

SUMMARY	
Mitigation Zone **Seismic surveys (including sparkers)** **Other geophysical surveys**	 1,000 m 500 m
Predicted maximum instantaneous PTS onset impact ranges **Seismic surveys (including sparker)** **Sonar-based geophysical surveys** **Geotechnical surveys**	 22 m N/E 15 m
Predicted cumulative PTS impact ranges **Seismic surveys (including sparker)** **Sonar-based geophysical surveys** **Geotechnical surveys**	 130 m 517 m 62 m
Predicted maximum instantaneous TTS onset impact ranges **Seismic surveys (including sparker)** **Sonar-based geophysical surveys** **Geotechnical surveys**	 40 m N/E 33 m
Predicted cumulative TTS impact ranges **Seismic surveys (including sparker)** **Sonar-based geophysical surveys** **Geotechnical surveys**	 1,524 m 3,150 m 856 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, SBP and USBL. 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) Marine Mammal Observers (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 *et al.,* 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. The JNCC guide on making a rangefinder stick will be used (JNCC, n.d.) as well as the Marine Mammal Observer Association (MMOA)'s guide to distance estimation using reticular binoculars (MMOA, 2024).

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 MMOs 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, SBP and/or USBL 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. The mitigation measures outlined for UXO clearance below are compliant with the measures outlined for blasting in the DAHG (2014) guidance. The mitigation measures are also compliant with the Joint Nature Conservation Committee (JNCC) guidelines for minimising the risk of injury to marine mammals from unexploded ordnance (UXO) clearance in the marine environment (JNCC, 2025).

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 methodologies. 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 (Revised March 2026).** Alternative methods of detonation such as 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 order disposal, as the impact ranges correspond only to the size of the donor charges to be used, rather than the size of the UXO itself.

5.2 Assessment Outcomes and Mitigation Procedures

Table 25.2.5-1 summarises the PTS-onset 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 Environmental Impact Assessment (EIA) terms, it is important to note that all cetaceans are EPS and under EPS legislation it is an offence to kill or disturb EPS (this is taken to include 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 can be mitigated using visual searches and an ADD would be required to implement alternative clearance methods or noise abatement to reduce risk of injury to mitigatable ranges (JNCC, 2025).

To deter marine mammals from potential injury zones, ADDs will be deployed during pre-watch periods. Details of ADD use 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 25.2.5-1 shows the potential PTS-onset impact radius of up to 14 km for unmitigated detonations up to a maximum of 800 kg. Avoidance and alternatives, such as low-order disposal, 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 (Revised March 2026)**, 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 (Revised March 2026),** 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 duration of noise emissions during UXO clearance.

In addition, **Table 25.2** summarises the TTS-onset impact ranges for the various FHGs against various charge weights. It shows the potential TTS-onset impact radius of up to 120 km for unmitigated detonations up to a maximum of 800 kg. Avoidance and alternatives, such as low-order disposal, will be considered for the UXO inventory for the Proposed Development where appropriate.

Table 25.2.5-1 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

Table 25.2.5-2 Summary of TTS-onset impact ranges for UXO detonation using the impulsive noise criteria from Southall *et al.* (2019) for marine mammals.

Charge weight (kg)	**TTS-onset (unweighted SPL_{peak})**				**TTS-onset (weighted SEL_{ss})**			
	VHF cetacean	HF cetacean	LF cetacean	PCW	VHF cetacean	HF cetacean	LF cetacean	PCW
0.5 (low order)	2.3 km	130 m	410 m	450 m	930 m	50 m	4.5 km	800 m
25 + donor	8.5 km	490 m	1.5 km	1.6 km	2.4 km	150 m	29.0 km	5.2 km
55 + donor	11.0 km	640 m	1.9 km	2.1 km	2.8 km	210 m	41.0 km	7.5 km
120 + donor	14.0 km	830 m	2.5 km	2.8 km	3.2 km	300 m	57.0 km	10 km
240 + donor	18.0 km	1.0 km	3.2 km	3.5 km	3.5 km	390 m	76.0 km	14 km
525 + donor	23.0 km	1.3 km	4.1 km	4.6 km	4.0 km	530 m	100.0 km	19 km
700 + donor	25.0 km	1.4 km	4.5 km	5.0 km	4.1 km	590 m	110.0 km	22 km
800 + donor	26.0 km	1.5 km	4.7 km	5.3 km	4.2 km	620 m	120.0 km	23 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 Passive Acoustic Monitoring (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 (2025) guidance, and any updated guidance prior to the undertaking of UXO operations. The pre-detonation monitoring should be conducted for a minimum of 1 hour prior to UXO clearance, in accordance with JNCC (2025). This exceeds the recommendation in DAHG (2014) for blasting which is that monitoring should occur for at least 30 minutes before the sound-producing activity is due to commence. Should a marine mammal be detected within the mitigation zone during this time, they will be monitored and if required a delay will be implemented. Once 30 minutes has elapsed since the last marine mammal detection in the mitigation zone, 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.

Distances to sightings are estimated using reticule binoculars or range finder sticks. The JNCC guide on making a rangefinder stick will be used (JNCC, n.d.) as well as the Marine Mammal Observer Association (MMOA)'s guide to distance estimation using reticular binoculars (MMOA, 2024).

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 (minimum of 15 minutes), concurrent to the pre-detonation search, to deter marine mammals to a greater distance prior to any detonation. Deployment beyond 15 minutes will only be required if high order clearance of UXO is required. For the site-specific UXO clearance activities, the ADD will be operated for different durations according to the UXO disposal method used, UXO/charge size, and associated predicted impact ranges. As the identification of UXO in the site, UXO disposal method and UXO/charge size are not currently known, ADD durations have not been presented at this time.

Following JNCC guidelines, a 30-minute visual search will be undertaken prior to ADD activation to ensure that there are no marine mammals within the 100 m of the deployed ADD. If an animal is detected, activation will be delayed until the animal has moved away. If the ADD duration is longer than 30 minutes, then the 1-hour pre-watch will be extended to ensure that a 30-minute visual search occurs prior to ADD activation.

5.5 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.

5.6 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 and ADD duration;
- All marine mammal sightings and completed marine mammal recording forms; and

- Any problems encountered and instances of non-compliance with the JNCC (2025)/DAHG (2014) guidelines, MMMP and variations from agreed procedures.

Reports will be collated and provided to Maritime Area Regulatory Authority (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 (Revised March 2026)**) consisting of:

- Marine mammal monitoring of a 1,000 m MMMZ prior to piling;
- Marine Mammal Observers during daylight hours, passive acoustic monitoring (PAM) during the hours of darkness/poor visibility;
- Ramp-up (including soft-start) procedure; and
- Pre-piling deployment of ADD.

Details of each of the mitigation measures listed above, are provided in their relevant sections below. The mitigation measures listed above will also be implemented for drilling of monopile installations, should this be required .

Furthermore, additional mitigation has been committed to as part of piling for the WTGs and OSPs. Under this extended ramp-up mitigation scenario, the start of the ramp-up (soft start) will commence at 400 kJ and the ramp-up duration will be extended. This will be implemented in order to comply with an r_{safe} of 1,000 min compliance with the Danish standard (see **Volume III, Appendix 11.1: Underwater Noise Assessment (Revised March 2026)** for more detail). The mitigation measures and underpinning impact range tables presented for impact hammer piling in this MMMP reflect the extended ramp-up mitigation scenario, which has been committed to by the Applicant.

6.2 Assessment Outcomes and Mitigation Procedures

6.2.1 Instantaneous and cumulative impact ranges

Impact ranges for marine mammals were calculated using the Southall *et al.* (2019) impulsive criteria. **Table 25.2.6-1 Summary of the modelled PTS onset impact ranges for marine** mammals at the various locations presents modelled PTS onset impact ranges for marine mammals at each of the five modelling locations. The largest instantaneous PTS-onset impact range (SPL_{peak}) for impact piling is estimated at 680 m for harbour porpoise at the C location. For all other marine mammal receptors, the maximum range was 70 m or less.

The largest PTS-onset impact range was for the weighted cumulative sound exposure level (SEL_{cum}) for minke whales, which was predicted to be 870 m at the C location. For all other marine mammal receptors, the maximum range was <50 m (**Table 25.2**). The greatest impact ranges correlated with the location 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 impact range for mortality and potential mortal injury and recoverable injury (>213 dB SPL_{peak}) was estimated at 140 m from the C location (**Table 25.2.6-2**). 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 SEL_{cum}) or 207 dB re 1µPa (unweighted SPL_{peak}), which at the C location are anticipated to be exceeded at < 50 m and 330 m, respectively. 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 25.2.6-2**).

If an individual is within the impact ranges of SPL_{peak} 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 ramp-up procedure (including soft start), in addition to the implementation of ADDs and PAM. 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 SEL_{cum} 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 680 m and the largest cumulative PTS-onset impact ranges (SEL_{cum}) falls within 870 m, both of which will be fully mitigated for with passive mitigation measures (pre-watch over the recommended 1,000 m mitigation zone (DAHG, 2014) and extended ramp-up procedure). An ADD will also be used to ensure that marine mammals are beyond the predicted PTS-onset ranges and r_{safe} range of 1,000 m. Furthermore, these impact ranges are based on a maximum representative scenario for piling parameters. For example, piling is modelled to occur at a maximum hammer energy of 3,500 kJ, but seabed conditions may allow for successful pile installation using less than the maximum hammer energies modelled, which would lessen the impact ranges.

Given the above and the information assessed within **Volume II, Chapter 11: Marine Mammals (Revised March 2026)**, the risk of injury from underwater noise as a result of an extended ramp-up mitigation scenario will be Negligible adverse for all marine mammal receptors. Given the above and the information assessed within **Volume II, Chapter 10: Fish, Shellfish and Sea Turtle Ecology (Revised March 2026),** the risk of injury from underwater noise as a result of piling will be Slight adverse for basking shark and sea turtles.

In addition, modelled TTS onset impact ranges for marine mammals at each of the five modelling locations are presented in Error! Reference source not found.. The largest instantaneous TTS-onset impact range (SPL_{peak}) for impact piling is estimated at 1,600 m for harbour porpoise at the C location. For all other marine mammal receptors, the maximum instantaneous range was 160 m or less. The largest TTS-onset impact range was for the weighted cumulative sound exposure level (SEL_{cum}) for minke whales, which was predicted to be 51,000 m at the C location. For other marine mammal receptors, the maximum range for SEL_{cum} was 30,000 m for harbour porpoise, 12,000 m for seal species and <50 m for dolphin species. The largest cumulative threshold for TTS effects on basking sharks (>186 dB SEL_{cum}) was modelled at the C location with exceedance of the threshold up to 24,000 m. The TTS-onset ranges are presented for illustrative purposes only. Whilst it is not possible to mitigate the full TTS-onset ranges, the mitigation measures committed to by the Applicant will reduce the likelihood of marine mammals being within the part of the TTS-onset range closest to the pile, where the most extreme TTS-onset may occur.

