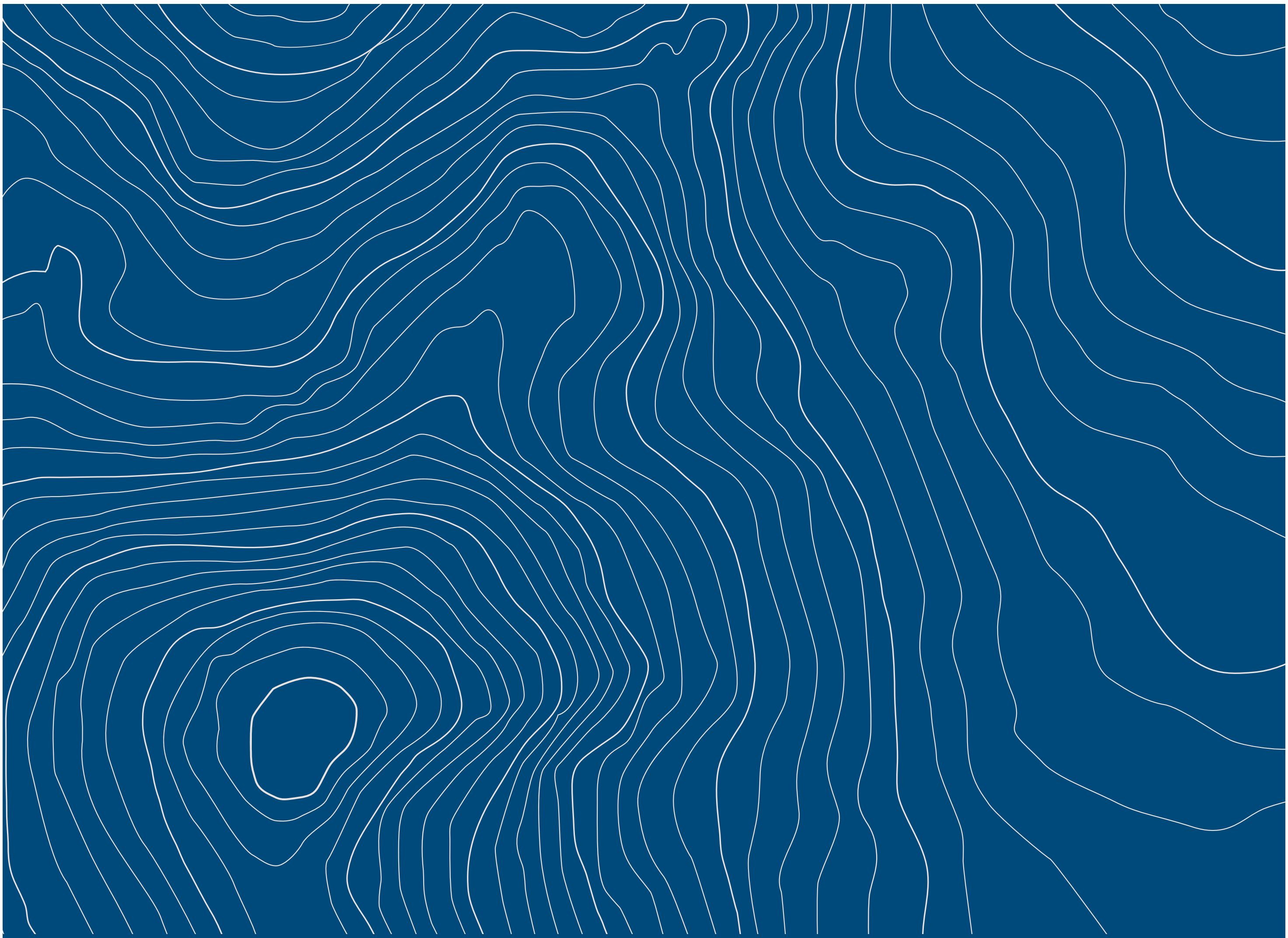

Dublin Array
Generation for generations

EIAR Volume 3: Offshore Infrastructure Assessment Chapters
Chapter 5: Marine Mammals

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Dublin Array Offshore Wind Farm

Environmental Impact Assessment Report

Volume 3, Chapter 5: Marine Mammals

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Glossary

Term	Definition
Permanent Threshold Shift (PTS)	Permanent threshold shift (or PTS) is a permanent increase in the threshold of hearing (minimum intensity needed to hear a sound) at a specific frequency above a previously established reference level.
Sound Exposure Level (SEL)	The decibel level of the time integral (summation) of the squared pressure over the duration of a sound event; units of dB re 1 µPa2/s.
Sound Pressure Level (SPL)	A means of characterising the amplitude of a sound. There are several ways sound pressure can be measured. The most common of these are the root-mean-square (RMS) pressure, the peak pressure and the peak-to-peak pressure.
Temporary Threshold Shift (TTS)	Temporary threshold shift (or TTS) is a temporary increase in the threshold of hearing (minimum intensity needed to hear a sound) at a specific frequency above a previously established reference level.
Passive Acoustic Monitoring (PAM)	Used to measure, monitor and determine the sources of sound in underwater environments. This is a versatile, non-invasive and cost effective method to detect, classify and track marine mammals over large areas for long periods.
Noise abatement	A primary mitigation methodology used to reduce the noise emissions at source.
Marine Mammal Observer (MMO)	A marine mammal observer (MMO) is a professional in environmental consulting who specialises in whales and dolphins and is responsible for spotting and identifying animals through visual or passive acoustic means.
Mitigation Zone	The zone which is required to remain clear of marine mammals for a specified time-frame, prior to a noisy activity taking place.
PTS-Onset Distance	The distance from the sound source at which the received level decreases to below the level of PTS-onset for a specific marine mammal hearing group.

Acronyms

Term	Definition
ADD	Acoustic Deterrent Device
ADO	Alternative Design Option
BEIS	Department for Business, Energy & Industrial Strategy
CEA	Cumulative Effects Assessment
CI	Confidence Interval
cSAC	Candidate Special Area of Conservation
CSIP	Cetacean Strandings Investigation Programme
CTV	Crew Transfer Vessel
CV	Coefficient of Variation
dB	Decibels
DEB	Dynamic Energy Budget
DEPONS	Disturbance Effects on the Harbour Porpoise Population in the North Sea
DCCAE	Department of Communications, Climate Action & Environment
DAHG	Department of Arts, Heritage and the Gaeltacht
EEA	European Economic Area
ECC	Export Cable Corridor
EDR	Effective Deterrence Range
EMF	Electromagnetic Field
EPA	Environmental Protection Agency
EIAR	Environmental Impact Assessment Report
EIA	Environmental Impact Assessment
EPS	European Protected Species
EVMP	Environmental Vessel Management Plan
HF	High Frequency
IAMMWG	Inter-Agency Marine Mammal Working Group
INSPIRE	Impulse Noise Sound Propagation and Impact Range Estimator
iPCoD	interim Population Consequences of Disturbance
IRCG	Irish Coast Guard
IWDG	Irish Whale and Dolphin Group
JCP	Joint Cetacean Protocol
JNCC	Joint Nature Conservation Committee

Term	Definition
LF	Low Frequency
MBES	Multibeam Echosounder
MDO	Maximum Design Option
MERP	Marine Ecosystem Research Programme
MI	Marine Institute
MMMP	Marine Magafauna Mitigation Protocol
MNR	JNCC Marine Noise Registry
MU	Management Unit
NAS	Noise Abatement System
NE	Northeast
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPWS	National Parks and Wildlife Service
NRA	Navigational Risk Assessment
NIS	Nature Impact Statement
OWF	Offshore Wind Farm
PAM	Passive Acoustic Monitoring
PEMP	Project Environment Management Plan
PCW	Phocid carnivores in water
PEIR	Preliminary Environmental Information Report
PTS	Permanent Threshold Shift
RIAA	Report to Inform Appropriate Assessment
RoI	Republic of Ireland
ROV	Remotely Operated Vehicle
SAC	Special Area of Conservation
SAFESIMM	Statistical Algorithms for Estimating the Sonar Influence on Marine Megafauna
SAM	Static Acoustic Monitoring
SBP	Sub-bottom Profiler
SCANS	Small Cetaceans in European Atlantic waters and the North Sea
SE	Southeast
SEL	Sound Exposure Level
SEL_{cum}	Cumulative Sound Exposure Level
SMRU	Sea Mammal Research Unit

Term	Definition
SNCB	Statutory Nature Conservation Body
SPL	Sound Pressure Level
SPL_{peak}	Peak Sound Pressure Level
SSC	Suspended Sediment Concentration
SSS	Side Scan Sonar
SI	Statutory Instrument
TTS	Temporary Threshold Shift
USBL	Ultra-short Baseline
UXO	Unexploded Ordnance
VHF	Very High Frequency
VMP	Vessel Management Plan
WTG	Wind Turbine Generator

5 Marine Mammals

5.1 Introduction

5.1.1 This chapter presents the results of the Environmental Impact Assessment (EIA) for the potential impacts of the construction, operation and maintenance (O&M), and decommissioning phases within the array area and offshore Export Cable Corridor (the latter referred to as the Offshore ECC) on marine mammal ecology. This chapter has been prepared by SMRU Consulting.

5.1.2 This EIAR chapter should be read in conjunction with the following documents included within the EIAR, due to interactions between the technical aspects:

- Volume 3, Chapter 2: Marine Water and Sediment Quality (hereafter referred to as the Marine Water and Sediment Quality chapter): to be referenced for an overview on the suspended sediment concentrations expected during construction, operation and decommissioning phases, which can have direct impacts on marine mammals (e.g. impairment of visibility and therefore foraging ability which might be expected to reduce foraging success);
- Volume 3, Chapter 4: Fish and Shellfish Ecology (hereafter referred to as the Fish and Shellfish Ecology Chapter): to be referenced for an overview of the potential impacts to fish species, which could indirectly impact marine mammals;
- Volume 4, Appendix 4.3.5-7: Dublin Array: Underwater noise assessment (hereafter referred to as the Underwater noise assessment): to be referenced for an overview of the detailed methodologies for the underwater noise modelling and presents the results of this modelling;
- Volume 4, Appendix 4.3.5-1: Technical Baseline Report – Marine Mammals (hereafter referred to as the Marine Mammal Technical Baseline): to be referenced for a description of the marine mammal baseline and justification for the chosen density estimates used in the assessment;
- Volume 4, Appendix 4.3.5-6: Phase 1 Irish Offshore Wind Farms: Cumulative iPCoD modelling (hereafter referred to as the Cumulative iPCoD modelling): to be referenced for detail on the cumulative population modelling for disturbance from piling activities across the five Phase 1 projects; and
- Volume 4, Appendix 4.3.10-1: Dublin Array Offshore Wind Farm Navigation Risk Assessment (hereafter referred to as the NRA): to be referenced for an overview of the existing levels of vessel activity in the area.

5.1.3 The Marine Mammal Technical Baseline provides a detailed characterisation of the marine mammal study area and the wider management units (MUs), based on existing literature sources and survey data, and includes information on marine mammal species of ecological importance and of commercial and conservation value.

5.2 Regulatory background

5.2.1 The legislation, policy and guidance relevant to the whole Planning Application is set out in Consents, Legislation, Policy & Guidance (Volume 2, Chapter 2). The principal legislation, policy and guidance relevant to this chapter is set out in Annex A.