Table 25.2.6-1 Summary of the modelled PTS onset impact ranges for marine mammals at the various locations

Species	Threshold	Maximum range (m)				
		N location	C location	SW location	N-OSP location	S-OSP location
Very high frequency (VHF) cetacean (e.g. harbour porpoise)	Unweighted SPL_{peak} 202 dB re 1µPa	580	680	580	520	380
	Weighted SEL_{cum} 155 dB re 1 µPa² s	<50	<50	<50	<50	<50
High frequency (HF) cetacean (e.g. bottlenose, common and Risso's dolphin)	Unweighted SPL_{peak} 230 dB re 1µPa	<50	<50	<50	<50	<50
	Weighted SEL_{cum} 185 dB re 1 µPa² s	<50	<50	<50	<50	<50
Low frequency (LF) cetacean (e.g. minke whale)	Unweighted SPL_{peak} 219 dB re 1µPa	50	60	50	50	<50
	Weighted SEL_{cum} 183 dB re 1 µPa² s	170	870	330	120	70
Phocids in water (PCW; e.g. grey and harbour seal)	Unweighted SPL_{peak} 218 dB re 1µPa	60	70	60	60	<50
	Weighted SEL_{cum} 185 dB re 1 µPa² s	<50	<50	<50	<50	<50

Table 25.2.6-2 Summary of the modelled impact ranges for basking shark and sea turtles at the various locations

Species	Threshold	Maximum range (m)				
		N location	C location	SW location	N-OSP location	S-OSP location
Basking shark – Mortality and potential mortal injury	>213 dB SPL_{peak}	120	140	120	110	80
	>219 dB SEL_{cum}	< 50	< 50	< 50	< 50	< 50
Basking shark – Recoverable injury	>213 dB SPL_{peak}	120	140	120	110	80
	>216 dB SEL_{cum}	< 50	< 50	< 50	< 50	< 50
Basking Shark - TTS	>186 dB SEL_{cum}	18,000	24,000	21,000	16,000	12,000
Sea turtles – Mortality and potential mortal injury[1]	>210 dB SEL_{cum}	< 50	< 50	< 50	< 50	< 50
	>207 dB SPL_{peak}	290	330	280	260	190

[1] There is no numerical criteria at which sea turtles may experience recoverable injury and TTS effects.

Table 25.2.6-3 Summary of the modelled TTS onset impact ranges for marine mammals at the various locations

Species	Threshold	Maximum range (m)				
		N location	C location	SW location	N-OSP location	S-OSP location
Very high frequency (VHF) cetacean (e.g. harbour porpoise)	Unweighted SPL_{peak} 202 dB re 1µPa	1,400	1,600	1,400	1,200	880
	Weighted SEL_{cum} 155 dB re 1 µPa² s	25,000	30,000	29,000	24,000	24,000
High frequency (HF) cetacean (e.g. bottlenose, common and Risso's dolphin)	Unweighted SPL_{peak} 230 dB re 1µPa	<50	<50	<50	<50	<50
	Weighted SEL_{cum} 185 dB re 1 µPa² s	<50	<50	<50	<50	<50
Low frequency (LF) cetacean (e.g. minke whale)	Unweighted SPL_{peak} 219 dB re 1µPa	120	140	120	110	80
	Weighted SEL_{cum} 183 dB re 1 µPa² s	44,000	51,000	50,000	41,000	33,000
Phocids in water (PCW; e.g. grey and harbour seal)	Unweighted SPL_{peak} 218 dB re 1µPa	140	160	140	130	100
	Weighted SEL_{cum} 185 dB re 1 µPa² s	8,800	12,000	12,000	7,900	7,400

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. 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. 680 m). Therefore, following a precautionary approach, the Proposed Development will use a 1,000 m mitigation zone, which is compliant with the DAHG (2014) guidance.

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. Therefore, a 30-minute pre-piling search will be implemented for the Proposed Development, to ensure compliance with the DAHG (2014) guidance on this measure. 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° 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. Distances to sightings are estimated using reticule binoculars or range finder sticks. The JNCC guide on making a rangefinder stick will be used (JNCC, n.d.) as well as the Marine Mammal Observer Association (MMOA)'s guide to distance estimation using reticular binoculars (MMOA, 2024).

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, and during poor weather conditions or visibility as required (see **Section 6.5**). 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 pre-piling search, the soft-start procedure will be delayed until it has been observed, assessed and confirmed that the individual(s) has vacated the MMMZ, and there have been no detections for at least 30 minutes. This is compliant with the DAHG (2014) guidance. If a marine mammal is detected 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 detected within the mitigation zone during full power, pile-driving may continue and the MMO/PAM Operator 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)

While the DAHG (2014) guidance states that *"the use of PAM in Ireland is broadly encouraged as a helpful and beneficial tool for detecting and monitoring certain cetacean species, the Department does not believe it is sufficiently developed to be regarded as the primary or sole monitoring approach for risk-management purposes,"* it is highlighted that this guidance has not been reviewed since 2014. Since 2014, several regulators and Statutory Nature Conservation Bodies have issued guidance recommending the use of PAM for mitigation purposes, reflecting the advances in PAM, technological reliability, and detection algorithms.

For example, the IWDG (2020) advises that seabed surveys should apply standard mitigation practices and incorporate the use of PAM in periods of poor visibility or darkness to *"allow detection of cetaceans in poor visibility during the hours of darkness and for detecting animals underwater where source levels are often highest."* Similarly, multiple iterations of JNCC guidance (2017, 2023, 2025) recommend that PAM should be used when visual observations by a MMO are not feasible, such as during darkness, fog, glare, or heavy sea states. It is also highlighted that the DCCAE (2018) guidance recommends the use of PAM for pre-construction and post-construction monitoring of marine mammals.

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.

The Developer commits to implementing PAM as it 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.

6.5.1 Alternate monitoring approaches during low visibility

To complement the use of PAM under low visibility conditions (e.g. fog, heavy rain, or darkness), the Applicant will consider the use of complementary detection technologies to operate alongside PAM and enhance monitoring of the mitigation zone during the periods of low visibility. The Applicant will commit to using these alternate monitoring approaches if required.

Infrared imaging systems and night-vision devices are increasingly used internationally to support marine mammal monitoring when traditional visual detection using MMOs is limited. Their use is well-established within Protected Species Observer programmes in the United States, where several offshore projects along the East Coast have integrated night-vision technologies into standard survey operations (e.g., Alpine Ocean Seismic Survey Inc., 2017; Smultea Environmental Sciences, 2018; Ørsted, 2025). These technologies have been used to observe marine mammals during nighttime operations.

Thermal-detection systems are another option for complementary monitoring to PAM. Whilst the technology is still in development, recent advances in sensor quality and detection range indicate strong potential for the technology to support future monitoring, particularly in low-light environments, and demonstrate increased survey effectiveness when thermal and acoustic approaches are combined (Heather et al., 2020; APTIM Federal Services et al., 2025). While system performance varies, the literature consistently emphasises that technology selection should be tailored to project-specific environmental conditions and monitoring objectives.

Infrared and thermal-imaging systems are limited insofar as detections typically allow only broad-scale identification rather than species-level classification (Smith et al., 2020). However, species identification is not required for the purpose of mitigation specifically; the same mitigating actions would be implemented irrespective of the specific species. Furthermore, these tools would be supplementary to PAM in detecting marine mammals during low visibility conditions. The addition of PAM would increase the potential for species-level classification, if required.

Furthermore, relevant international regulatory frameworks recognise the value of these technologies. For instance, licences issued under the U.S. Marine Mammal Protection Act state that *"during surveys conducted at night, night-vision equipment and infrared technology shall be used in addition to PAM"*. Multiple projects have since demonstrated the efficacy of these tools, providing an evidence base for their continued integration in conditions where visual monitoring alone is not an option.

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 alternatives are also available (McGarry *et al.,* 2022). MARA and National Parks and Wildlife Service (NPWS) will be informed of the intended ADD use prior to commencing any piling. 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 deterring harbour and grey seals to 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 (which was 15 minutes; McGarry *et al.,* 2017).

Based on this evidence, the Applicant considers that the ranges suitable for ADD effectiveness are 5 km for minke whale (McGarry et al., 2017) 1 km for seals (Götz and

Janik, 2010; Götz, 2008), and 7.5 km for harbour porpoise (Brandt et al., 2013). As dolphins are less acoustically sensitive than harbour porpoise and minke whale, it is assumed that dolphin species would also be deterred to a minimum of 1 km through the use of an ADD. Since 1 km represents the minimum displacement distance for marine mammals using ADDs, this range has been adopted as the r_{safe} distance.

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 JNCC guidelines, a 30-minute visual search will be undertaken prior to ADD activation to ensure that there are no marine mammals within the 100 m of the ADD. If an animal is detected during the visual search, activation of the ADD will be delayed until the animal has moved away.

The approach to calculating an appropriate ADD duration has been based on the predicted PTS-onset ranges presented in the underwater noise modelling (**Volume III, Appendix 11.1: Underwater Noise Assessment (Revised March 2026)**). The proposed ADD duration is calculated based on the time it would take a marine mammal to flee beyond the distance of PTS-onset, using both the SPL_{peak} and SEL_{cum} metrics. The underwater noise modelling assumes an average swim speed of 1.5 ms^{-1} for harbour porpoise, dolphins and seals, and 3.25 ms^{-1} for minke whale to determine the cumulative PTS-onset range; these have also been used to calculate fleeing distance during ADD activation (Error! Reference source not found.). 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}; Lesage *et al.,* 1999).

Table 25.2 Table 25.2.6-4 Modelled PTS onset ranges for SPLpeak and SELcum 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 rangesprovides 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 25.2.6-4 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	60	<1
	LF cetacean (183 dB SEL_{cum})	3.25	870	5
Dolphins (e.g. bottlenose dolphin)	HF cetacean (230 dB SPL_{peak})	1.5	<50	<1
	HF cetacean (185 dB SEL_{cum})	1.5	<50	<1
Harbour porpoise	VHF cetacean (202 dB SPL_{peak})	1.5	680	8
	VHF cetacean (155 dB SEL_{cum})	1.5	<50	<1
Seals	PCW (218 dB SPL_{peak})	1.5	70	<1
	PCW (185 dB SEL_{cum})	1.5	<50	<1

⁺ based on a starting distance of 0 m from the pile

6.6.1 ADD duration summary

The ADD durations presented in **Table 25.2** would ensure that the risk of injury from piling is reduced to negligible (by allowing all animals time to swim out of any potential PTS onset ranges, prior to the first hammer strike). The ADD duration would need to be a minimum of 8 minutes in order to ensure that the risk of injury from piling is reduced to negligible (by allowing all animals time to swim out of any potential PTS-onset ranges, prior to the first hammer strike). To ensure that an r_{safe} distance of 1,000 m is achieved for all species, an ADD duration of 15 minutes will be implemented. The ADD has been proven to displace marine mammal species to distances beyond the maximum injury range, therefore there is negligible risk of injury. This conclusion of negligible risk is further contributed to by the monitoring (by MMO or PAM Operator) of the mitigation zone prior to the start of piling.

As presented in **Table 25.2.6-5**, the period of ADD activation will allow minke whale to reach 2.9 km, and other marine mammal species to reach 1.4 km, prior to pile driving commencing. The piling sequence will then commence with a ramp-up (including soft-start) while it is expected that marine mammals will continue moving away from the sound source. **Table 25.2.6-5** estimates the distances that could potentially be reached by the receptors if the estimated swim speed was maintained and individuals swam continuously and directly away from the ADD for the entire duration of ADD activation, followed by the modelled soft-start procedure at the start of the ramp-up. The specified soft start and ramp-up procedure 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 25.2.6-5 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 15 minutes ADD activation	Total distance reached after additional 60 minutes of ramp-up (soft-start)
Minke whale	3.25	2.9 km	14.6 km
Bottlenose dolphin, harbour porpoise, grey and harbour seals	1.5	1.4 km	6.8 km

The proposed ADD duration, combined with the MMO/PAM pre-piling watch described in **Section 6.4** (or PAM described in **Section 6.6**), present the best available pre-piling mitigation measures to reduce the risk of injury 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. These mitigation measures will be implemented in conjunction with measures focussed on the piling activity itself (e.g. soft-start procedure as described in **Section 6.7**).

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), piling will always begin with a ramp-up that commences with a soft-start procedure (as shown in **Table 25.2**Error! Reference source not found.). 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. The ramp-up will start at a lower energy and thereafter build up gradually over a period of no less than 120 minutes before reaching necessary maximum output. The application of this ramp-up to all piling is therefore compliant with the DAHG (2014) guidance.

The extended ramp-up mitigation scenario will implement a soft-start that will comprise a maximum scenario of 30 minutes slow strike rate of one blow every 10 seconds up to 400 kJ (11.4% of the maximum hammer energy modelled) followed by 30 minutes of 15 blows per minute at 400 kJ. Once the proposed 60 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.

Table 25.2.6-6 Summary of the soft start and ramp-up scenario used for the monopile foundation modelling at the WTG and OSP locations. Source: Volume III, Appendix 11.1: Underwater Noise Assessment (Revised March 2026).

	400 kJ	400 kJ	800 kJ	1,550 kJ	2,275 kJ	3,500 kJ
Number of strikes	18	450	600	600	600	3,600
Duration	30 min	30 min	20 min	20 min	20 min	120 mins
Strike rate	0.6 blow/min	15 blow/min	30 blow/min			
5,868 strikes, 4 hours duration						

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 ramp-up (including 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 for 20 minutes 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 operator 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)

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

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, additional mitigation measures, 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.

References

AdBm Technologies, (2020). ‘Reporting’. Available online: https://adbmtech.com/reporting [Accessed March 2026].

Alpine Ocean Seismic Survey Inc. on behalf of Ocean Wind LLC (2017). ‘Ocean Wind High Resolution Geophysical and Geotechnical Survey’. Gardline Report Ref 10969. Available online: Ocean Wind Environmental Baseline Monitoring Report [Accessed March 2026].

Anderwald, P., Brandecker, A., Coleman, M., Collins, C., Denniston, H., Haberlin, M. D., O'Donovan, M., Pinfield, R., Visser, F. and Walshe, L. (2013), ‘Displacement responses of a mysticete, an odontocete, and a phocid seal to construction-related vessel traffic’, Endangered Species Research, 21(3): 231-240. Available online: (PDF) Displacement responses of a mysticete, an adontocete, and a phacid seal to construction-related vessel traffic [Accessed March 2026].

APTIM Federal Services, LLC, and CSA Ocean Sciences Inc. (2025). ‘Efficacy of thermal detection technology for nighttime protected species observer surveys’. Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 57 p. Obligation No.: 140M0121D0006. Report No.: OCS Study BOEM 2025-006. Available online: BOEM 2025-006 Efficacy of thermal detection technology for nighttime protected species observer surveys.[Accessed March 2026].

Bailey, H. and Thompson, P. (2010). ‘Effect of oceanographic features on fine-scale foraging movements of bottlenose dolphins’. *Marine Ecology Progress Series*, 418, pp.223-233. (PDF) Effect of oceanographic features on fine-scale foraging movements of bottlenose dolphins [Accessed March 2026].

Bellmann M. A., Brinkmann J., May A., Wendt T., Gerlach S. and Remmers P. (2020). ‘Underwater noise during the impulse pile-driving procedure: Influencing factors on pile-driving noise and technical possibilities to comply with noise mitigation values’. Supported by the *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety* (*Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit* (BMU)), FKZ UM16 881500. Commissioned and managed by the *Federal Maritime and Hydrographic Agency* (*Bundesamt für Seeschifffahrt und Hydrographie* (BSH)), Order No. 10036866. Edited by the *itap GmbH*. ERa-Report [Accessed March 2026].

Berrow, S. D., Hickey, R., O’Brien, J. O’Connor, I. and McGrath, D. (2008), ‘Harbour Porpoise Survey 2008’, Report to the National Parks and Wildlife Service (Irish Whale and Dolphin Group). Available online: Microsoft Word - Harbour Porpoise Survey 2008.doc [Accessed March 2026].

Berrow, S. D., Whooley, P., O’Connell, M. and Wall, D. (2010), ‘Irish Cetacean Review (2000-2009)’, Irish Whale and Dolphin Group. Available online: https://iwdg.ie/downloads/IWDG%20Cetacean%20Sightings%20Review_lr.pdf [Accessed March 2026].

Blackwell, S.B., Nations, C.S., McDonald, T.L., Thode, A.M., Mathias, D., Kim, K.H., Greene Jr, C.R. and Macrander, A.M. (2015). 'Effects of airgun sounds on bowhead whale calling rates: evidence for two behavioral thresholds'. *PloS one*, 10(6), p.e0125720. Available online: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0125720 [Accessed March 2026].

Bland, R., Methion, S., Sharp, S.P. and López, B.D. (2023). 'Assessing variability in marine traffic exposure between baleen whale species off the Galician Coast, Spain'. *Marine Pollution Bulletin*, 186, p.114439. Available online: https://www.sciencedirect.com/science/article/abs/pii/S0025326X22011213?via%3Dihub [Accessed March 2026].

Bohne, T., Grießmann, T. and Rolfes, R. (2019). 'Modeling the noise mitigation of a bubble curtain'. *The Journal of the Acoustical Society of America*, 146(4), pp.2212-2223. Available online: Modeling the noise mitigation of a bubble curtain | The Journal of the Acoustical Society of America | AIP Publishing [Accessed March 2026].

Boisseau, O., McGarry, T., Stephenson, S., Compton, R., Cucknell, A.C., Ryan, C., McLanaghan, R. and Moscrop, A. (2021). 'Minke whales *Balaenoptera acutorostrata* avoid a 15 kHz acoustic deterrent device (ADD)'. *Marine Ecology Progress Series*, 667, pp.191-206. Available online: (PDF) Minke whales avoid a 15 kHz acoustic deterrent device [Accessed March 2026].

Bonn Convention, (1979). 'Convention on the Conservation of Migratory Species (CMS)', Homepage | Convention on the Conservation of Migratory Species of Wild Animals [Accessed March 2026].

Botterell, Z. L. R., Penrose, R., Witt, M. J. and Godley, B. J. (2020), 'Long-term insights into marine turtle sightings, strandings and captures around the UK and Ireland (1910– 2018)', *Journal of the Marine Biological Association of the United Kingdom*, 100: 869–877. Available online: Long-term insights into marine turtle sightings, strandings and captures around the UK and Ireland (1910–2018) | Journal of the Marine Biological Association of the United Kingdom | Cambridge Core [Accessed March 2026].

Brandt, M. J., Diederichs, A., and Nehls, G. (2009). 'Investigations into the effects of pile driving at the offshore wind farm Horns Rev II and the FINO III research platform', Report to DONG Energy; BioConsult SH, Germany. Available online: dong_cpods_response20100319.doc [Accessed March 2026].

Brandt, M. J., Diederichs, A., Betke, K., and Nehls, G. (2011). 'Responses of harbour porpoises to pile driving at the Horns Rev II offshore wind farm in the Danish North Sea'. *Marine Ecology Progress Series*, 421:205-216. Available online: (PDF) Responses of harbour porpoises to pile driving at the Horns Rev II offshore wind farm in the Danish North Sea [Accessed March 2026].

Brandt, M. J., Dragon, A., Diederichs, A., Schubert, A., Kosarev, V., Nehls, G., Wahl, V., Michalik, A., Braasch, A., Hinz, C., Katzer, C., Todeskino, D., Gauger, M., Laczny, M., and

Piper, W. (2016). 'Effects of offshore pile driving on harbour porpoise abundance in the German Bight'. Report by BioConsult SH. Report for Offshore Forum Windenergie. Available online: Effects of Offshore Pile Driving on Harbour Porpoise Abundance in the German Bight: Assessment of Noise Effects | Tethys [Accessed March 2026].

Brandt, M. J., Hoeschle, C., Diederichs, A., Betke, K., Matuschek, R., and Nehls, G. (2013). 'Seal scarers as a tool to deter harbour porpoises from offshore construction sites'. *Marine Ecology Progress Series,* 475:291-302. Available online: Marine Ecology Progress Series 475:291 [Accessed March 2026].

Broner, N. and Huber, M. (2012). 'Establishing a safety zone for marine mammals due to underwater blasting'. *The Effects of Noise on Aquatic Life.* pp. 533-536. Springer New York. Available online: Establishing a Safety Zone for Marine Mammals Due to Underwater Blasting | Springer Nature Link [Accessed March 2026].

Carstensen, J., Henriksen, O.D., and Teilmann, J. (2006). 'Impacts of offshore wind farm construction on harbour porpoises: acoustic monitoring of echolocation activity using porpoise detectors (T-PODS)'. *Marine Ecology Progress Series* 321:295-308. Available online: (PDF) Impacts of offshore wind farm construction on harbour porpoises: Acoustic monitoring of echolocation activity using porpoise detectors (T-PODs) [Accessed March 2026].