5.2.2 The assessment of potential impacts upon marine mammals has been made with specific reference to the relevant regulations, guidelines and guidance, which include:

- National Legislation:
    - Wildlife Acts, 1976 as amended
    - Whale Fisheries Act 1937

5.2.3 An assessment of the impact of the construction, operation and maintenance and decommissioning of the offshore infrastructure on European sites and their supporting species and habitat qualifying interests is presented in the Natura Impact Statement (NIS) (Part 4: Habitats Directive Assessments, Volume 4: NIS) that accompanies this EIAR.

5.2.4 This chapter considers relevant Irish guidance, where available. Additional / other guidance relevant to marine mammals is sourced from other relevant jurisdictions with established offshore renewable energy sectors. Relevant source guidance includes:

- Guidance and guidelines:
    - DAHG (2014) Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters;
    - IWDG (2020) Policy on Offshore Wind Farm Development for marine mammals;
    - Southall *et al*. (2019) Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects[1] (PTS and TTS-onset thresholds) and Southall *et al*. (2007) Marine mammal noise exposure criteria: initial scientific recommendations (information on TTS as a proxy for disturbance and description of how TTS is used to inform PTS-onset thresholds);
    - JNCC *et al.* (2020) Guidance for assessing the significance of noise disturbance against Conservation Objectives of harbour porpoise SACs;
    - JNCC (2023) DRAFT guidelines for minimising the risk of injury to marine mammals from unexploded ordnance clearance in the marine environment;
    - JNCC (2017) JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys; and

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[1] Whilst the use of Southall et al. (2007) is referenced within the DAHG (2014) Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters document, it is recognised that the Southall et al. (2019) Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects provides the most up to date and relevant PTS and TTS thresholds for marine mammals.

- JNCC (2010) Statutory Nature Conservation Agency Protocol for Minimising the Risk of Injury to Marine Mammals from Piling Noise.

5.3 Consultation

5.3.1 As part of the EIA for Dulin Array, non-statutory consultation has been undertaken with various statutory and non-statutory authorities. A record of key areas of consultation undertaken during the pre-application phases is summarised within Table 1.

5.3.2 Following the recommendation outlined in the DCCAE guidelines[2] the Applicant has sought to consult with the National Parks and Wildlife Service (NPWS), the Marine Institute, Irish Whale and Dolphin Group (IWDG), Irish Seal Sanctuary, Environmental Protection Agency, the Irish Wildlife Trust and Coastwatch: Environmental Pillar. A copy of the Dublin Array Scoping Report was provided to each of these organisations.

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[2] Guidance on Environmental Impact Statement (EIS) and Natura Impact Statement (NIS) Preparation for Offshore Renewable Energy Projects (Environmental Working Group of the Offshore Renewable Energy Steering Group and the DCCAE, 2017)

Table 1 Summary of consultation relating to marine mammals

Date	Consultation type	Consultation and key issues raised	Section where provision is addressed
9 May 2019	Meeting with National Parks and Wildlife Service (NPWS)	NPWS agreed that the baseline datasets give good spatial and temporal coverage and are sufficient to inform the assessment.	Volume 4, Appendix 4.3.5-1: Marine Mammal Technical Baseline.
9 May 2019	Meeting with NPWS	The project should take account of the Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters (2014)	This guidance was taken into consideration (see Volume 7, Appendix 4: Marine Megafauna Mitigation Protocol [MMMP])
9 May 2019	Meeting with NPWS	NPWS advised that in addition to existing data sets presented there was a 2nd survey of harbour porpoise associated with Rockabill to Dalkey Island SAC.	The results of the 2021 Rockabill to Dalkey Island SAC survey for harbour porpoise (which NPWS refer to as the ‘2nd survey’) have been included in Volume 4, Appendix 4.3.5-1: Marine Mammal Technical Baseline. These results build upon the results of Berrow and O'Brien 2013 and O’Brien and Berrow 2016 which details the 2013 and 2014 surveys previously undertaken within the SAC.
3 Nov 2020	Email from Irish Whale and Dolphin Group (IWDG)	IWDG suggested that the following relevant documents should be considered for this development; CMS Family Guidelines on Environmental Impact Assessments for Marine Noise-generating Activities, COP Resolution 12.14, October, 2017; The United Nations Economic Commission for Europe (UNECE) Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters; Anon (2017) Guidance on EIS and NIS Preparation for Offshore Renewable Energy Projects. Prepared for the Environmental Working Group of the Offshore Renewable Energy Steering Group and the Department of Communications, Climate Action and Environment; Anon (2018a) Guidance on Marine Baseline Ecological Assessments & Monitoring Activities for Offshore Renewable Energy Projects Part 1. Department of Communications, Climate Action and Environment 2. April 2018; and Anon (2018b) Guidance on Marine Baseline Ecological Assessments & Monitoring Activities for Offshore Renewable Energy Projects Part 2 April 2018.	The key provisions of all statutory and non-statutory- policy and legislation and where these are addressed within the EIAR are detailed in section 5.2 and Annex A.

Date	Consultation type	Consultation and key issues raised	Section where provision is addressed
3 Nov 2020	Email from IWDG	IWDG comments that it is recommended in literature (Anon 2018a) that two years (24 months) of baseline monitoring is conducted rather than the 12 months recommended in the original document. Additionally, two years of Static Acoustic Monitoring (SAM) is recommended. This is especially relevant off the east coast where porpoises are the dominant cetacean species present but hard to survey visually. SAM is also recommended to provide robust temporal data for site usage.	In total 19 monthly visual boat-based surveys were conducted during 17 months between June 2019 and January 2020, between May and September 2020, and between December 2020 and April 2021. Justification for the duration of the baseline surveys is included in Volume 4, Appendix 4.3.5-1: Marine Mammal Technical Baseline. Whilst SAM was considered for use in site-specific baseline surveys, it is not a suitable tool for monitoring grey seals or minke whales, nor to differentiate between dolphin species. Additionally, it is difficult to estimate the true density of each species from SAM surveys as it requires knowledge on the detection distance and cue rates of individuals. Line transect distance sampling surveys are a standard technique to obtain robust density estimates for marine mammals, where there are sufficient sightings to estimate a detection function.
3 Nov 2020	Email from IWDG	IWDG suggested that the German approach to marine mammal mitigation for wind farm development should be adopted over the Irish guidelines[3]. This includes PAM for 24-hour monitoring and the use of noise thresholds to reduce impacts - these methods are still in line with Irish obligations under CMS COP12.	This is addressed in section 5.12.
3 Nov 2020	Email from IWDG	IWDG suggested that while harbour porpoises and grey seals are the two species dominating the community in this area, connectivity should be considered. This includes species such as bottlenose dolphins which are occasionally seen as part of a highly mobile coastal population. Due to the size of this population any individual impacts could result in population effects so should be considered.	Volume 4, Appendix 4.3.5-1: Marine Mammal Technical Baseline assesses all marine mammals within a defined study area encompassing the offshore infrastructure, including harbour porpoise, grey seal, harbour seal, minke whale, bottlenose dolphin and common dolphin. Potential connectivity to protected bottlenose dolphin populations has been considered and presented therein.

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[3] https://www.npws.ie/sites/default/files/general/Underwater%20sound%20guidance_Jan%202014.pdf

Date	Consultation type	Consultation and key issues raised	Section where provision is addressed
3 Nov 2020	Email from IWDG	IWDG commented that the scoping report lists impacts, but does not consider the operational noise of turbines. They request that this is stated along with the frequency and source levels with modelling for the potential zones of disturbance. Additionally, noise from geophysical surveys prior to construction and after, may or may not need mitigation but frequencies and source levels of equipment differ markedly from other activities mentioned (dredging, trenching and vessel noise) and as such are likely to elicit different responses and levels of disturbance.	Operational noise has been scoped out of assessment (see Section 5.10: Scope of the assessment). Other activities such as geophysical surveys, dredging, trenching, vessel noise and pre and post construction geophysical surveys are included in the impact assessment.
3 Nov 2020	Email from IWDG	IWDG mentioned that noise abatements are not covered within the scoping report. They state that a lack of noise abatements will increase avoidable impacts and they should be considered.	10 dB noise reduction mitigation (via noise abatement technology) has been assumed in the modelling (see section 5.5) and will be adhered to in the development. The impact ranges are addressed in sections 5.14 and 5.15.
3 Nov 2020	Email from IWDG	IWDG question how prey species will be defined for harbour porpoise as there is very poor knowledge of the prey of harbour porpoise off the east coast of Ireland.	Prey species for all marine mammal receptors are discussed in section 5.13 - Impact 10: Changes in prey availability and distribution.
30 Nov 2020	Email from IWDG	There seems to be an unnecessary replication of cumulative effects assessment (CEA) within the suite of projects that might exist in the region and that a single CEA for all projects would be completed with associated data sharing across projects.	See Section 5.16.
30 Nov 2020	Email from IWDG	Aerial surveys can also be used to survey marine mammals.	Given the project already had existing boat-based data, it was considered to be most appropriate to continue with boat-based surveys and combine the data with the most recent boat-based survey data. Survey data is presented in Volume 4, Appendix 4.3.5-1: Marine Mammal Technical Baseline.
10 Nov 2020	National Parks and Wildlife Service (NPWS)	NPWS advised that the project should ensure that the “long-list” of projects is very extensive and demonstrate that some may be too distant for in-combination effects to occur. NPWS acknowledged the challenge presented by projects being at different stages in the process and welcomed the fact that the Applicants were engaging with other developers and through IWEA at an industry level.	See section 5.16
10 Nov 2020	Meeting with NPWS	NPWS advised that a survey of the Rockabill to Dalkey Island SAC was conducted in 2016 and harbour porpoise data from that was now	Volume 4, Appendix 4.3.5-1 Marine Mammal Technical Baseline includes these recommended data sources.

Date	Consultation type	Consultation and key issues raised	Section where provision is addressed
		available. Also the recently published Irish Wildlife Manual would provide data for both harbour and grey seal.	
1 Dec 2020	Dublin Array project update meeting	IWDG advised that there was little evidence of bottlenose dolphins from Wales being present on the Irish coast, rather there is evidence of a nearshore population which move around the coast of Ireland with some connectivity with Scotland. A University College Cork study estimated this coastal population to be approximately 200 individuals. IWDG estimate a population between 300 – 400.	Bottlenose dolphin population size is considered in Volume 4, Appendix 4.3.5-1: Marine Mammal Technical Baseline and used to assess the number of percentage of the Management Unit (MU) that may be disturbed in - Impact 6: Behavioural displacement and disturbance from foundation piling activity.
1 Dec 2020	Dublin Array project update meeting	IWDG concerned about the effectiveness of mitigation for impact on the conservation objectives of the Rockabill to Dalkey Island SAC from the project alone and in-combination with other east coast projects will be difficult to demonstrate.	A precautionary approach is taken when assessing impacts throughout sections 5.14, 5.15 and 5.16. The potential for impacts on the conservation objectives of SACs, and the mitigation measures applied are provided in Part 4: Habitats Directive Assessments, Volume 4: NIS
1 Dec 2020	Dublin Array project update meeting	IWDG would like to see noise measurements which have been taken during soft-start presented within the EIAR as previously there has not always been a period of gradual ramp up in noise energy.	See Volume 4, Appendix 4.3.5-7 Underwater noise assessment
1 Dec 2020	Dublin Array project update meeting	IWDG considered the proposed density estimates to be quite low and advised that the density estimates derived from the 2016 survey of the Rockabill to Dalkey SAC were 1.3 - 1.7 harbour porpoise/km^2.	The impact assessment does not rely on site specific surveys alone and considered a range of data sets within the Volume 4, Appendix 4.3.5-1: Marine Mammal Technical Baseline that were used to predict the number of animals exposed to an effect in section 5.13 – section 5.15.
1 Dec 2020	Dublin Array project update meeting	IWDG asked whether habituation of animals to ambient noise was taken into account in the assessment.	Habituation of animals to ambient noise is taken into consideration. For example, when assessing the impacts of vessels on marine mammals, the assessment highlights that vessel activity and vessel noise is not a novel impact pathway.
03 Oct 2024	Online meeting with NPWS	NPWS query whether any acoustic monitoring was undertaken to provide insight into habitat usage at night and in unfavourable weather conditions. Acoustic data was available from the Irish Whale and Dolphin Group (IWDG) static acoustic monitoring surveys.	No SAM has been undertaken. Whilst SAM was considered for use in site-specific baseline surveys, it is not a suitable tool for monitoring grey seals or minke whales, nor to differentiate between dolphin species. Additionally, it is difficult to estimate the true density of each species from SAM surveys as it requires

Date	Consultation type	Consultation and key issues raised	Section where provision is addressed
			knowledge on the detection distance and cue rates of individuals. Line transect distance sampling surveys are a standard technique to obtain robust density estimates for marine mammals, where there are sufficient sightings to estimate a detection function.
03 Oct 2024	Online meeting with NPWS	NPWS advised they are expecting the first draft of the revised Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters soon and it is anticipated that this will be provided for public consultation and extensive engagement with ORE industry.	Noted. Unfortunately, this guidance was not available at the time of drafting this EIAR.
March 2024	Email correspondence from NPWS	Confirmation of notice in relation to new qualifying interest being added to a number of existing SACs.	All existing sites identified for harbour porpoise and bottlenose dolphins as new QIs have been considered within the NIS.

5.4 Methodology

5.4.1 For a full description of the methodology as to how this EIAR was prepared, see Volume 2, Chapter 3: EIA Methodology Chapter. The methodology that follows below is specific to this chapter.

Study area

5.4.2 The marine mammal study area (hereafter referred to in this chapter as the study area) varies depending on the species, considering individual species ecology and behaviour. For all species, the study area covers the array area, Offshore Export Cable Corridor (ECC)[4] as shown in Figure 1 and is extended over an appropriate area considering the scale of movement and population structure for each species. The study areas for which marine mammals impacts have been assessed, has been defined at two spatial scales: the MU scale for species specific population units and the marine mammal survey area for an indication of the local densities of each species.

5.4.3 The MU study area is as follows for each species:

- Harbour porpoise: Celtic and Irish Seas MU;
- Bottlenose dolphin: Irish Sea MU;
- Risso's dolphin: Celtic and Greater North Seas MU;
- Common dolphin: Celtic and Greater North Seas MU;
- Minke whale: Celtic and Greater North Seas MU;
- Grey seal: East & South-east regions of Republic of Ireland (RoI) and the Northern Ireland MU; and
- Harbour seal: East & South-east regions of RoI and the Northern Ireland MU.

5.4.4 The marine mammal survey area covers the array area plus 4 km buffer.

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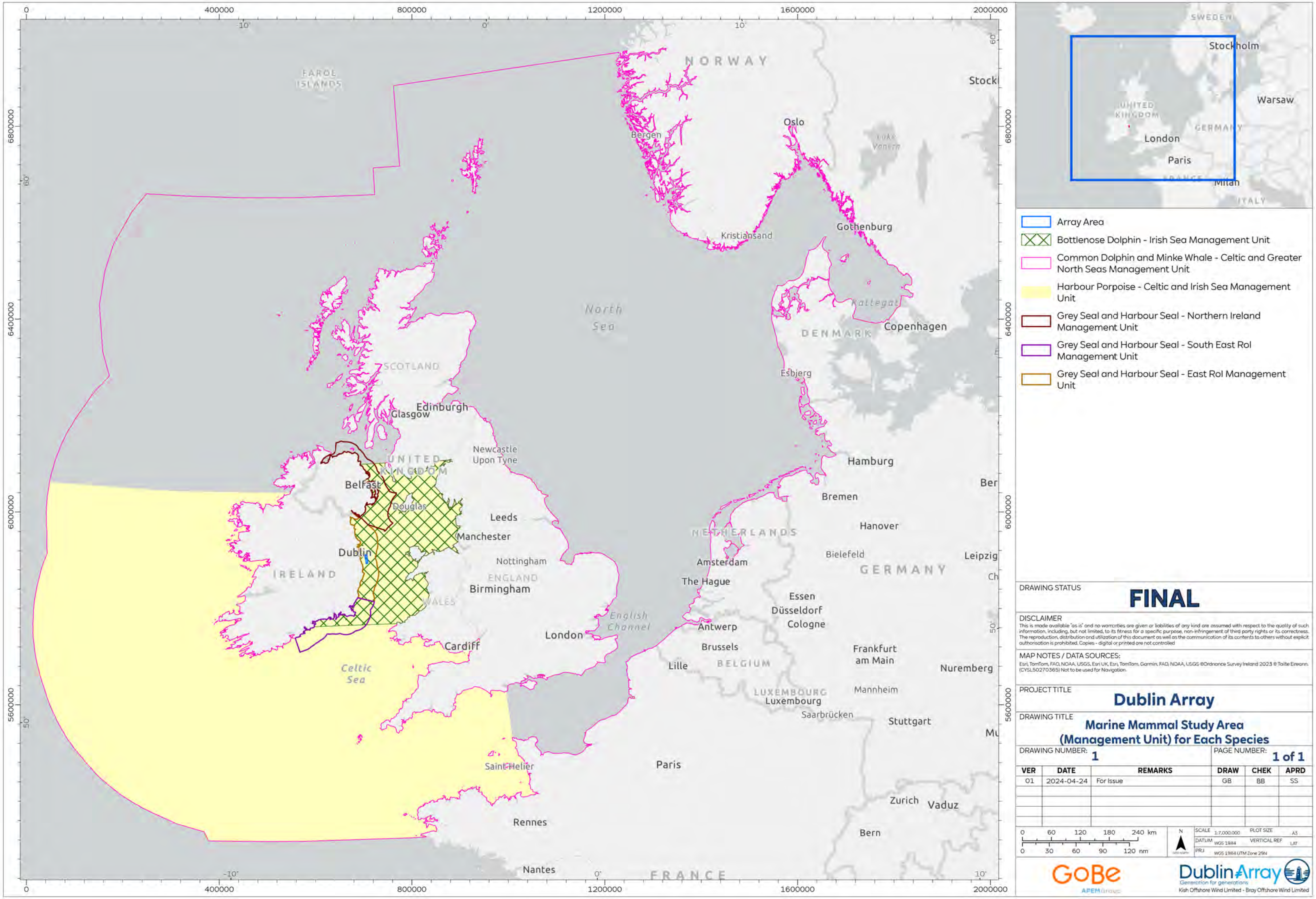
[4] All distances are taken from the outer boundary of all offshore works incorporating the offshore infrastructure, the buffer also incorporates the temporary occupation area and as such are inherently precautionary



DRAWING STATUS

FINAL

DISCLAIMER

MAP NOTES / DATA SOURCES:

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PROJECT TITLE

Dublin Array

DRAWING TITLE

Marine Mammal Study Area (Management Unit) for Each Species

DRAWING NUMBER: 1

PAGE NUMBER: 1 of 1

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GRID NORTH

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DATUM	WGS 1984	VERTICAL REF	LAT
PRJ	WGS 1984 UTM Zone 29N		

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Baseline data

5.4.5 A technical report has been prepared to provide a detailed characterisation of the receiving environment (see Marine Mammal Technical Baseline report), and describes the range of species and the abundance and density of marine mammals that could potentially be impacted, informed by data collected which cover the marine mammal MUs that include the array area.

5.4.6 The characterisation of the receiving environment has been informed by numerous data sources which comprised combining a desk based review of existing data sources and consideration of site-specific survey data (Table 2).

Table 2 Data sources examined to inform the receiving environment characterisation for marine mammals.

Data source	Type of data	Temporal and spatial coverage
Site-specific surveys	Vessel based visual line transect surveys	▪ 19 surveys: June 2019-April 2021. ▪ Marine Mammal Survey Area (array area plus 4 km buffer - see Marine Mammal Technical Baseline report for full details).
Previous site-specific baseline surveys: 2001-2002 (Saorgus Energy Ltd, 2012)	Visual boat transect surveys, boat fixed point surveys and aerial surveys	▪ 14 boat surveys between September 2001 and September 2002. ▪ Seven fixed point surveys September 2001 and May 2002. ▪ Vessel: array area +4 km from the banks. ▪ Aerial: vessel area +16 km north, 22 km south, 8 km east and 8 km west
ObSERVE programme[5] (Rogan et al., 2018)	Visual aerial surveys	▪ Four surveys: summer 2015, winter 2015, summer 2016 and winter 2016. ▪ Offshore waters around Ireland, within and beyond Ireland's continental shelf.
IWDG bottlenose dolphin surveys (O'Brien et al., 2009)	Photo ID surveys	▪ Eight surveys between July and September 2008. ▪ Entire Irish coast.
IWDG bottlenose dolphin surveys (Berrow et al., 2012)	Vessel-based visual line transect surveys	▪ 12 transects (three per month) between July and October 2010. ▪ Lower Shannon candidate SAC (cSAC).
IWDG Irish Sea surveys (Berrow et al., 2011)	Visual and acoustic surveys	▪ Two surveys in August 2011. ▪ Inshore surveys in 2 blocks: Block A (northern Irish Sea – including the study area) and Block B (southern Irish Sea).
IWDG SAC surveys (Berrow and O'Brien, 2013, O'Brien and Berrow, 2016, Berrow et al., 2021)	Visual and acoustic line transect surveys	▪ One survey in 2013 and four surveys in 2016. ▪ Additional surveys in 2021. ▪ Rockabill to Dalkey Island SAC.

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[5] https://www.gov.ie/en/publication/12374-observe-programme/

Data source	Type of data	Temporal and spatial coverage
IWDG Irish coastal water surveys (Berrow *et al.*, 2008)	Vessel based visual line transect surveys and T-POD acoustic monitoring.	▪ Six survey days between July-September 2008. ▪ Five sites (North County Dublin, Dublin Bay, Cork coast, Roaringwater Bay cSAC and Galway Bay)
IWDG Greater Dublin Drainage Project surveys: (Meade *et al.*, 2017)	Land based observations, vessel-based surveys and CPOD acoustic monitoring.	▪ 24 surveys: March 2015-March 2017. ▪ Land: North-eastern cliffs of Howth Head ▪ Vessel: waters off Loughshinny and Portmarnock area ▪ CPODs: 3 sites: East of Loughshinny, North of Lambay Island and off Portmarnock.
Small Cetaceans in European Atlantic waters and the North Sea (SCANS) IV (Gilles *et al.*, 2023)	Aerial and vessel visual surveys	▪ June - Aug 2022. ▪ All European Atlantic waters. Dublin Array offshore infrastructure located in block CS-D (western Irish Sea)
SCANS III (Hammond *et al.*, 2017)	Aerial and vessel visual surveys	▪ June & July 2016. ▪ All European Atlantic waters. Dublin Array offshore infrastructure located in block E (western Irish Sea)
SCANS II (Hammond *et al.*, 2013)	Aerial and vessel visual surveys	▪ June & July 2005. ▪ All European Atlantic waters. Dublin Array offshore infrastructure located in block O (entire Irish Sea)
Irish marine mammal atlas (Wall *et al.*, 2013)	Collation of data from IWDG, the ISCOPE I and II projects, ferry survey programme and the PReCAST surveys.	▪ 2005-2011 ▪ Irish Exclusive Economic Zone
Codling surveys (Codling Wind Park Limited, 2020)	Visual vessel surveys	▪ April 2013 – March 2014 and again in Oct 2018 – Oct 2019. ▪ Codling Wind Park array area.
Arklow surveys (RPS, 2020)	Visual vessel surveys Digital aerial surveys	▪ Monthly vessel surveys: July 1996 and March 1997, and June 2000 and June 2009. Arklow Bank wind farm array area plus a 5 km buffer. ▪ Monthly aerial surveys between March 2018 and February 2020. Lease Area plus a 4 km buffer.
Marine Ecosystem Research Programme (MERP) maps (Waggitt *et al.*, 2019)	Collation of data from Joint Cetacean Protocol (JCP) (aerial and vessel)	▪ 1980 and 2018. ▪ European Atlantic waters.
Seal counts 2003 (Cronin *et al.*, 2004, Cronin *et al.*, 2007)	Aerial survey	▪ August 2003. ▪ Entire coastline of RoI.
Seal counts 2005 (Ó Cadhla *et al.*, 2007)	Aerial survey	▪ Spring & summer 2005. ▪ Entire coastline of RoI.