Carter, M. I. D., Boehme, L., Duck, C. D., Grecian, W. J., Hastie, G. D., McConnell, B. J., Miller, D. L., Morris, C. D., Moss, S. E. W., Thompson, D., Thompson, P. D. and Russell, D. J. F. (2020). 'Habitat-based predictions of at-sea distribution for grey and harbour seals in the British Isles', Sea Mammal Research Unit, University of St Andrews, Report to BEIS, OESEA-16-76/OESEA-17-78. Available online: Habitat-based predictions of at-sea distribution for grey and harbour seals in the British Isles : Report to BEIS, OESEA-16-76, OESEA-17-78 [Accessed March 2026].

Carter, M. I., Boehme, L., Cronin, M. A., Duck, C. D., Grecian, W. J., Hastie, G. D., Jessopp, M., Matthiopoulos, J., McConnell, B. J., Miller, D. L. and Morris, C. D. (2022), 'Sympatric seals, satellite tracking and protected areas: habitat-based distribution estimates for conservation and management', *Frontiers in Marine Science*, 9. Available online: https://www.frontiersin.org/journals/marine-science/articles/10.3389/fmars.2022.875869/full [Accessed March 2026].

Cholewiak, D., Clark, C.W., Ponirakis, D., Frankel, A., Hatch, L.T., Risch, D., Stanistreet, J.E., Thompson, M., Vu, E. and Van Parijs, S.M. (2018). Communicating amidst the noise: Modelling the aggregate influence of ambient and vessel noise on baleen whale communication space in a national marine sanctuary. Endangered Species Research, 36, pp.59-75. Available online: Communicating amidst the noise: modeling the aggregate influence of ambient and vessel noise on baleen whale communication space in a national marine sanctuary [Accessed March 2026].

Clarke, M., Farrell, E. D., Roche, W., Murray, T. E., Foster, S. and Marnell, F. (2016). 'Ireland Red List No. 11: Cartilaginous fish [sharks, skates, rays and chimaeras]', (Dublin, Ireland:

National Parks and Wildlife Service, Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs). Available online: https://www.npws.ie/sites/default/files/publications/pdf/Red List 11 Sharks et al.pdf [Accessed March 2026].

Cork Ecology (2007). Arklow Bank Seabird and Marine Mammal Monitoring Programme Year 7 Final Report. A report to Airtricity. December 2007.

Cork Ecology (2009). Arklow Bank Seabird and Marine Mammal Monitoring Programme Year 8 Final Report. A report to Airtricity. February 2009.

Cork Ecology (2010). Arklow Bank Seabird and Marine Mammal Monitoring Programme Year 9 Final Report. A report to Airtricity. May 2010.

CSA Ocean Sciences Inc. (2020). Application for incidental harassment authorization for the non-lethal taking of marine mammals: site characterization surveys Lease OCS-A 0486, 0517, 0487, 0500 and Associated Export Cable Routes. Submitted to Orsted. July 2020. Available online: https://media.fisheries.noaa.gov/dam-migration/orsted_hrg_2020proposediha_app_opr1.pdf [Accessed March 2026].

CWC (2003; 2004; 2005). Volume III, Appendix 11.2: Marine Mammals Technical Report.

Department of Communication, Climate Action & Environment (DCCAE). (2018). Guidance on Marine Baseline Ecological Assessments & Monitoring Activities for Offshore Renewable Energy Projects Part 2 April 2018. Department of Communications, Climate Action and Environment, pp.1-75. Available online: https://assets.gov.ie/static/documents/f957f02d-guidance-on-marine-baseline-ecological-assessments-monitoring-activities-for-.pdf [Accessed March 2026].

Department of Arts, Heritage and the Gaeltacht (DAHG) (2014). ‘Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters’. https://www.npws.ie/sites/default/files/general/Underwater%20sound%20guidance_Jan%202014.pdf [Accessed March 2026].

Díaz, M. P., Kunc, H. P. and Houghton, J. D. (2024), 'Anthropogenic noise predicts sea turtle behavioural responses', *Marine Pollution Bulletin*, 198: 115907. Available online: Anthropogenic noise predicts sea turtle behavioural responses - ScienceDirect [Accessed March 2026].

Doherty, P. D., Baxter, J. M., Gell, F. R., Godley, B. J., Graham, R. T., Hall, G., Hall, J., Hawkes, L. A., Henderson, S. M., Johnson, L. and Speedie, C. (2017). ‘Long-term satellite tracking reveals variable seasonal migration strategies of basking sharks in the north-east Atlantic’, Scientific Reports, 20:7: 42837. Available online: https://pubmed.ncbi.nlm.nih.gov/28216646/ [Accessed March 2026].

Dow Piniak W. E., Eckert, S. A., Harms, C. A. and Stringer, E. M. (2012). ‘Underwater hearing sensitivity of the leatherback sea turtle (*Dermochelys coriacea*): Assessing the potential effect of anthropogenic noise’. U.S. Dept. of the Interior, Bureau of Ocean Energy

Management, Headquarters, Herndon, VA. OCS Study BOEM 2012-01156. 35pp. Available online: 5279.pdf [Accessed March 2026].

Durbach, I.N., Harris, C.M., Martin, C., Helble, T.A., Henderson, E.E., Ierley, G., Thomas, L. and Martin, S.W. (2021). Changes in the movement and calling behavior of minke whales (*Balaenoptera acutorostrata*) in response to navy training. *Frontiers in Marine Science*, 8, p.660122. Available online: https://www.frontiersin.org/journals/marine-science/articles/10.3389/fmars.2021.660122/full [Accessed March 2026].

Elmer, K.H. and Savery, J. (2014). October. New Hydro Sound Dampers to reduce piling underwater noise. In INTER-NOISE and NOISE-CON Congress and Conference Proceedings (Vol. 249, No. 2, pp. 5551-5560). Institute of Noise Control Engineering.

Erbe, C., Dunlop, R. and Dolman, S. (2018). 'Effects of noise on marine mammals. Effects of anthropogenic noise on animals', pp.277-309 in, Slabbekoorn, H., Dooling, R.J., Popper, A.N., Fay, R.R. (2018), Effects of Anthropogenic Noise on Animals (Eds)., Springer, New York, USA. ISSN 0947-2657. Available online: https://www.researchgate.net/publication/327124348_Effects_of_Noise_on_Marine_Mammals [Accessed March 2026].

European Commission (1992) European Union Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (Habitats Directive).

Fulmar Ecological Services (2006) Seabird and Marine Mammal Monitoring of the Arklow Bank: Interim Report for the period July 2005 to June 2006. Unpublished report for Airtricity Ltd.

Gavin & Doherty Geosolutions Ltd (2020a), 'Arklow Bank Wind Park (ABWP) Phase 2 Repeat Multibeam Survey (July – August 2020) Marine Mammal Mitigation Report', Document reference: 18086-R-001-01.

Gavin & Doherty Geosolutions Ltd (2020b), 'Arklow Bank Wind Park - Geotechnical Survey MMO Daily Observation Log Compilation Geoquip Saentis Campaign 2020', unpublished.

Gilles, A., Authier, M., Ramirez-Martinez, N. C., Araújo, H., Blanchard, A., Carlström, J., Eira, C., Dorémus, G., Fernández-Maldonado, C., Geelhoed, S. C. V., Kyhn, L., Laran, S., Nachtsheim, D., Panigada, S., Pigeault, R., Sequeira, M., Sveegaard, S., Taylor, N. L., Owen, K., Saavedra, C., Vázquez-Bonales, J. A., Unger, B., Hammond, P. S. (2023). 'Estimates of cetacean abundance in European Atlantic waters in summer 2022 from the SCANS-IV aerial and shipboard surveys.' Available online: Estimates of cetacean abundance in European Atlantic waters in summer 2022 from the SCANS-IV aerial and shipboard surveys - Wageningen University & Research [Accessed March 2026].

Gillespie, D., Mellinger, D.K., Gordon, J., Mclaren, D., Redmond, P.A.U.L., McHugh, R., Trinder, P.W., Deng, X.Y. and Thode, A. (2008). PAMGUARD: Semiautomated, open source software for real-time acoustic detection and localisation of cetaceans. *Journal of the Acoustical Society of America*, 30(5), pp.54-62. Available online: https://eprints.gla.ac.uk/78899/ [Accessed March 2026].

Goertner, J. F., Wiley, M. L., Young, G. A. and McDonald, W. W. (1994). 'Effects of underwater explosions on fish without swim bladders', Naval Surface Warfare Center. Report No. NSWC/TR-76-155. Available online: https://apps.dtic.mil/sti/pdfs/ADA276407.pdf [Accessed March 2026].

Gomez, C., Lawson, J.W., Wright, A.J., Buren, A.D., Tollit, D. and Lesage, V. (2016). 'A systematic review on the behavioural responses of wild marine mammals to noise: the disparity between science and policy'. *Canadian Journal of Zoology*,94(12), pp.801-819. Available online: (PDF) A systematic review on the behavioural responses of wild marine mammals to noise: the disparity between science and policy [Accessed March 2026].

Gordon, J., Gillespie, D., Potter, J., Frantzis, A., Simmonds, M.P., Swift, R. and Thompson, D., (2003). 'A review of the effects of seismic surveys on marine mammals'. *Marine Technology Society Journal*, 37(4), pp.16-34. Available online: (PDF) A Review of The Effects of Seismic Surveys on Marine Mammals [Accessed March 2026].

Götz, T. (2008). Aversiveness in marine mammals: psycho-physiological basis, behavioural correlates and potential applications. PhD Thesis. University of St Andrews. Available online: https://research-repository.st-andrews.ac.uk/bitstream/handle/10023/848/Thomas%20Goetz%20PhD%20thesis.pdf?sequence=3&isAllowed=y [Accessed March 2026].

Götz, T. and Janik, V. (2010). 'Aversiveness of sounds in phocid seals: psychological factors, learning processes and motivation'. *Journal of Experimental Biology*, 213(9): 1536-1548. Available online: https://cob.silverchair-cdn.com/cob/content_public/journal/jeb/213/ [Accessed March 2026].

Government of Ireland (1976), The Wildlife Act, 1976, (as amended).

Graham, I. M., Gillespie, D., Gkikopoulou, K. C., Hastie, G. D. and Thompson, P. M. (2023). 'Directional hydrophone clusters reveal evasive responses of small cetaceans to disturbance during construction at offshore windfarms', *Biology Letters*, 19/1: 20220101. Available online: https://royalsocietypublishing.org/rsbl/article/19/1/20220101/63211/Directional-hydrophone-clusters-reveal-evasive [Accessed March 2026].

Graham, I.M., Merchant, N.D., Farcas, A., Barton, T.R, Cheney, B., Bono, S. and Thompson, P.M. (2019). 'Harbour porpoise responses to pile-driving diminish over time', *Royal Society Open Science*, 6(6), p.190335. Available online: https://royalsocietypublishing.org/rsos/article/6/6/190335/95082/Harbour-porpoise-responses-to-pile-driving [Accessed March 2026].

Haelters, J., Van Roy, W., Vigin, L., and Degraer, S. (2012). The effect of pile driving on harbour porpoise in Belgian waters. Pages 127-144 in Degraer, S., Brabant, R., and Rumes, B. (editors). Offshore wind farms in the Belgian part of the North Sea: Heading for an understanding of environmental impacts. Available online:

(PDF) Environmental Impacts of Offshore Wind Farms in the Belgian Part of the North Sea: Progressive Insights in Changing Species Distribution Patterns Informing Marine Management.

[Accessed March 2026].

Halvorsen, M. B., Casper, B. C., Matthew, D., Carlson, T. J. and Popper, A. N. (2012). 'Effects of exposure to pile driving sounds on the lake sturgeon, Nila tilapia, and hogchoker', *Proc. Roy. Soc. B*, 279: 4705-4714. Available online:

Effects of exposure to pile-driving sounds on the lake sturgeon, Nile tilapia and hogchoker | Proceedings B | The Royal Society

[Accessed March 2026].

Hammond, P. S., Lacey, C., Gilles, A., Viquerat, S., Börjesson, P., Herr, H., Macleod, K., Ridoux, V., Santos, M. B., Scheidat, M, Teilmann, J., Vingada, J. and Øien, N. (2021). 'Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys'. Available online:

Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys - Wageningen University & Research

[Accessed March 2026].

Smith, H.R., Zitterbart, D.P., Norris, T.F., Flau, M., Ferguson, E.L., Jones, C.G., Boebel, O., Moulton, V.D. (2020). 'A field comparison of marine mammal detections via visual, acoustic, and infrared (IR) imaging methods offshore Atlantic Canada', *Marine Pollution Bulletin*, Volume 154, 111026, ISSN 0025-326X. Available online: https://doi.org/10.1016/j.marpolbul.2020.111026 [Accessed March 2026].

HiDef Aerial Surveying Limited (2020a). 'Digital video aerial surveys of seabirds and marine mammals at Arklow Bank: Two-year survey report March 2018 – February 2020 survey programme (plus April 2020)', DOCUMENT NUMBER: HP00091-703-01.

HiDef Aerial Surveying Limited (2020b). 'Digital video aerial surveys of seabirds and marine mammals at Arklow Bank: Two-year survey report March 2018 - February 2020 survey programme (plus April 2020) – population and density estimates', DOCUMENT NUMBER: HP00091-704-01.

Irish Whale and Dolphin Group (2019). 'Sightings', Irish Whale and Dolphin Group (iwdg.ie) Available online:

Sightings | Irish Whale and Dolphin Group

[Accessed March 2026].

Irish Whale and Dolphin Group (IWDG) (2020). 'Offshore Wind Policy Document', Published by the Irish Whale and Dolphin Group, 2020. Available online:

(PDF) IWDG POLICY ON OFFSHORE WINDFARM DEVELOPMENT

[Accessed March 2026].

Joint Nature Conservation Committee (JNCC) (n.d.). Guide to making a rangefinder stick. Excel spreadsheet. Available online: Guide-making-rangefinder-stick-rev01-Web.xls [Accessed February 2026].

JNCC (2010). JNCC guidelines for minimising the risk of injury to marine mammals from using explosives. JNCC, Peterborough. Available online:

JNCC guidelines for minimising the risk of injury to marine mammals from explosive use in the marine environment | JNCC Resource Hub

[Accessed March 2026].

JNCC (2017). JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys. JNCC, Aberdeen. Available online:

JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys (seismic survey guidelines) | JNCC Resource Hub

[Accessed March 2026].

JNCC (2022). Marine environment: unexploded ordnance clearance joint interim position statement. Available online: https://www.gov.uk/government/publications/marine-environment-unexploded-ordnance-clearance-joint-interim-position-statement/marine-environment-unexploded-ordnance-clearance-joint-interim-position-statement [Accessed March 2026].

JNCC (2023). JNCC guidance for the use of Passive Acoustic Monitoring in UK waters for minimising the risk of injury to marine mammals from offshore activities. JNCC, Peterborough. Available online:

JNCC guidance for the use of Passive Acoustic Monitoring in UK waters for minimising the risk of injury to marine mammals from offshore activities | JNCC Resource Hub

[Accessed March 2026].

JNCC (2025). JNCC guidelines for minimising the risk of disturbance and injury to marine mammals whilst using explosives. JNCC, Aberdeen. Available online:

JNCC guidelines for minimising the risk of injury to marine mammals from unexploded ordnance (UXO) clearance in the marine environment

[Accessed March 2026].

Johnston, E. M., Mayo, P. A., Mensink, P. J., Savetsky, E. and Houghton, J. D. (2019). ‘Serendipitous re-sighting of a basking shark *Cetorhinus maximus* reveals inter-annual connectivity between American and European coastal hotspots’, *Journal of Fish Biology*, 95/6: 1530-1534. Available online:

Serendipitous re-sighting of a basking shark Cetorhinus maximus reveals inter-annual connectivity between American and European coastal hotspots - Johnston - 2019 - Journal of Fish Biology - Wiley Online Library

[Accessed March 2026].

Juretzek, C., Schmidt, B. and Boethling, M. (2021). 'Turning scientific knowledge into regulation: effective measures for noise mitigation of pile driving', *Journal of Marine Science and Engineering*, 9/8: 819. Available online:

(PDF) Turning Scientific Knowledge into Regulation: Effective Measures for Noise Mitigation of Pile Driving

[Accessed March 2026].

Ketten, D.R. (1995). ‘Estimates of blast injury and acoustic trauma zones for marine mammals from underwater explosions’. *Sensory systems of aquatic mammals*, pp.391-407. Available online:

(PDF) Estimates of blast injury and acoustic trauma zones for marine mammals from underwater explosions

[Accessed March 2026].

Kim, J., Jeong, Y.J. and Park, M.S. (2019). Numerical Analysis of a Single Large-diameter Cofferdam under Offshore Loadings. Available online:

Numerical Analysis of a Single Large-diameter Cofferdam under Offshore Loadings | Request PDF

[Accessed March 2026].

King, G. L. and Berrow, S. D. (2009). ‘Marine turtles in Irish waters’, *The Irish Naturalists' Journal*, 30: 1-30. Available online:

Marine turtles in Irish waters on JSTOR

[Accessed March 2026].

Koschinski, S. (2011). Underwater noise pollution from munitions clearance and disposal, possible effects on marine vertebrates, and its mitigation. *Marine Technology Society Journal*, *45*(6), pp.80-88. Available online:

Underwater Noise Pollution From Munitions Clearance and Disposal, Possible Effects on Marine Vertebrates, and Its Mitigation | Request PDF

[Accessed March 2026].

Koschinski, S. and Lüdemann, K. (2013). 'Development of noise mitigation measures in offshore wind farm construction', Commissioned by the Federal Agency for Nature Conservation, pp.1-102. Available online:

(PDF) Development of Noise Mitigation Measures in Offshore Wind Farm Construction

[Accessed March 2026].

Koschinski, S. and Lüdemann, K. (2015). 'Quieting technologies for offshore pile driving'. Progress in Marine Conservation in Europe 2015, p.217. Available online:

Progress in Marine Conservation iin Europe 2015

[Accessed March 2026].

Marine Mammal Observer Association (2024). Distance Estimation Using Reticular Binoculars. Available online: https://mmo-association.org/about-us/news/distance-estimation-using-reticular-binoculars [Accessed February 2026].

McGarry, T., De Silva, R., Canning, S., Mendes, S., Prior, A., Stephenson, S. and Wilson, J. (2022). 'Evidence base for application of Acoustic Deterrent Devices (ADDs) as marine mammal mitigation (Version 4.0)'. JNCC Report No. 615, JNCC, Peterborough. ISSN 0963-8091. Available online:

Evidence base for application of Acoustic Deterrent Devices (ADDs) as marine mammal mitigation (Version 4)

[Accessed March 2026].

McGarry, T., Boisseau, O., Stephenson, S., and Compton, R. (2017). 'Understanding the Effectiveness of Acoustic Deterrent Devices (ADDs) on Minke Whale (*Balaenoptera acutorostrata*), a Low Frequency Cetacean'. Report for the Offshore Renewables Joint Industry Programme (ORJIP) Project 4, Phase 2. Prepared on behalf of the Carbon Trust. Available online:

Understanding the Effectiveness of Acoustic Deterrent Devices on Minke Whale

[Accessed March 2026].

Merchant, N.D., and Robinson, S.P. (2020). 'Abatement of underwater noise pollution from pile-driving and explosions in UK waters'. Report of the UKAN workshop held on Tuesday 12 November 2019 at The Royal Society, London. pp.31. Available online: (PDF) Abatement of underwater noise pollution from pile-driving and explosions in UK waters [Accessed March 2026].

Morris, C. D. and Duck, C. D. (2019). 'Aerial thermal-imaging survey of seals in Ireland, 2017 to 2018'. *Irish Wildlife Manuals*, No. 111. Ireland: National Parks and Wildlife Service, Department of Culture, Heritage and the Gaeltacht. Available online: npws.ie/sites/default/files/publications/pdf/IWM111.pdf [Accessed March 2026].

O'Kelly, B.C. and Arshad, M. (2016). Offshore wind turbine foundations–analysis and design. In Offshore Wind Farms (pp. 589-610). Woodhead Publishing. Available online: Offshore wind turbine foundations – analysis and design - ScienceDirect [Accessed March 2026].

Orsted (2025). Annual Protected Species Monitoring Report – 2024BOEM Lease OCS-A 0487. Sunrise Windfarm Construction, Operations, Maintenance and Decommissioning Project. June – December 2024. Available online: fisheries.noaa.gov/s3/2025-06/SRW-2024-PSO-AnRep-OPR1.pdf [Accessed March 2026].

OSPAR Commission (2015). Background Document on Basking shark, *Cetorhinus maximus* – Update. Biodiversity and Ecosystem Series. Available online: ospar.org/documents?v=7377 [Accessed March 2026].

Otani, S., Naito, Y., Kato, A., and Kawamura, A. (2000). 'Diving behaviour and swimming speed of a free-ranging harbour porpoise, *Phocoena phocoena*'. *Marine Mammal Science,* 16:811-814. Available online: DIVING BEHAVIOR AND SWIMMING SPEED OF A FREE-RANGING HARBOR PORPOISE, PHOCOENA PHOCOENA - Otani - 2000 - Marine Mammal Science - Wiley Online Library [Accessed March 2026].

Popper, A. N., Hawkins, A. D., Fay, R. R., Mann, D., Bartol, S., Carlson, Th., Coombs, S., Ellison, W. T., Gentry, R., Hal vorsen, M. B., Lokkeborg, S., Rogers, P., Southall, B. L., Zeddies, D. G. and Tavolga, W. N. (2014). 'ASA S3/SC1.4 TR-2014 Sound Exposure Guidelines for Fishes and Sea Turtles', A Technical Report prepared by ANSIAccredited Standards Committee S3/SC1 and registered with ANSI. Springer and ASA Press, Cham, Switzerland. Available online: (PDF) Sound Exposure Guidelines [Accessed March 2026].