Data source	Type of data	Temporal and spatial coverage
Seal counts 2017-2018 (Morris and Duck, 2019)	Aerial survey	▪ August 2017 and 2018. ▪ Entire coastline of Ireland.
Seal telemetry (Cronin *et al.*, 2016)	Telemetry tags	▪ Strangford Lough: 33x harbour seals (2006, 2008 & 2010) ▪ Raven Point: 19x grey seals 2013 & 2014 ▪ Great Blasket Island: 8x grey seals 2009

5.4.7 Site-specific surveys across the study area included vessel-based line transect surveys with distance sampling to augment the ObSERVE data, to obtain recent and robust density and abundance estimates for the key marine mammal species. A total of 19 monthly surveys were conducted between June 2019 and April 2021 using trained observers, over a survey area covering the array area plus 4 km buffer, covering 1,940 km of transect lines within an area of 266 km^2. Previous baseline surveys were conducted of the study area in 2001 and 2002, also using vessel-based line transect surveys. Full details of the survey methodologies are presented in the Marine Mammal Technical Baseline.

5.4.8 Additional baseline data were available from a variety of sources, including the previous baseline surveys, ObSERVE, IWDG surveys, SCANS, Irish marine mammal atlas, surveys undertaken for other wind farm areas in proximity, MERP maps, aerial seal surveys and seal telemetry data. These data provide additional context and provide a good indication of the species present in the study area, however, they do not provide fine scale spatial[6] or temporal[7] data when compared with the site-specific surveys (which provide a more contemporary estimate at both fine temporal and spatial scales), with many of the areas surveyed not directly overlapping with the array area or Offshore ECC.

5.4.9 Due to the variability in spatial and temporal data regarding marine mammal abundance, a precautionary approach is taken in the EIAR. The EIAR uses the higher of the density estimates in the baseline data for each of the species assessed.

5.5 Assessment criteria

5.5.1 This assessment for marine mammals is consistent with the EIA Methodology Chapter. The criteria for determining the sensitivity of the receiving environment and the magnitude of impacts for marine mammal ecology assessment are defined in Table 3 and Table 4 respectively. A matrix was used for the determination of significance in EIA terms (see Table 5). The combination of the magnitude of the impact with the sensitivity of the receptor determines the assessment of significance of effect.

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[6] Fine spatial scales refer to patterns in species densities over small areas (e.g., site-specific surveys) whilst large spatial scales refer to patterns in species densities over large areas (e.g., ObSERVE, SCANS, etc.).

[7] Fine temporal scales may record species densities daily, weekly, or monthly (e.g., site-specific surveys), whilst large temporal scales may encompass data collected within a set period of time once every few years (e.g. ObSERVE, SCANS, etc.).

5.5.2 Information about the project and the project activities for all stages of the life cycle (construction, operational and decommissioning phases) have been combined with information about the receiving environment to identify the potential interactions between the project and the environment. These potential interactions are known as potential impacts.

5.5.3 From the assessment of these potential impacts, the significance of the effect upon the receiving environment/receptor can then be determined against predetermined criteria (Table 5).

Sensitivity of receptor criteria

5.5.4 The sensitivities of marine mammal receptors are defined by both their potential vulnerability to an impact from the proposed development, their recoverability, and the value or importance of the receptor. The criteria for defining marine mammal sensitivity in this chapter are outlined in Table 3. Please note, the value of the receptor is not included in the definition of sensitivity as all marine mammals are considered to have a high value, since all marine mammals are either listed under Annex IV of the Habitats Directive as European Protected Species (EPS) of Community Interest and in need of strict protection and/or are listed in the under Annex II of the Habitats Directive as species of Community Interest.

Table 3 Sensitivity/ importance of marine mammals

Receptor sensitivity	Definition
High	No ability to adapt behaviour so that individual survival and reproduction rates are affected. No tolerance – Effect will cause a change in both individual reproduction and survival rates. No ability for the animal to recover from any impact on vital rates (reproduction and survival rates).
Medium	Limited ability to adapt behaviour so that individual survival and reproduction rates may be affected. Limited tolerance – Effect may cause a change in both individual reproduction and survival of individuals. Limited ability for the animal to recover from any impact on vital rates (reproduction and survival rates).
Low	Ability to adapt behaviour so that individual reproduction rates may be affected but survival rates not likely to be affected. Some tolerance – Effect unlikely to cause a change in both individual reproduction and survival rates. Ability for the animal to recover from any impact on vital rates (reproduction and survival rates)
Negligible	Receptor is able to adapt behaviour so that individual survival and reproduction rates are not affected. Receptor is able to tolerate the effect without any impact on individual reproduction and survival rates. Receptor is able to return to previous behavioural states/activities once the impact has ceased.

Magnitude of impact criteria

5.5.5 The magnitude of potential impacts is defined by a series of factors including the spatial extent of any interaction, the likelihood, duration, frequency and reversibility of a potential impact. The criteria for defining magnitude in this chapter are outlined in Table 4.

Table 4 Magnitude of the impact

Magnitude	Definition
High	**Extent:** The effect is expected in a high proportion of the population. **Duration:** The impact is anticipated to be permanent (i.e., over 60 years). **Frequency:** The impact will occur constantly throughout the relevant project phase. **Probability:** The effect is reasonably expected to occur. **Consequence (Adverse):** The impact would affect the behaviour and distribution of sufficient numbers of individuals, with sufficient severity, to affect the favourable conservation status and/or the long-term viability of the population at a generational scale. **Consequence (Beneficial):** Long-term, large-scale increase in the population trajectory at a generational scale.
Medium	**Extent:** The effect is expected in a medium proportion of the population. **Duration:** medium-term effects: effects lasting seven to 15 years) to long-term effects (15 – 60 years). **Frequency:** The impact will occur constantly throughout a relevant project phase **Probability:** The effect is reasonably expected to occur. **Consequence (Adverse):** Temporary changes in behaviour and/or distribution of individuals at a scale that would result in potential reductions to lifetime reproductive success to some individuals although not enough to affect the population trajectory over a generational scale. Permanent effects on individuals that may influence individual survival but not at a level that would alter population trajectory over a generational scale. **Consequence (Beneficial):** Benefit to the habitat influencing foraging efficiency resulting in increased reproductive potential and increased population health and size.
Low	**Extent:** The effect is expected in a low proportion of the population. **Duration:** The impact is anticipated to be temporary (i.e., lasting less than one year) to short-term (i.e., one to seven years). **Frequency:** The impact will occur frequently throughout a relevant project phase **Probability:** The effect is unlikely to occur. **Consequence (Adverse):** Short-term and/or intermittent and temporary behavioural effects in a small proportion of the population. Reproductive rates of individuals may be impacted in the short term (over a limited number of breeding cycles). Survival and reproductive rates very unlikely to be impacted to the extent that the population trajectory would be altered. **Consequence (Beneficial):** Short term (over a limited number of breeding cycles) benefit to the habitat influencing foraging efficiency resulting in increased reproductive potential.
Negligible	**Extent:** The effect is expected in a very low proportion of the population. **Duration:** The impact is anticipated to be momentary (seconds to minutes) to brief (lasting less than one day).

Magnitude	Definition
	Frequency: The impact will occur once or infrequently throughout a relevant project phase. **Probability:** The effect is highly unlikely to occur. **Consequence (Adverse):** Very short term, recoverable effect on the behaviour and/or distribution in a very small proportion of the population. No potential for the any changes in the individual reproductive success or survival therefore no changes to the population size or trajectory. **Consequence (Beneficial):** Very minor benefit to the habitat influencing foraging efficiency of a limited number of individuals.

Defining the significance of effect

5.5.6 Assessment of the significance of potential effects is described in Table 5. For the purposes of this assessment, potential effects identified to be above moderate significance are significant in EIA terms and additional mitigation will be required. Any effect that is slight or below is not significant in EIA terms. Moderate levels of effect have the potential, subject to the assessor's professional judgement, to be significant. Moderate will be considered as significant or not significant in EIA terms, depending on the sensitivity and magnitude of change factors evaluated.

Table 5 Significance of potential effects

			Existing Environment - Sensitivity			
			High	Medium	Low	Negligible
Description of Impact - Magnitude	**Adverse impact**	**High**	**Profound or Very Significant** **(significant)**	**Significant**	**Moderate***	Imperceptible
		Medium	**Significant**	**Moderate***	Slight	Imperceptible
		Low	**Moderate***	Slight	Slight	Imperceptible
	Neutral	**Negligible**	Not significant	Not significant	Not significant	Imperceptible
	Positive impact	**Low**	**Moderate**	Slight	Slight	Imperceptible
		Medium	**Significant**	**Moderate**	Slight	Imperceptible
		High	**Profound or Very Significant** **(significant)**	**Significant**	**Moderate**	Imperceptible

*Moderate levels of effect have the potential, subject to the assessor's professional judgement, to be significant. Moderate will be considered as significant or not significant in EIA terms, depending on the sensitivity and magnitude of change factors evaluated. These evaluations are explained as part of the assessment, where they occur.

Assessment methodology

5.5.7 As described above, the baseline was established through the compilation of best available evidence from desk-based studies and site-specific field surveys.

5.5.8 The methods used in undertaking the modelling and assessing the impacts of underwater noise are detailed in the below sections (and are presented in the Underwater noise assessment). The assessment methodology for marine mammals is consistent with that presented in the Environmental Protection Agency's (EPA's) guidance (Environmental Protection Agency, 2022).

Underwater noise assessment – Impact pile driving

5.5.9 The noise levels likely to occur as a result of pile driving were predicted by Subacoustech Environmental Ltd using their INSPIRE (Impulse Noise Sound Propagation and Impact Range Estimator) model (v5.2)[8]. A detailed description of the modelling approach is presented in the Underwater noise assessment.

5.5.10 The Applicant has committed to the reduction of noise levels at source through the use of a noise abatement system (NAS). This measure, which was identified during the early development phase of the project when considering engineering and environmental parameters, is incorporated in as a constituent element of the project and referenced in the Volume 2, Chapter 6: Project Description (hereafter referred to as Project Description Chapter).

5.5.11 A number of NAS systems are commercially available and appropriate for use on the project. In order to inform the impact assessment, a review of available literature pertaining to the effectiveness of NAS has been completed (see Volume 7, Appendix 4, MMMP Annex A - NAS). The outcome of the review, and consideration of the project site, has concluded that a 10dB reduction can be achieved through the implementation of NAS. On this basis, the underwater noise modelling for pile driving assumes a 10 dB reduction at source.

5.5.12 The final decision on the NAS system used will be driven by engineering considerations including finalised project design, meeting the project commitment of a 10 dB reduction at source.

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[8] INSPIRE noise model has been developed based on an extensive database of previous sound pressure monitoring data at a range of locations and for a variety of sound sources (see Section 3 of the Underwater Noise Modelling Technical Report for further details on the validation data and modelling confidence). This includes noise monitoring data of the current largest installed monopiles (up to 8 m), ensuring a robust validation dataset.

Piling parameters

5.5.13 Two modelling locations were selected: Northeast (NE) and Southeast (SE) which represent the corners of the array area furthest offshore and where depth ranges differed (32.5 m at NE, 19.2 m at SE). The NE location was also selected as the deeper water gives a worst-case location for overlap with the Rockabill to Dalkey Island SAC. Table 6 and Table 7 present the worst-case piling parameters modelled for monopiles and multi-leg pin-piled jackets respectively.

5.5.14 For the calculation of cumulative Permanent Threshold Shift (PTS) onset from monopiles, the proposed development involves a construction approach of one monopile installed in a 24-hour period. For the calculation of cumulative PTS-onset from multi-leg pin-piled jackets, the construction approach is that four pin-piles can be installed at one location in a 24-hour period (see Project Description Chapter).

5.5.15 There will not be any concurrent piling (2 vessels impact piling at the same time).

Table 6 Piling parameters for monopiles

Monopile										**Total**
Hammer energy (kJ)	670.7	670.7	1,341.5	3,353.7	4,024.4	4,695.1	5,365.9	6,036.6	6,372	-
# strikes	10	600	1,079	255	440	300	299	304	4,747	**8,034**
Duration (s)	300	1,800	1295	306	755	514	513	520	8,137	**235.7 min (3.93 hr)**
Strike rate (strike/min)	2	20	50	50	35	35	35	35	35	-

Table 7 Piling parameters for multi-leg pin-piled jackets

Pin-piled Jackets									**Total**	
Hammer energy (kJ)	670.7	670.7	670.7	2,012.2	2,682.9	3,353.7	4,024.4	4,695	**1 pile**	**4 piles**
# strikes	10	600	895	540	521	416	744	2,730	**64,56**	**25,824**
Duration (s)	300	1,800	1,074	648	625	499	1,275	4,680	**235.7 min (3.93 hr)**	**726.7 min (12.11 hr)**
Strike rate (strike/min)	2	20	50	50	50	50	35	35	-	-

Auditory injury (Permanent Threshold Shift)

5.5.16 For marine mammals, the main impacts will be as a result of underwater noise produced during the construction phase. Therefore, a detailed assessment has been provided for this impact pathway.

5.5.17 Exposure to loud sounds can lead to a reduction in hearing sensitivity (a shift in hearing threshold), which is generally restricted to particular frequencies. This threshold shift results from physical injury to the auditory system and may be temporary or permanent. The PTS onset thresholds used in this assessment are those presented in Southall *et al.* (2019) (Figure 2). These include two different thresholds covering 'instantaneous' PTS (SPL_{peak}, sound pressure from a single noise pulse), and 'cumulative' PTS (SEL_{cum}, accumulated sound energy over 24 hours) (see Volume 4, Appendix 4.3.5-7: Underwater noise assessment), with the latter thresholds being frequency-weighted to marine mammal functional hearing groups.

Table 8 PTS-onset thresholds for impulsive noise (Southall *et al*., 2019)

Hearing group	**Species**	**Cumulative PTS (SEL_{cum} dB re 1 µPa^{2}s weighted)**	**Instantaneous PTS (SPL_{peak} dB re 1 µPa unweighted)**
Very High Frequency (VHF) cetacean	Harbour porpoise	155	202
High Frequency (HF) cetacean	Bottlenose & Common dolphin	185	230
Low Frequency (LF) cetacean	Minke whale	183	219
Phocid carnivores (seals) in water (PCW)	Grey seal & Harbour seal	185	218

5.5.18 In calculating the received noise level that animals are likely to receive during the whole piling sequence, all animals were assumed to start moving away at a swim speed of 1.5 m/s once the piling has started (based on reported sustained swimming speeds for harbour porpoises) (Otani *et al.*, 2000), except for minke whales which are assumed to swim at a speed of 3.25 m/s (Blix and Folkow, 1995)[9]. The calculated PTS -onset impact ranges therefore represent the minimum starting distances from the piling location for animals to escape and prevent them from receiving a dose higher than the threshold.

5.5.19 Southall *et al.* (2019) propose the SPL_{peak} is used for instantaneous PTS, being either unweighted or flat weighted across the entire frequency band of a hearing group. This is because the direct mechanical damage to the auditory system[10] that is associated with high peak sound pressures is not frequency dependent (i.e., it is not restricted to the audible frequency range of a species).

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[9] This aligns with the swimming speeds recommended by the MMO and Natural England, that are used for all English projects.

[10] In this case, mechanical damage is damage to the mammalian cochlea which plays a vital role in the sense of hearing.

5.5.20 The physiological damage that sound energy can cause is mainly restricted to energy occurring in the frequency range of a species' hearing range[11]. Therefore, for the cumulative sound exposure level (SEL_{cum}), sound has been weighted based on species group specific weighting curves given in Southall *et al.* (2019) (Figure 2).

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[11] Physiological damage, in this instance, refers to noise-induced hearing loss.

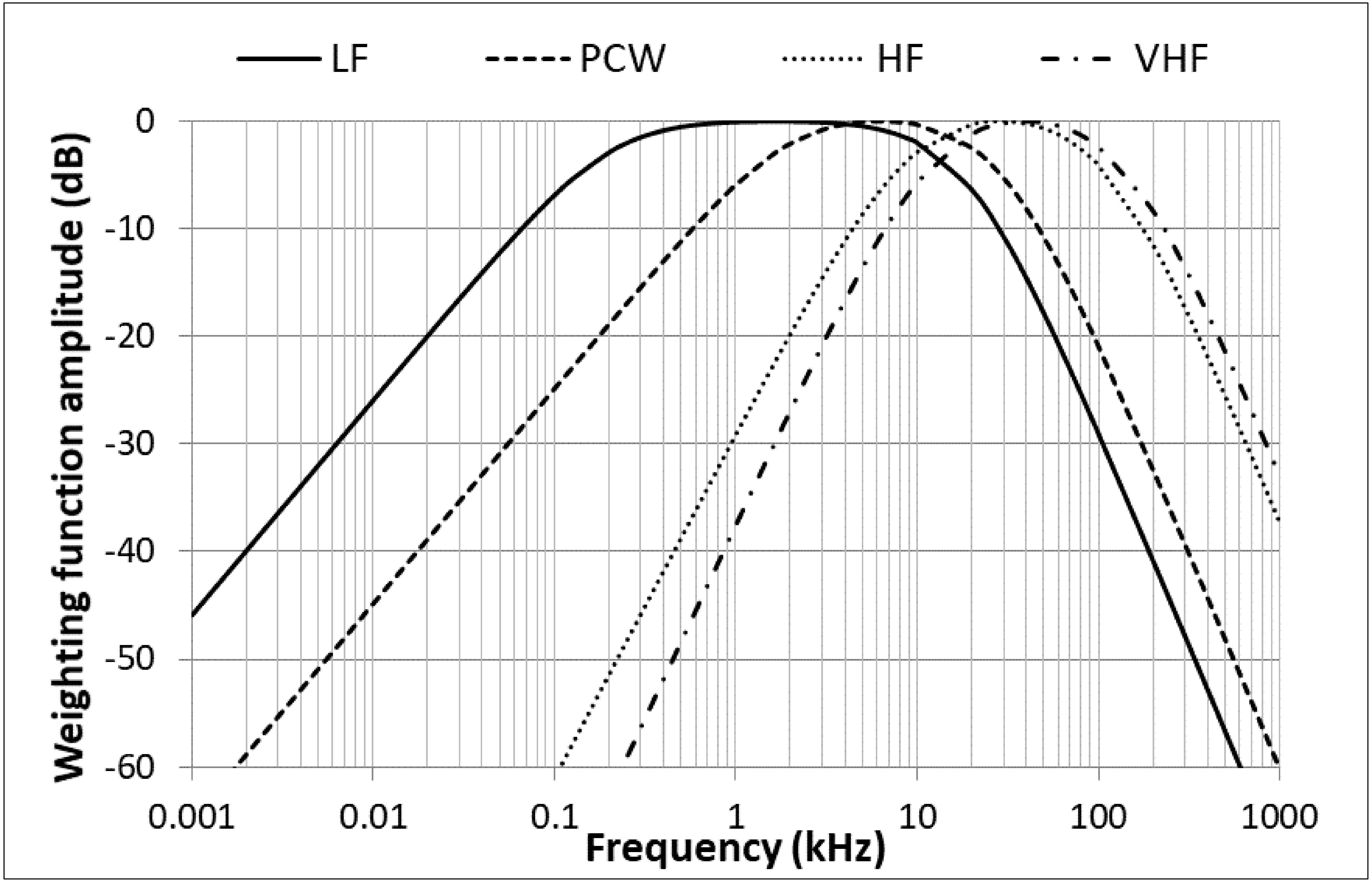

Figure 2 Auditory weighting functions for low frequency (LF), high frequency (HF) and very high frequency (VHF) cetaceans as well as phocid (PCW) pinnipeds in water taken from to Southall *et al.* (2019).

5.5.21 To quantify the impact of noise with regard to PTS, the PTS-onset impact range (the area around the piling location within which the noise levels exceed the PTS-onset threshold) will be determined using the thresholds presented by Southall *et al.* (2019). Based on agreed density estimates for each species presented in the Underwater noise assessment, the number of animals expected within the PTS onset impact range has been calculated and presented as a proportion of the relevant (estimated) population size.

5.5.22 The SEL_{cum} threshold for PTS-onset considers the sound exposure level received by an animal and the duration of exposure, accounting for the accumulated exposure over the duration of an activity within a 24-hour period. Southall *et al.* (2019) recommends the application of SEL_{cum} for the individual activity alone (i.e., not for multiple activities occurring within the same area or over the same time). To inform this impact assessment, sound modelling has considered the SEL_{cum} over a piling event. Consecutive piling scenarios where two piling events occur one after another within 24 hours, have also be modelled (e.g. four pin-piles installed at one location in a 24-hour period).

Disturbance assessment – harbour porpoise dose-response function

5.5.23 The assessment of disturbance from pile driven foundations was based on the current best practice methodology as described below, making use of the best available scientific evidence. This incorporates the application of a species-specific dose-response approach rather than a fixed behavioural threshold approach.

5.5.24 For example, the latest guidance provided in Southall *et al.* (2019) is that:

> *"Apparent patterns in response as a function of received noise level (sound pressure level) highlighted a number of potential errors in using all-or-nothing "thresholds" to predict whether animals will respond. Tyack and Thomas (2019a) subsequently and substantially expanded upon these observations. The clearly evident variability in response is likely attributable to a host of contextual factors, which emphasizes the importance of estimating not only a dose-response function but also characterizing response variability at any dosage".*

5.5.25 Noise contours at 5 dB SEL_{ss} intervals were generated by noise modelling and were overlain on species density surfaces (see the Marine Mammal Technical Baseline and Section: Receiving environment) to predict the number of animals potentially disturbed. This allowed for the quantification of the number of animals that will potentially respond.