Reid, J. B., Evans, P. G. H., and Northridge, S. P. (2003). 'Atlas of cetacean distribution in northwest European waters', (Peterborough: JNCC). Available online: data.jncc.gov.uk/data/a5a51895-50a1-4cd8-8f9d-8e2512345adf/atlas-cetacean-distribution-web.pdf [Accessed March 2026].

Rigby, C. L., Barreto, R., Carlson, J., Fernando, D., Fordham, S., Francis, M. P., Herman, K., Jabado, R. W., Liu, K. M., Marshall, A., Romanov, E. and Kyne, P. M. (2021). 'Cetorhinus maximus (amended version of 2019 assessment)', The IUCN Red List of Threatened Species 2021. Available online: https://dx.doi.org/10.2305/IUCN.UK.2021-1.RLTS.T4292A194720078.en [Accessed March 2026].

Risch, D., Norris, T., Curnock, M. and Friedlaender, A. (2019). 'Common and Antarctic minke whales: Conservation status and future research directions'. *Frontiers in Marine Science*, 6, p.247. Available online: Frontiers | Common and Antarctic Minke Whales: Conservation Status and Future Research Directions [Accessed March 2026].

Rogan, E., Breen, P., Mackey, M., Cañadas, A., Scheidat, M., Geelhoed, S. and Jessopp, M. (2018). 'Aerial surveys of cetaceans and seabirds in Irish waters: Occurrence, distribution and abundance in 2015- 2017'. Department of Communications, Climate Action and Environment and National Parks and Wildlife Service. (Dublin, Ireland: Department of Culture, Heritage and the Gaeltacht). Available online: https://secure.dccae.gov.ie/downloads/SDCU_DOWNLOAD/ObSERVE_Aerial_Report.pdf [Accessed March 2026].

Romano, T.A., Keogh, M.J., Kelly, C., Feng, P., Berk, L., Schlundt, C.E., Carder, D.A. and Finneran, J.J. (2004). 'Anthropogenic sound and marine mammal health: measures of the nervous and immune systems before and after intense sound exposure'. Canadian *Journal of Fisheries and Aquatic Sciences*, 61(7), pp.1124-1134. Available online: (PDF) Anthropogenic sound and marine mammal health: Measures of the nervous and immune systems before and after intense sound exposure [Accessed March 2026].

Seagreen Wind Energy Ltd. (2020). Offshore Transmission Asset Piling Strategy. Marine Licence Offshore Transmission Asset (OTA) Condition 3.2.2.5. Document reference number: LF000009-CST-OF-PLN-0003. Available online: marine.gov.scot/sites/default/files/ota_piling_strategy.pdf [Accessed March 2026].

Seiche Ltd. (2022). Arklow Geophysical and Geotechnical Surveys Subsea Noise Assessment. Technical Report P1523-REPT-02-R1 for RPS Energy.

Shirihai, H., Jarrett, B., Kirwan, G. M., Cresswell, G., Macleod, K., Walker, D. and Dando, J. (2006).' Whales, dolphins and seals: a field guide to the marine mammals of the world' (A&C Black). Available online: Whales, dolphins and seals : a field guide to the marine mammals of the world in SearchWorks catalog [Accessed March 2026].

Sims, D. W., Southall, E. J., Humphries, N. E., Hays, G. C., Bradshaw, C. J. A. and Pitchford, J. W. (2008). 'Scaling laws of marine predator search behaviour', *Nature*, 451: 1089-1102. Available online: Scaling laws of marine predator search behaviour | Nature [Accessed March 2026].

Smith, H.R., Zitterbart, D.P., Norris, T.F., Flau, M., Ferguson, E.L., Jones, C.G., Boebel, O., & Moulton, V.D. (2020). 'A field comparison of marine mammal detections via visual, acoustic, and infrared (IR) imaging methods offshore Atlantic Canada'. *Marine pollution bulletin*, 154, 111026. Available online: A field comparison of marine mammal detections via visual, acoustic, and infrared (IR) imaging methods offshore Atlantic Canada - ScienceDirect [Accessed March 2026].

Smultea Environmental Sciences. (2018). Protected Species Observer Technical Report OCW01 Geotechnical Investigation 1ANew Jersey (2017 & 2018). Available online:

https://media.fisheries.noaa.gov/dam-migration/5_ocean_wind_2017_iha_monitoring.pdf [Accessed March 2026].

Southall, B. L., Bowles, A. E., Ellison, W. T., Finneran, J. J., Gentry, R. L., Greene, C. R. J., Kastak, D., Ketten, D. R., Miller, J. H., Nachtigall, P. E., Richardson, W. J., Thomas, J. A., Tyack, P. L. (2007), 'Marine mammal noise exposure criteria: initial scientific recommendations', Aquatic Mammals 33: 411-414. Available online: (PDF) Marine mammal noise exposure criteria [Accessed March 2026].

Southall, B., J. J. Finneran, C. Reichmuth, P. E. Nachtigall, D. R. Ketten, A. E. Bowles, W. T. Ellison, D. Nowacek, and P. Tyack. (2019). 'Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects'. *Aquatic Mammals,* 45:125-232. Available online: (PDF) Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects [Accessed March 2026].

Special Committee on Seals (2022), 'Scientific Advice on Matters Related to the Management of Seal Populations: 2021'. Available online: smru.st-andrews.ac.uk/files/2022/08/SCOS-2021.pdf [Accessed March 2026].

Special Committee on Seals (2023), 'Scientific Advice on Matters Related to the Management of Seal Populations: 2022'. Available online: smru.st-andrews.ac.uk/files/2023/09/SCOS-2022.pdf [Accessed March 2026].

Speedie, C. D., Johnson, L. A., and Witt, M. J. (2009). Basking Shark Hotspots on the West Coast of Scotland: Key sites, threats and implications for conservation of the species. Commissioned Report No.339. Available online: https://www.nature.scot/sites/default/files/2023-01/Publication%202009%20-%20SNH%20Commissioned%20Report%20339%20-%20Basking%20Shark%20Hotspots%20on%20West%20Coast%20of%20Scotland.pdf [Accessed March 2026].

Stephenson, J. R., Gingerich, A. J., Brown, R. S., Pflugrath, B. D., Deng, Z., Carlson, T. J., Langeslay, M. J., Ahmann, M. L., Johnson, R. L. and Seaburg, A. G. (2010). 'Assessing barotrauma in neutrally and negatively buoyant juvenile salmonids exposed to simulated hydro-turbine passage using a mobile aquatic barotrauma laboratory', *Fisheries Research* Volume 106, Issue 3, pp 271-278, December 2010. Available online: Assessing barotrauma in neutrally and negatively buoyant juvenile salmonids exposed to simulated hydro-turbine passage using a mobile aquatic barotrauma laboratory - ScienceDirect [Accessed March 2026].

Teilmann, J. (2003). 'Influence of sea state on density estimates of harbour porpoises (*Phocoena phocoena*)'. *Journal of Cetacean Research and Management*, 5(1), pp.85-92. Available online: (PDF) Influence of sea state on density estimates of harbour porpoises (Phocoena phocoena) [Accessed March 2026].

Thompson, D., Onoufriou, J., Brownlow, A. and Morris, C. (2016). 'Data based estimates of collision risk: an example based on harbour seal tracking data around a proposed tidal turbine array in the Pentland Firth'. *Scottish natural heritage Commissioned Report No. 900.* Available online: Data based estimates of collision risk: an example based on harbour seal tracking data around a proposed tidal turbine array in the Pentland Firth - University of St Andrews Research Portal [Accessed March 2026].

Tsouvalas, A. (2020). Underwater Noise Emission Due to Offshore Pile Installation: A Review. *Energies*, 13(12), p.3037. Available online: Underwater Noise Emission Due to Offshore Pile Installation: A Review | MDPI [Accessed March 2026].

United Nations (1982) United Nations Convention of the Law of the Sea (UNCLOS).

Van Oord (2020). Pile Driving Report WTG B406-G04. Doc. No. 144386-VOOW-TF-INS-ASB-1406. Available online: adbmtech.com/wp-content/uploads/2020/08/144386-VOOW-TF-INS-ASB-1406-Pile-driving-report-WTG-B406-G04-Approved-for-Release_opt.pdf [Accessed March 2026].

Vattenfall (2017). Appendix 12.2: ADDs as effective mitigation for marine mammals. Preliminary Environmental Information Report. Norfolk Vanguard Ltd. Available online: nsip-documents.planninginspectorate.gov.uk/published-documents/EN010079-001542-Appendix 12.02 ADD Mitigation.pdf [Accessed March 2026].

Verfuss, U.K., Sinclair, R.R. and Sparling, C.E. (2019). 'A Review of Noise Abatement Systems for Offshore Wind Farm Construction Noise, and the Potential for their Application in Scottish Waters'. *Scottish Natural Heritage Research Report*, 1070. Available online: nature.scot/sites/default/files/2019-07/Publication_2019_-_SNH_Research_Report_1070_-_A_review_of_noise_abatement_systems_for_offshore_wind_farm_construction_noise%2C_and_the_potential_for_their_application_in_Scottish_waters.pdf [Accessed March 2026].

von Benda-Beckmann, A. M., Aarts, G., Sertlek, H. Ö. Lucke, K., Verboom, W.C., Kastelein, R.A., Ketten, D.R., van Bemmelen, R., Lam, F.-P. A., and Kirkwood, R.J. (2015). 'Assessing the impact of underwater clearance of unexploded ordnance on harbour porpoises (*Phocoena phocoena)* in the southern North Sea'. *Aquatic Mammals,* 41(4):503. Available online: (PDF) Assessing the Impact of Underwater Clearance of Unexploded Ordnance on Harbour Porpoises (Phocoena phocoena) in the Southern North Sea [Accessed March 2026].

Wall, D., Murray, C., O'Brien, J. M. and Kavanagh, L. (2013). 'Atlas of the Distribution and Relative Abundance of Marine Mammals in Irish Waters: 2005-2011.' (Kilrush, Co Clare: Irish Whale and Dolphin Group). Available online: (PDF) Atlas of the Distribution and Relative Abundance of Marine Mammals in Irish Offshore Waters: Atlas of the Distribution and Relative Abundance of Marine Mammals in Irish Offshore Waters: 2005 -2011 [Accessed March 2026].

Wood, M.A., Ainslie, M.A., and Burns, R.D.J. (2023). Energy Conversion Factors in Underwater Radiated Sound from Marine Piling: Review of the method and recommendations. Document 03008, Version 1.2. Technical report by JASCO Applied Sciences for Marine Scotland. Available online:

tethys.pnnl.gov/sites/default/files/publications/Wood-et-al-2023.pdf [Accessed March 2026].