5.5.26 Compared with the Effective Deterrence Range (EDR)[12] and fixed noise threshold approaches, the application of a dose-response curve allows for more realistic assumptions about animal response varying with dose, which is supported by a growing number of studies (Miller *et al.*, 2014, Williams *et al.*, 2014, Tougaard and Beedholm, 2019, Tyack and Thomas, 2019b, von Benda-Beckmann *et al.*, 2019). A dose-response function is used to quantify the probability of a response from an animal to a dose of a certain stimulus or stressor (Dunlop *et al.*, 2017) and is based on the assumption that not all animals in an impact zone will respond. The dose can either be determined using the distance from the sound source or the received weighted or unweighted sound level at the receiver (Sinclair *et al.*, 2023).

Harbour porpoise dose-response function

5.5.27 To estimate the number of porpoise predicted to experience behavioural disturbance as a result of pile driving, this impact assessment uses the porpoise dose-response function presented in Graham *et al.* (2017b) (Figure 3). Graham *et al.* (2017b) dose-response function was developed using data on harbour porpoise collected during the first six weeks of impact piling during Phase 1 of the Beatrice Offshore Wind Farm (Moray Firth, Scotland) monitoring programme. Changes in porpoise occurrence (detection positive hours per day) were estimated using 47 CPODs[13] placed around the wind farm site during piling and compared with baseline data from 12 sites outside of the wind farm area prior to the commencement of operations, to characterise this variation in occurrence. Porpoise were considered to have exhibited a behavioural response to piling when the proportional decrease in occurrence was greater than 0.5 (i.e., 50%). The probability that porpoise occurrence did or did not show a response to piling was modelled along with the received single-pulse sound exposure levels piling source levels based on the received noise levels (Graham *et al.*, 2017b).

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[12] The definition of an EDR varies across studies, but generally relates to the maximum distance of detectable effect, or a distance over which effects appear to plateau or the average habitat lost by an individual {Brown, 2023 #9585}. =

[13] CPODs monitor the presence and activity of toothed cetaceans by the detection within the CPOD app of the trains of echolocation clicks that they make. See https://www.chelonia.co.uk/index.html

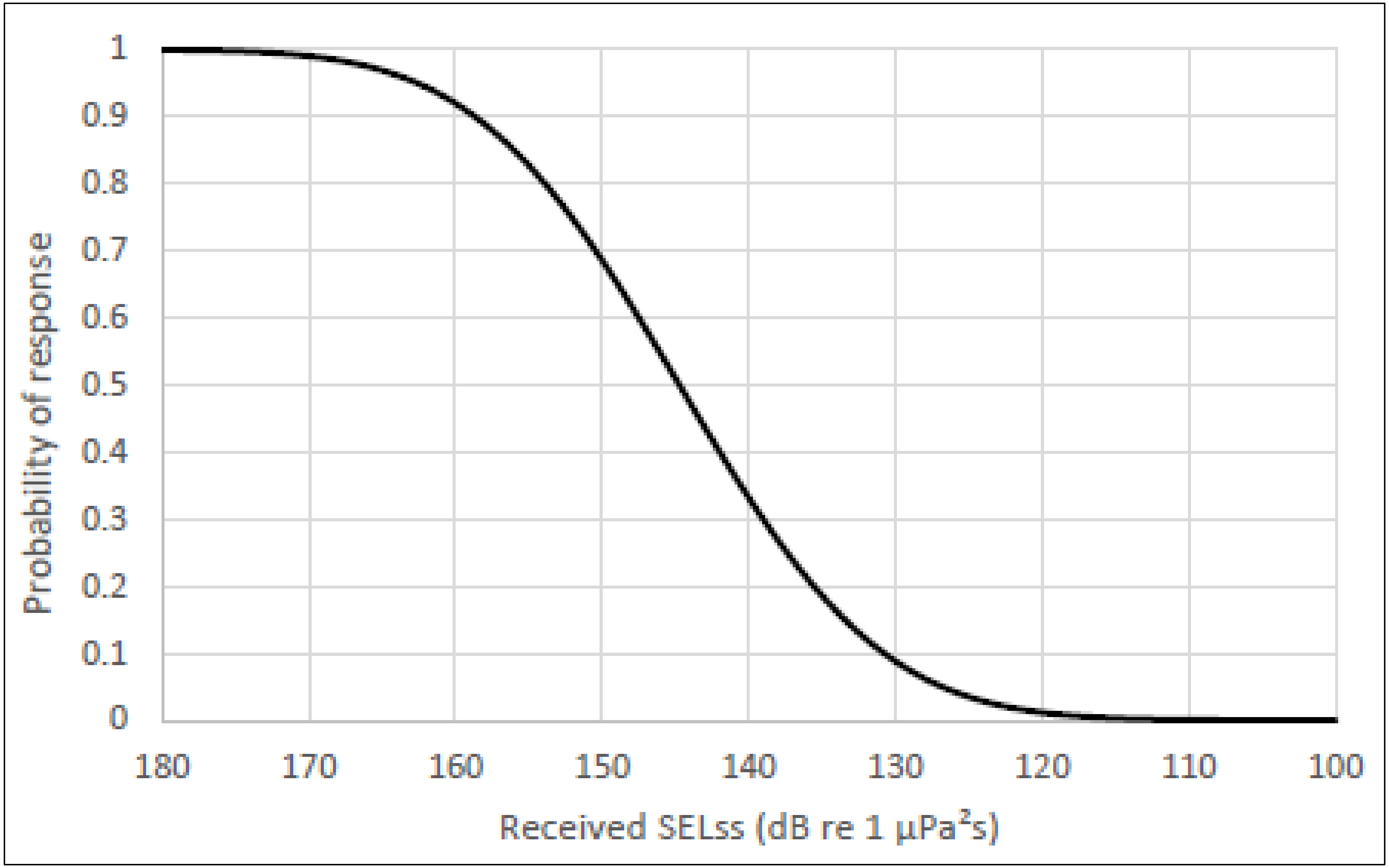

Figure 3 Relationship between the proportion of porpoise responding and the received single strike SEL (SEL_{ss}) (Graham *et al.*, 2017b).

5.5.28 Since the initial development of the dose-response function in 2017, additional data from the remaining pile driving events at Beatrice Offshore Wind farm have been processed, and are presented in Graham *et al.* (2019). The passive acoustic monitoring (using 68 CPOD locations and 6 autonomous noise recorder locations) showed a 50% probability of porpoise response (a significant reduction in detection relative to baseline) within 7.4 km at the first location piled, with decreasing response levels over the construction period to a 50% probability of response within 1.3 km by the final piling location (Figure 4) (Graham *et al*., 2019). Therefore, using the dose-response function derived from the initial piling events for all piling events in the impact assessment is precautionary, as evidence shows that porpoise response is likely to diminish over the construction period.

5.5.29 It is noted that Graham *et al.* (2019) presents an updated dose-response function for harbour porpoise, however this function is audiogram weighted specific to VHF-cetaceans and as such cannot be used as a proxy for other species. Therefore, the assessment uses the Graham *et al.* (2017b) dose-response function as it is a) more precautionary (predicts higher responses) than the Graham *et al.* (2019) dose-response function and b) can be used across other cetacean species since the curve is not audiogram weighted (this is explained further in paragraph 5.5.30 etc, below).

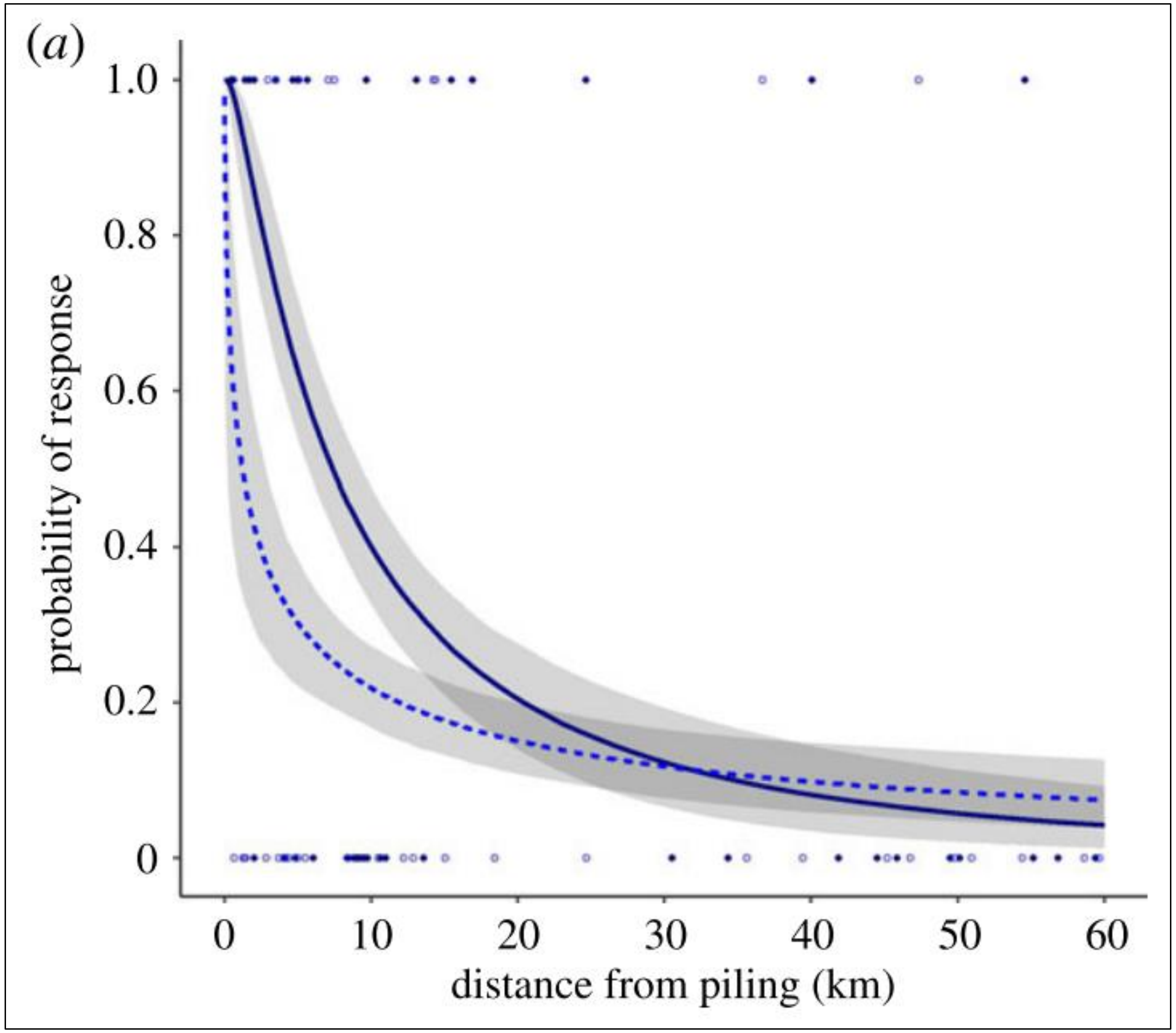

Figure 4 The probability of a harbour porpoise response (24 h) in relation to the partial contribution of distance from piling (solid navy line) and the final location piled (dashed blue line). Obtained from Graham *et al.* (2019)[14].

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[14] Predicted assuming the number of AIS vessel locations within 1 km; confidence intervals (shaded areas) estimated for uncertainty in fixed effects only. Harbour porpoise occurrence was considered to have responded to piling when the proportional decrease in occurrence (DPH) exceeded a threshold of 0.5. Points show actual response data for the first location piled (filled navy circles) and the final location piled (open blue circles).

5.5.30 In the absence of species-specific data on bottlenose dolphins, common dolphins, or minke whales, this dose-response function has been adopted for all cetaceans, however it is considered that the application of the porpoise dose-response function to other cetacean species is highly over precautionary. Harbour porpoise are considered to be particularly responsive to anthropogenic disturbance, with playback experiments showing avoidance reactions to very low levels of sound (Tyack, 2009) and multiple studies showing that porpoise respond (avoidance and reduced vocalisation) to a variety of anthropogenic noise sources to distances of multiple kilometres (e.g., Brandt *et al.*, 2013, Thompson *et al.*, 2013, Tougaard *et al.*, 2013, Brandt *et al.*, 2018, Sarnocinska *et al.*, 2019, Thompson *et al.*, 2020, Benhemma-Le Gall *et al.*, 2021b).

5.5.31 Various studies have shown that other cetacean species show comparatively less of a disturbance response from underwater noise compared with harbour porpoise. For example, through an analysis of 16 years of marine mammal observer data from seismic survey vessels, Stone *et al.* (2017) found a significant reduction in porpoise detection rates when large seismic airgun arrays were actively firing, but not for bottlenose dolphins. While the strength and significance of responses varied between porpoise and other dolphin species for different measures of effect, the study emphasised the sensitivity of the harbour porpoise (Stone *et al.*, 2017). In the Moray Firth (Scotland), bottlenose dolphins have been shown to remain in the impacted area during both seismic activities and pile installation activities (Fernandez-Betelu *et al.*, 2021) which highlights a lack of complete displacement response. Likewise, other high-frequency cetacean species, such as striped and common dolphins, have been shown to display less of a response to underwater noise signals and construction-related activities compared with harbour porpoise (e.g. Kastelein *et al.*, 2006, Culloch *et al.*, 2016).

5.5.32 As there is no disturbance threshold (EDR or dose-response function) for any other cetacean species included in this assessment, in the complete absence of an alternative, the assessment for all cetacean species has used the porpoise dose-response function. This is considered highly precautionary and as such the number of animals predicted to experience behavioural disturbance is considered to be an over-estimate and should be interpreted with a large degree of caution. In light of this, the Level B harassment threshold has also been presented as an alternative disturbance threshold for dolphins and minke whales, which is described below (see section 5.5.33).

Disturbance assessment – Level B harassment

5.5.33 Acknowledging that there are limitations to the application of the porpoise dose-response function to dolphins and minke whales, an alternative threshold for disturbance has also been presented in this assessment. The National Marine Fisheries Service (NMFS) uses the Level B harassment threshold to predict marine mammal behavioural harassment. This threshold predicts that Level B harassment will occur when an animal is exposed to received levels above 160 dB re 1 µPa (rms) for non-explosive impulsive (e.g., seismic airguns, impact pile driving) or intermittent (e.g. scientific, non-tactical sonar) sound sources (Guan and Brookens, 2021, NMFS, 2022). The Level B harassment threshold originates from a study on a grey whale mother and calf, which were shown to exhibit avoidance responses when exposed to air gun playback signals at levels above 160 dB re 1µPa$_{rms}$ (Malme *et al.*, 1984)/

5.5.34 The Level B Harassment threshold has been used in this assessment as an alternative method to assess the potential for disturbance from pile driving to minke whales and dolphin species.

Disturbance assessment – Seal dose-response function

5.5.35 For seals, the dose-response function adopted was based on the data presented in Whyte *et al.* (2020b) (Figure 5). The Whyte *et al.* (2020b) study updates the initial dose-response information presented in Russell *et al.* (2016b) and Russell and Hastie (2017), where the percentage change in harbour seal density was predicted at the Lincs offshore wind farm. The original study used telemetry data from 25 harbour seals tagged in the Wash (located in Norfolk, England) between 2003 and 2006, in addition to a further 24 harbour seals tagged in 2012, to estimate levels of seal usage in the area in order to assess how seal usage changed in relation to the pile driving activities at the Lincs Offshore wind farm in 2011-2012.

5.5.36 In the Whyte *et al.* (2020b) dose-response function it has been assumed that all seals are displaced at sound exposure levels above 180 dB re 1µPa^{2}s. This is a conservative assumption since there were no data presented in the study for harbour seal responses at this level. It is also important to note that the percentage decrease in response in the categories 170 ≤ 175 and 175 ≤ 180 dB re 1µPa^{2}s is slightly anomalous (higher response at a lower sound exposure level) due to the small number of spatial cells included in the analysis for these categories (n = 2 and 3 respectively). Given the large confidence intervals on the data, this assessment presents the mean number of seals predicted to be disturbed alongside the 95% confidence intervals (CI), for context.

5.5.37 There are no corresponding data for grey seals and, as such, the harbour seal dose-response function is applied to the grey seal disturbance assessment. This is considered to be an appropriate proxy for grey seals, since both species are categorised within the same functional hearing group (Southall *et al.*, 2019). However, it is likely that this over estimates the grey seal response, since grey seals are considered to be less sensitive to behavioural disturbance than harbour seals and could tolerate more days of disturbance before there is likely to be an effect on vital rates (Booth *et al.*, 2019). Studies of tagged grey seals have shown that there is vast individual variation in responses to pile driving, with some animals not showing any evidence of a behavioural response (Aarts *et al.*, 2018). Likewise, if the impacted area is considered to be a high quality foraging patch, it is likely that some grey seals may show no behavioural response at all, given their motivation to remain in the area for foraging (Hastie *et al.*, 2021). Therefore, the adoption of the harbour seal dose-response function for grey seals is considered to be precautionary as it will likely over-estimate the potential for impact on grey seals.

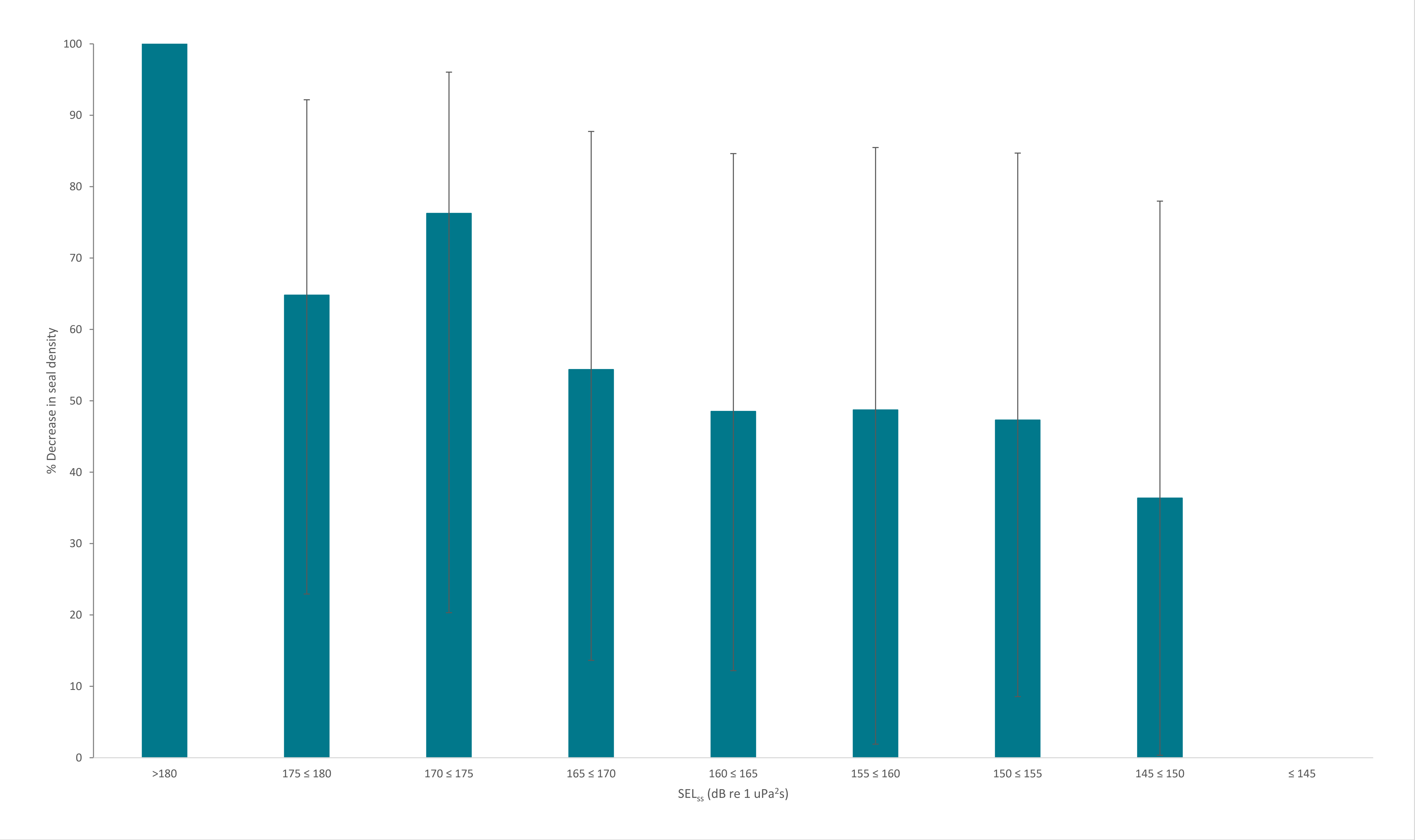

Figure 5 Predicted decrease in seal density as a function of estimated sound exposure level, error bars show 95% CI (Whyte *et al.*, 2020b).

Underwater noise assessment – UXO

Auditory injury (Permanent Threshold Shift)

5.5.38 Current practice in the UK is that auditory injury thresholds as described in Southall *et al.* (2019) should be used for assessing the impacts from UXO detonation on marine mammals. These criteria are also considered the most appropriate for use within the impact assessment in the absence of Irish specific guidance. The suitability of these criteria for UXO however, is under discussion due to the lack of empirical evidence from UXO detonations using these metrics, in particular the range dependent characteristics of the peak sounds, and whether current propagation models can accurately predict the range at which these thresholds are reached. Until alternative thresholds are provided, the Southall *et al.* (2019) thresholds are assessed as they are the best PTS-onset thresholds currently available.

5.5.39 Full details of the underwater noise modelling and the resulting PTS-onset impact areas and ranges are detailed in the Underwater noise assessment. A selection of explosive sizes have been considered based on the types of ordnance that might be found in Irish waters and, in each case, it has been assumed that the maximum explosive charge in each device is present and detonates with the clearance (a “high-order” event). The range of equivalent charge weights for the potential UXO devices have been estimated as 25, 55, 120, 240, and 525 kg for high-order events. In each case, an additional donor weight of 0.5 kg has been included to initiate detonation. Additionally, a low-order clearance scenario (deflagration) has been modelled, assuming a donor charge of 0.25 kg. The low-order deflagration method uses a shaped explosive donor charge that burns the explosive material in the UXO which destroys but does not explode the explosives in the UXO. Estimation of the source noise level for each charge weight has been carried out in accordance with the methodology of Soloway and Dahl (2014), which follows Arons (1954) and the Marine Technical Directorate (Barett, 1996). Therefore, these results are considered to be an indication of the potential maximum noise output from each charge size and, as such, likely an overestimate of PTS-onset impact ranges, especially for larger charge sizes.

5.5.40 This approach does not consider any degradation of explosive material over time, despite most historic UXOs having laid on the seabed exposed to saltwater for over 70 years. Therefore, these results are considered to be a conservative estimate of the true noise output from each charge weight and, as such, likely an overestimate of PTS-onset impact ranges, especially for larger charge weights.