Annex 1: Acoustic Deterrent Device (ADD) Review

1. Deployment of ADDs during the Proposed Development

ADDs will be used during unexploded ordnance (UXO) clearance and impact hammer piling or drilling for the Proposed Development. No other activities for the Proposed Development require the use of ADDs.

1.1 Unexploded Ordnance Clearance

In the unlikely event UXO is encountered the developer will use an ADD, alongside other mitigation measures (as described Section 5 of the Marine Mammal Mitigation Plan (MMMP)), prior to the clearance of UXO. For all methods of UXO disposal and UXO/charge sizes that have been assessed, Permanent Threshold Shift (PTS)-onset impact ranges for very high frequency (VHF) cetaceans (e.g. harbour porpoise) exceed the 1,000 m Marine Mammal Mitigation Zone (MMMZ). For low frequency (LF) cetaceans, the PTS-onset range exceeds 1,000 m for high order detonation of charge sizes greater than 25 kg (plus donor), and for phocid pinnipeds in water (PCW) the PTS-onset range exceeds 1,000 m for high order detonation of charge sizes greater than 55 kg (plus donor). PTS-onset ranges are not predicted to exceed 1,000 m for high frequency cetaceans (e.g. dolphin species). Thus, without ADD there is a residual risk of auditory injury to most marine mammal species at a greater range than can be mitigated by monitoring of the MMMZ alone, and additional mitigation measures will therefore be implemented to ensure that all marine mammal species are beyond PTS-onset ranges prior to UXO clearance.

Accordingly, an ADD will be operated for a pre-determined length of time (minimum of 15 minutes), concurrent to monitoring of the MMMZ. This monitoring (visual and passive acoustic monitoring (PAM)) will be carried out as part of the pre-detonation search (as described in Section 5.4 of the MMMP). The ADD deployment will deter marine mammals out of the PTS-onset range prior to any detonation. The duration of ADD deployment will be calculated based on the extent of the PTS-onset range. Deployment beyond 15 minutes will only be required if high order clearance of UXO is required.

For any UXO clearance activities that may be required, the ADD will be operated for different durations according to the UXO disposal method used, UXO/charge size, and associated predicted impact ranges. The identification of UXO in the site, UXO disposal method and UXO/charge size cannot be confirmed at this time, as the details of the UXO are unknown at this stage. Therefore, ADD durations have not been presented at this time, however as stated above, duration will be a minimum of 15 minutes. The approach to calculating ADD duration will be the same approach outlined for calculated ADD durations for piling. The proposed ADD duration is calculated based on the time it would take a marine mammal to flee beyond the distance of PTS-onset, using both the peak sound pressure level (SPL_{peak}) and cumulative sound exposure level (SEL_{cum}) metrics. The duration of ADD for UXO clearance will consider balance the need to reduce the risk of injury with the need to avoid introducing unnecessary noise in the environment, in line with guidance from the Joint Nature Conservation Committee (JNCC, 2025).

It is proposed that during UXO clearance activities, one or two ADDs will be deployed from the deck of the survey vessels upon which the MMOs are stationed. The number of ADDs will be selected to ensure that the full PTS-onset zone is ensonified by the ADD, taking into consideration the location of the vessel(s) relative to the clearance location.

1.2 Pile Driving

The Developer will use an ADD, alongside other mitigation measures (as described in Section 6 of the MMMP), prior to the commencement of piling. The MMMP outlines the mitigation measures that will be implemented under the extended ramp-up mitigation scenario, which has been committed to by the Applicant. This review document follows the same structure.

Under the extended ramp-up mitigation scenario, PTS-onset ranges from pile driving are predicted to be within the 1,000 m MMMZ for all marine mammal hearing groups. Therefore, there is no residual risk of auditory injury, without the requirement to implement an ADD.

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. This will ensure that the acoustic signals emitted by the ADD are not blocked by the hull of the vessel, and can propagate fully in the water column.

For pile driving, the approach to calculating an appropriate ADD duration has been based on the predicted PTS-onset ranges as presented in the underwater noise modelling (**Volume III, Appendix 11.1: Underwater Noise Assessment**). The proposed ADD duration is calculated based on the time it would take a marine mammal to flee beyond the distance of PTS-onset, using both the SPL_{peak} and SEL_{cum} metrics. The underwater noise modelling assumes an average swim speed of 1.5 ms^{-1} for harbour porpoise, dolphins and seals (Otani *et al.*, 2000), and 3.25 ms^{-1} for minke whale (Blix and Folkow, 1995). These fleeing speeds are industry standard and precautionary. Otani *et al.* (2000) cite a maximum speed of 4.3 ms^{-1} for harbour porpoise, and other citations have also noted greater swim speeds of 6.2 ms^{-1} for harbour porpoise (Leatherwood *et al.*, 1982), 1.52 ms^{-1} for bottlenose dolphin (Bailey and Thompson, 2010) and 2.8 ms^{-1} for seals (Thompson *et al*. 2016) Therefore, swim speeds are considered to be a precautionary estimate of flee speeds as marine mammals are expected to be able to swim at much faster speeds under stress conditions (Kastelein *et al.*, 2018).

The ADD will be activated for a 20 minute duration to ensure that marine mammals are displaced beyond the area of PTS-onset, under the extended ramp-up.

For each monopile foundation, the maximum piling time per foundation is expected to be up to four hours. The addition of up to 20 minutes of ADD activation prior to the commencement of piling would therefore be only a small addition of noise relative to piling time (an approximate 8.33% increase in duration of noisy activity per pile). Therefore, as a proportion of the total piling duration across foundation installation, ADD activation will only make up a very small proportion of the noise emitted. This would not comprise a significant increase in the duration of noise and would not increase the magnitude of the noise effect in EIA terms.

2. ADD Details

2.1 ADD Model

The typical ADD used for mitigation during the development of offshore wind in UK waters is a Lofitech AS Seal Scarer (McGarry *et al.,* 2022). Whilst other models are also available (McGarry *et al.,* 2022), the Lofitech AS Seal Scarer has the greatest body of supporting evidence on its efficacy in displacing marine mammals, particularly over larger ranges (i.e. kilometres) that align with typical PTS distances from offshore wind development in UK waters. Hence, based on the Developer's experience, it is proposed that the Lofitech AS Seal Scarer will be used during the Proposed Development and so this model is the basis of this review.

Maritime Area Regulatory Authority (MARA) and National Parks and Wildlife Service (NPWS) will be informed of the intended ADD use prior to commencing any piling.

2.2 Sound Source Level and Frequency

The Lofitech AS Seal Scarer produces sounds ranging from 13 to 15 kHz in frequency and sound pressure levels of up to 189 dB re1µPa @1 m (rms) (Phillips *et al*., 2025).

The device emits approximately 500 ms (0.5 s) long pulses in variable length blocks containing a randomised number of pulses. The minimum pulse interval within blocks is approximately 0.5 s and consecutive blocks are separated by 20-60 s intervals (Götz and Janik, 2013).

3. PTS and TTS Ranges

When considering the potential for ADDs to cause auditory impacts, both instantaneous and cumulative effects must be considered.

To date, relatively few studies have examined the potential for instantaneous PTS resulting from ADD exposure. McGarry *et al*. (2017) concluded that under the National Oceanic and Atmospheric Administration acoustic criteria, the Lofitech AS Seal Scarer was highly unlikely to cause instantaneous PTS in minke whales (LF cetaceans). It is highlighted that the source level of the Lofitech AS Seal Scarer is below the thresholds for instantaneous PTS-onset (based on SPL peak, unweighted; Southall *et al.,* 2019), therefore instantaneous PTS-onset is not anticipated.

To investigate the potential of auditory injury from the use of ADDs, McGarry et al. (2022) developed a simple empirical model to estimate the received SEL_{cum} that marine mammals swimming away from the noise source, at a generalised swim speed of 2.5 ms^{-1}, could be exposed to. Modelling found that for all mammals, PTS-onset thresholds were not exceeded beyond a 100 m range for all modelled devices, with the exception of one which is no longer commercially avaliable (McGarry et al., 2022 as summarised in Phillips et al., 2025).

Other studies have considered potential impacts from ADDs based on 24-hour ADD operation. It is highlight that this is significantly greater than the maximum ADD duration that will be implemented for the Proposed Development (e.g. a maximum 37 minutes for piling). These other studies indicate that ADDs may be capable of causing auditory effects in marine mammals in the form of cumulative PTS (SEL_{cum}). Findlay *et al*. (2021) estimated that a single ADD could induce PTS in harbour porpoise (VHF cetaceans) within 0.2–0.9 km (median 0.5 km), while predicted temporary threshold shift (TTS) ranged from 11–53 km (median 28 km). Using desk-based noise-propagation modelling of real and fictional ADDs, Todd *et al*. (2021) found that the combined output of 23 operational ADDs could cause TTS in VHF cetaceans at distances of 4–31 km, while a single fictional ADD at the highest output was predicted to lead to TTS in VHF cetaceans at ranges of up to 32 km. It is important to recognise that these findings are based on scenarios involving continuous 24-hour device operation, expressed as SEL_{cum}, rather than short-term sound pressure levels. Within the context of the Proposed Development, ADDs will be activated only intermittently (as it will only be activated pre-piling and a maximum of one pile will be installed per day), and for much shorter periods than 24-hours, which substantially reduces the likelihood of auditory impacts.

Following JNCC guidelines, a 30 minute visual search will be undertaken prior to ADD activation to ensure that there are no marine mammals within the 100 m of the deployed ADD (JNCC, 2025). If an animal is detected, activation will be delayed until the animal has moved away. This will reduce any risk of instantaneous PTS to marine mammals within the vicinity of the ADD.

4. Efficacy Ranges for Marine Mammals

The Lofitech AS seal scarer has been used for marine mammal mitigation purposes at a number of UK offshore wind farm (OWF) projects during the construction phase. These include the Dudgeon OWF (Vattenfall, 2017), Beatrice OWF (Thompson *et al*., 2020), Race Bank OWF (Seagreen Wind Energy Ltd, 2020) and Moray East OWF (Graham *et al*., 2023). ADDs are used routinely for mitigation purposes during offshore wind construction in UK waters.

Manufacturer's specification states that the Lofitech AS Seal Scarer deterrence ranges from 300 m to 1.2 km from the source (Phillips *et al*., 2025). However, numerous studies have reported far greater efficacy ranges. PAM studies have shown that the Lofitech AS Seal Scarer deters harbour porpoises to ranges of 7 km (Graham *et al.,* 2023) and 7.5 km (Brandt *et al*., 2013). The device has proved to be consistently effective at deterring harbour porpoise. A short-range deterrence also observed for seals, though there are some reports of habituation (Sparling *et al*., 2015). Despite this, aerial survey studies have shown that ADDs are effective for deterring harbour and grey seals to a range of approximately 1 km (Götz and Janik, 2010; Götz, 2008). Minke whales have been observed to flee to distances greater than 5 km when exposed to a Lofitech AS Seal Scarer (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 (which was 15 minutes; McGarry *et al.,* 2017). Evidence of the Lofitech AS Seal Scarer's efficacy across marine mammals is supported by findings at Dudgeon OWF which found no reports of marine mammal sightings during soft start at active ADD locations using the Lofitech AS Seal Scarer (Dudgeon Offshore Wind Farm Ltd, 2016, as cited in Phillips *et al*., 2025).

Based on this evidence, the Developer considers that the ranges suitable for ADD effectiveness are 5 km for minke whale (McGarry *et al*., 2017), 1 km for seals (Götz and Janik, 2010; Götz, 2008), and 7.5 km for harbour porpoise (Brandt *et al*., 2013). As dolphins are less acoustically sensitive than harbour porpoise and minke whale, it is assumed that dolphin species would also be deterred to a minimum of 1 km through the use of an ADD. Under the extended ramp-up mitigation scenario, ADDs will be implemented in combination with monitoring to ensure animals are not present in within the maximum PTS-onset range which is within the 1 km MMMZ.

5. Summary

ADDs are an industry standard approach to mitigating underwater noise impacts on marine mammals where the impact ranges are greater than can be mitigated through monitoring alone. The available evidence indicates that deploying ADDs, such as the Lofitech AS Seal Scarer, provides effective mitigation against underwater noise impacts on marine mammals. For harbour porpoise, ADD activation can deter individuals out to approximately 7.5 km (Brandt *et al*., 2013), while other marine mammal species are expected to be displaced by at least 1 km. When used in combination with other mitigation measures, ADDs significantly reduce the potential for PTS during these activities. Although some studies suggest ADDs could induce PTS, these findings are based on continuous 24 hour operation, which does not reflect the actual use of ADDs during the Proposed Development. Noise modelling undertaken for 30 minutes ADD activation indicate that the PTS-onset threshold for all mammal was not exceeded beyond a range of 100 m for modelled devices including the Lofitech AS Seal Scarer. Therefore, the undertaking of a visual search to ensure that no marine mammals are present within 100 m of the ADD prior to activation will reduce any risk of instantaneous PTS from the ADD itself. The planned use of ADDs represents a safe and effective approach to mitigating underwater noise impacts on marine mammals through deterrence during UXO clearance and pile-driving operations.

6. References

Bailey, H. and Thompson, P. (2010). 'Effect of oceanographic features on fine-scale foraging movements of bottlenose dolphins'. *Marine Ecology Progress Series*, 418: 223-233. Available online: [(PDF) Effect of oceanographic features on fine-scale foraging movements of bottlenose dolphins] [Accessed March 2026].

Blix, A. S. and Folkow, L. P. (1995). 'Daily energy expenditure in free living minke whales'. *Acta Physiologica Scandinavica*, 153/1: 61-66. Available online: Daily energy expenditure in free living minke whales - PubMed [Accessed March 2026].

Brandt, M. J., Hoeschle, C., Diederichs, A., Betke, K., Matuschek, R. and Nehls, G. (2013). 'Seal scarers as a tool to deter harbour porpoises from offshore construction sites'. *Marine Ecology Progress Series,* 475: 291-302. Available online: https://www.int-res.com/articles/meps2013/475/m475p291.pdf [Accessed March 2026].

Findlay, C.R., Aleynik, D., Farcas, A., Merchant, N.D., Risch, D. and Wilson, B. (2021). 'Auditory impairment from acoustic seal deterrents predicted for harbour porpoises in a marine protected area'. *Journal of Applied Ecology*, 58/8: 1631-1642. Available online: https://besjournals.onlinelibrary.wiley.com/doi/epdf/10.1111/1365-2664.13910 [Accessed March 2026].

Graham, I. M., Gillespie, D., Gkikopoulou, K. C., Hastie, G. D. and Thompson, P. M. (2023). 'Directional hydrophone clusters reveal evasive responses of small cetaceans to disturbance during construction at offshore windfarms'. *Biology Letters*, 19/1: 20220101. Available online: https://royalsocietypublishing.org/rsbl/article/19/1/20220101/63211/Directional-hydrophone-clusters-reveal-evasive [Accessed March 2026].

Götz, T. (2008). Aversiveness in marine mammals: psycho-physiological basis, behavioural correlates and potential applications. PhD Thesis. University of St Andrews.

Gotz, T. and Janik, V. (2013). 'Acoustic deterrent devices to prevent pinniped depredation: efficiency, conservation concerns and possible solutions', *Marine Ecology Progress Series*, 492: 285-302. Available online: https://research-repository.st-andrews.ac.uk/bitstream/handle/10023/16356/goetz2013marineecologyseries285.pdf?sequence=1&isAllowed=y [Accessed March 2026].

Götz, T. and Janik, V. (2010). 'Aversiveness of sounds in phocid seals: psychological factors, learning processes and motivation'. *Journal of Experimental Biology*, 213/9: 1536-1548. Available online: (PDF) Gotz and Janik (2010) [Accessed March 2026].

Joint Nature Conservation Committee (JNCC). (2025). JNCC guidelines for minimising the risk of injury to marine mammals from unexploded ordnance (UXO) clearance in the marine environment. JNCC, Aberdeen. Available online: https://data.jncc.gov.uk/data/cbd480f1-47ea-4d78-b94c-04e0f9389daa/jncc-guidelines-unexploded-ordnance.pdf [Accessed March 2026].

Kastelein, R. A., Van de Voorde, S. and Jennings, N. (2018). Swimming Speed of a Harbor Porpoise (*Phocoena phocoena*) During Playbacks of Offshore Pile Driving Sounds. *Aquatic Mammals*, 44: 92-99. Available online: https://www.researchgate.net/publication/322507431_Swimming_Speed_of_a_Harbor_Porpoise_Phocoena_phocoena_During_Playbacks_of_Offshore_Pile_Driving_Sounds [Accessed March 2026].

Leatherwood, S. R., Reeves, R., Perrin, W. F. and Evans, W. E. (1982). Whales, dolphins, and porpoises of the Eastern North Pacific and adjacent arctic waters: A guide to their identification. (New York, NY: Dover Publications). Available online: https://repository.library.noaa.gov/view/noaa/5472 [Accessed March 2026].

Lesage, V., Hammill, M. O., and Kovacs, K. M. (1999). Functional classification of harbour seal (*Phoca vitulina*) dices using depth profiles, swimming velocity, and an index of foraging success. *Canadian Journal of Zoology,* 77: 74-87. Available online: https://www.researchgate.net/profile/Kit-Kovacs/publication/238042137_Functional_classification_of_harbor_seal_Phoca_vitulina_dives_using_depth_profiles_swimming_velocity_and_an_index_of_foraging_success/links/588dc73345851567c93f1eef/Functional-classification-of-harbor-seal-Phoca-vitulina-dives-using-depth-profiles-swimming-velocity-and-an-index-of-foraging-success.pdf [Accessed March 2026].

McGarry, T., De Silva, R., Canning, S., Mendes, S., Prior, A., Stephenson, S. and Wilson, J. (2022). Evidence base for application of Acoustic Deterrent Devices (ADDs) as marine mammal mitigation (Version 4.0). JNCC Report No. 615, JNCC, Peterborough. ISSN 0963-8091. Available online: Evidence base for application of ADDS (McGarry) [Accessed March 2026].

McGarry, T., Boisseau, O., Stephenson, S. and Compton, R. (2017). Understanding the Effectiveness of Acoustic Deterrent Devices (ADDs) on Minke Whale (*Balaenoptera acutorostrata*), a Low Frequency Cetacean. Report for the Offshore Renewables Joint Industry Programme (ORJIP) Project 4, Phase 2. Prepared on behalf of the Carbon Trust. Available online: https://tethys.pnnl.gov/sites/default/files/publications/McGarry-et-al-2017.pdf [Accessed March 2026].

Otani, S., Naito, Y., Kato, A. and Kawamura, A. (2000). 'Diving behavior and swimming speed of a free-ranging harbor porpoise, Phocoena Phocoena'. *Marine Mammal Science*, 16/4: 811-814. Available online: https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1748-7692.2000.tb00973.x?msockid=084f2fc5cf94684b215f3c1bceac698e [Accessed March 2026].

Phillips, B., Roberts, A., Buckland, L., Canning, S., Goulding, A., Mendes, S., Prior, A., De Silva, R., Stephenson, S. and McGarry, T. (2025). Evidence base for application of Acoustic Deterrent Devices (ADDs) as marine mammal mitigation (Version 5). JNCC Report 615. JNCC, Peterborough. ISSN 0963-8091. Available online: https://data.jncc.gov.uk/data/e2d08d7a-998b-4814-a0ae-4edf5d887a02/jncc-report-615-v5.pdf [Accessed March 2026].

Seagreen Wind Energy Ltd. (2020). Offshore Transmission Asset Piling Strategy. Marine Licence Offshore Transmission Asset (OTA) Condition 3.2.2.5. Document reference number: LF000009-CST-OF-PLN-0003.

Southall, B., Finneran, J. J., Reichmuth, C., Nachtigall, P. E., Ketten, D. R., Bowles, A. E., Ellison, W. T., Nowacek, D. and Tyack, P. (2019). 'Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects'. *Aquatic Mammals,* 45:125-232. Available online: https://www.researchgate.net/publication/302974965_Marine_mammal_noise_exposure_criteria [Accessed March 2026].

Sparling, C., Sams, C., Stephenson, S., Joy, R., Wood, J., Gordon, J., Thompson, D., Plunkett, R., Miller, B. and Götz, T. (2015). The use of Acoustic Deterrents for the mitigation of injury to marine mammals during pile driving for offshore wind farm construction. ORJIP Project 4, Stage 1 of Phase 2. Final Report. Available online: https://tethys.pnnl.gov/sites/default/files/publications/orjip-add-study-final-report-stage-1-phase-2.pdf [Accessed March 2026].

Todd, V.L.G., Williamson, L.D., Jiang, J., Cox, S.E., Todd, I.B. and Ruffert, M. (2021). Prediction of marine mammal auditory-impact risk from Acoustic Deterrent Devices used in Scottish aquaculture. *Marine Pollution Bulletin*, 165: 112-171. Available online: https://www.sciencedirect.com/science/article/abs/pii/S0025326X21002058 [Accessed March 2026].

Vattenfall (2017). Appendix 12.2: ADDs as effective mitigation for marine mammals. Preliminary Environmental Information Report. Norfolk Vanguard Ltd.