Disturbance assessment

5.5.41 While there are empirically-derived dose-response relationships for pile driving, these are not directly applicable to the assessment of UXO detonation due to the very different nature of the sound emission. While both sound sources (piling and explosives) are categorised as "impulsive" sound sources, they differ drastically in the number of pulses and the overall duration of the noise emission, both of which will ultimately drive the behavioural response. While one UXO-detonation is anticipated to result in a one-off startle-response or aversive behaviour, the series of pulses emitted during pile driving will more or less continuously drive animals out of the impacted area, giving rise to a measurable and quantifiable dose-response relationship. For UXO clearance, there are no dose-response functions available that describe the magnitude and transient nature of the behavioural impact of UXO detonation on marine mammals.

5.5.42 It is important for the impact assessment to acknowledge that the scientific community's understanding of the effect of disturbance from UXO detonation is limited, and as such the assessment can only provide an indication of the number of animals potentially at risk of disturbance given the limited evidence available.

5.5.43 Since there is no dose-response function available that has been demonstrated to reflect the behavioural disturbance from UXO detonation, other behavioural disturbance thresholds have been considered instead. These alternatives are summarised in the sections below.

EDR – 26 km for high order UXO clearance

5.5.44 Guidance available on the EDR that should be applied to assess the significance of noise disturbance can be found within the "Guidance for assessing the significance of noise disturbance against Conservation Objectives of harbour porpoise SACs [in England, Wales & Northern Ireland] (JNCC, 2020) document. This has been applied in the absence of equivalent Irish gfuidance. This guidance advises that an effective deterrence range of 26 km around the source location is used to determine the impact area from high-order UXO detonation (neutralisation of the UXO through full detonation of the original explosive content) with respect to disturbance of harbour porpoise in SACs.

5.5.45 The recommendation for the 26 km EDR comes from a report by Tougaard *et al*., (2013) which calculates the EDR using data from the Dahne *et al*., (2013) study. The Dahne *et al*., (2013) study was conducted at the first wind farm in German waters, where 12 jacket foundations were piled using a Menck MHU500T hydraulic hammer with up to 500 kJ hammer energy to install piles of 2.4 m to 2.6 m diameter up to 30 m penetration depth. The JNCC (2020) guidance itself acknowledges that this EDR is based on the EDR recommended for pile driving of monopiles, since there is no equivalent data for explosives. The guidance states that:

> *"The 26km EDR is also to be used for the high order detonation of unexploded ordnance (UXOs) despite there being no empirical evidence of harbour porpoise avoidance." (JNCC, 2020).*

5.5.46 The guidance also acknowledges that the disturbance resulting from a single explosive detonation would likely not cause the more wide-spread prolonged displacement that has been observed in response to pile driving activities:

> *"… a one-off explosion would probably only elicit a startle response and would not cause widespread and prolonged displacement…" (JNCC, 2020).*

5.5.47 It is important to acknowledge that there is no evidence to support the assumption that marine mammal species respond the same way to a high-order UXO clearance as harbour porpoise do to the pile driving of jacket foundations using 500 kJ hammer energy (Dähne *et al.*, 2013). Therefore, an alternative approach to the disturbance threshold (TTS-onset as a proxy for disturbance) has been provided in this assessment, alongside the 26 km EDR approach.

EDR – 5 km for low order UXO clearance

5.5.48 There are no empirical data upon which to set a threshold for disturbance from low-order UXO clearance. Data has shown that low-order deflagration detonations produce underwater noise that is over 20 dB lower than high-order detonation (Robinson *et al.*, 2020), which highlights that the EDR for low-order UXO clearance should be significantly lower than that assumed for high-order clearance methods. The JNCC Marine Noise Registry (MNR) disturbance tool (JNCC, 2023) provides default and worst-case EDRs for various noise sources, and lists the default low-order UXO clearance EDR as 5 km. In the absence of any further data, this 5 km EDR for low-order UXO clearance will be assumed here.

Fixed noise threshold – TTS-onset

5.5.49 Recent assessments of UXO clearance activities have used the TTS-onset threshold to indicate the level at which a 'fleeing' response may be expected to occur in marine mammals (e.g. Seagreen (Ordtek, 2017, 2019, Brown, 2021), Neart na Gaoithe (Neart na Gaoithe Offshore Wind Farm, 2019) and Awel y Mor (RWE, 2022)). This is a result of discussion in Southall *et al.* (2007) which states that in the absence of empirical data on responses, the use of the TTS-onset threshold may be appropriate for single pulses (like UXO detonation):

> *"Even strong behavioural responses to single pulses, other than those that may secondarily result in injury or death (e.g., stampeding), are expected to dissipate rapidly enough as to have limited long-term consequence. Consequently, upon exposure to a single pulse, the onset of significant behavioural disturbance is proposed to occur at the lowest level of noise exposure that has a measurable transient effect on hearing (i.e., TTS-onset). We recognize that this is not a behavioural effect per se, but we use this auditory effect as a de facto behavioural threshold until better measures are identified. Lesser exposures to a single pulse are not expected to cause significant disturbance, whereas any compromise, even temporarily, to hearing functions has the potential to affect vital rates through altered behaviour." (Southall et al., 2007).*

> *"Due to the transient nature of a single pulse, the most severe behavioural reactions will usually be temporary responses, such as startle, rather than prolonged effects, such as modified habitat utilization. A transient behavioural response to a single pulse is unlikely to result in demonstrable effects on individual growth, survival, or reproduction. Consequently, for the unique condition of a single pulse, an auditory effect is used as a de facto disturbance criterion. It is assumed that significant behavioural disturbance might occur if noise exposure is sufficient to have a measurable transient effect on hearing (i.e., TTS-onset). Although TTS is*

not a behavioural effect per se, this approach is used because any compromise, even temporarily, to hearing functions has the potential to affect vital rates by interfering with essential communication and/or detection capabilities. This approach is expected to be precautionary because TTS at onset levels is unlikely to last a full diel cycle or to have serious biological consequences during the time TTS persists." (Southall et al., 2007).

5.5.50 Therefore, an estimation of the extent of behavioural disturbance can be based on the sound levels at which the onset of TTS is predicted to occur from impulsive sounds. TTS-onset thresholds are taken as those proposed for different functional hearing groups by Southall *et al.* (2019).

5.5.51 TTS-onset as a proxy for disturbance has been presented alongside the 26 km EDR approach in acknowledgement that there is no empirically based threshold to assess disturbance from high-order UXO clearance currently available.

Summary

5.5.52 In the absence of agreed thresholds to assess the potential for behaviour disturbance in marine mammals from UXO detonations, this impact assessment presents results for each of the following behavioural disturbance thresholds:

- 26 km EDR for high-order detonations;
- 5 km EDR for low-order detonations; and
- TTS-onset thresholds for both high and low-order detonations.

5.5.53 While the Applicant acknowledges that there is no empirical data to validate these thresholds as appropriate for behavioural disturbance from UXO detonations, these thresholds do cover current understanding of the range of potential behavioural responses from impulsive sound sources, and, as such, provide the best indication as to the potential level of impact.

5.5.54 It is important for the impact assessment to acknowledge that understanding of the effect of disturbance from UXO detonation is limited, and as such the assessment can only provide an indication of the number of animals potentially at risk of disturbance given the limited evidence available.

Underwater noise assessment – other construction activities

5.5.55 While impact piling will be the loudest noise source during the construction phase, there will also be several other construction activities that will produce underwater noise. These include dredging, drilling, cable laying, rock placement and trenching and noise generated by the presence of construction vessels.

Auditory injury (Permanent Threshold Shift)

5.5.56 A simple assessment of the noise impacts from non-piling noise is presented in Volume 4, Appendix 4.3.5-7: Underwater noise assessment. This includes an assessment of the potential PTS and TTS-onset impact ranges for:

- Cable laying: Noise from the cable laying vessel and any other associated noise during the offshore cable installation;
- Dredging: Dredging may be required on site for seabed preparation work for certain foundation options, as well as for the export cable and inter array cables installation. Suction dredging has been assumed to represent the greatest potential impact;
- Drilling: Piles may be installed by drilling into the seabed or by a combination of driving and drilling (note: impact piling as assessed as the maximum design option for underwater noise);
- Rock placement: Potentially required on site for installation of offshore cables (cable crossings and cable protection) and scour protection around foundation structures;
- Trenching: Plough trenching may be required during offshore cable installation; and
- Vessel noise: Vessel noise from large and medium sized vessels.

Disturbance assessment

5.5.57 There is currently no guidance on the thresholds to be used to assess disturbance of marine mammals from other construction activity. Therefore, this impact assessment provides a qualitative assessment for these impacts. The assessment is based on the limited evidence that is available in the existing literature for that impact pathway and species combination, where available. The majority of available evidence on the impact of disturbance of marine mammals from other construction activities focuses on the impact of vessel activity and dredging. Both these activities are of relevance during the construction of the Project, with dredging potentially being required for seabed preparation work for foundations as well as for export cable and inter array cable installation.

Population modelling

5.5.58 The iPCoD[15] framework (Harwood *et al.*, 2014b, King *et al.*, 2015) was used to predict the potential population consequences of the predicted amount of PTS and disturbance resulting from the piling. iPCoD uses a stage structured model of population dynamics with nine age classes and one stage class (adults 10 years and older). The model is used to run a number of simulations of future population trajectory with and without the predicted level of impact, to allow an understanding of the potential future population level consequences of predicted behavioural responses and auditory injury.

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[15] Interim Population Consequences of Disturbance Model, a modelled approach for assessing and quantifying the potential consequences for marine mammal populations of any disturbance and/or injury that may result from offshore energy developments.

5.5.59 Simulations were run comparing projections of the baseline population (i.e., under current conditions, assuming current estimates of demographic parameters persist into the future) with a series of paired 'impact' scenarios with identical demographic parameters, incorporating a range of estimates for disturbance. Each simulation was repeated 1,000 times and each simulation draws parameter values from a distribution describing the uncertainty in the parameters. This creates 1,000 matched pairs of population trajectories, differing only with respect to the effect of the disturbance and the distributions of the two trajectories can be compared to demonstrate the magnitude of the long-term effect of the predicted impact on the population, as well as demonstrating the uncertainty in predictions.

5.5.60 The effects of disturbance on vital rates (survival and reproduction) are currently unknown. Therefore, expert elicitation was used to construct a probability distribution to represent the knowledge and beliefs of a group of experts regarding a specific quantity of interest. In this case, the quantity of interest is the effect of disturbance on the probability of survival and fertility in harbour porpoise, harbour seal and grey seals (Booth *et al.*, 2019). The elicitation assumed that the behaviour of the disturbed porpoise would be altered for six hours on the day of disturbance, and that no feeding (or nursing) would occur during the six hours of disturbance. For seals, the experts assumed that on average, the behaviour of the disturbed seals would be impacted for much less than 24 hours, but did not define an exact duration.

5.5.61 Two piling schedules were considered in population modelling (Figure 6). At the time of completing the population modelling, the Applicant considered there to be a need to install up to two OSP's. In the interim period, the project design has been refined and only one OSP is required (see Project Description Chapter). The modelling is therefore sufficiently precautionary, such that the conclusions remain equally valid in the context of the assessment presented in this chapter.

5.5.62 The parameters considered in developing the piling schedules include, but are not limited to, piling method and installation sequencing, supply vessel strategy (e.g. potential use of feeder barge), location of supply port and weather risk.

5.5.63 The two piling schedules considered are, in summary:

- S2: 50 monopile WTGs and two Offshore Substation Platforms (OSPs) – installed from September to December inclusive, and within 1 calendar year (57 piling days over four months); and

- S9: 50 jacket WTGs and two OSPs – installed over 3 calendar years from September (year 1) to March (year 3) inclusive (125 piling days over 19 months).

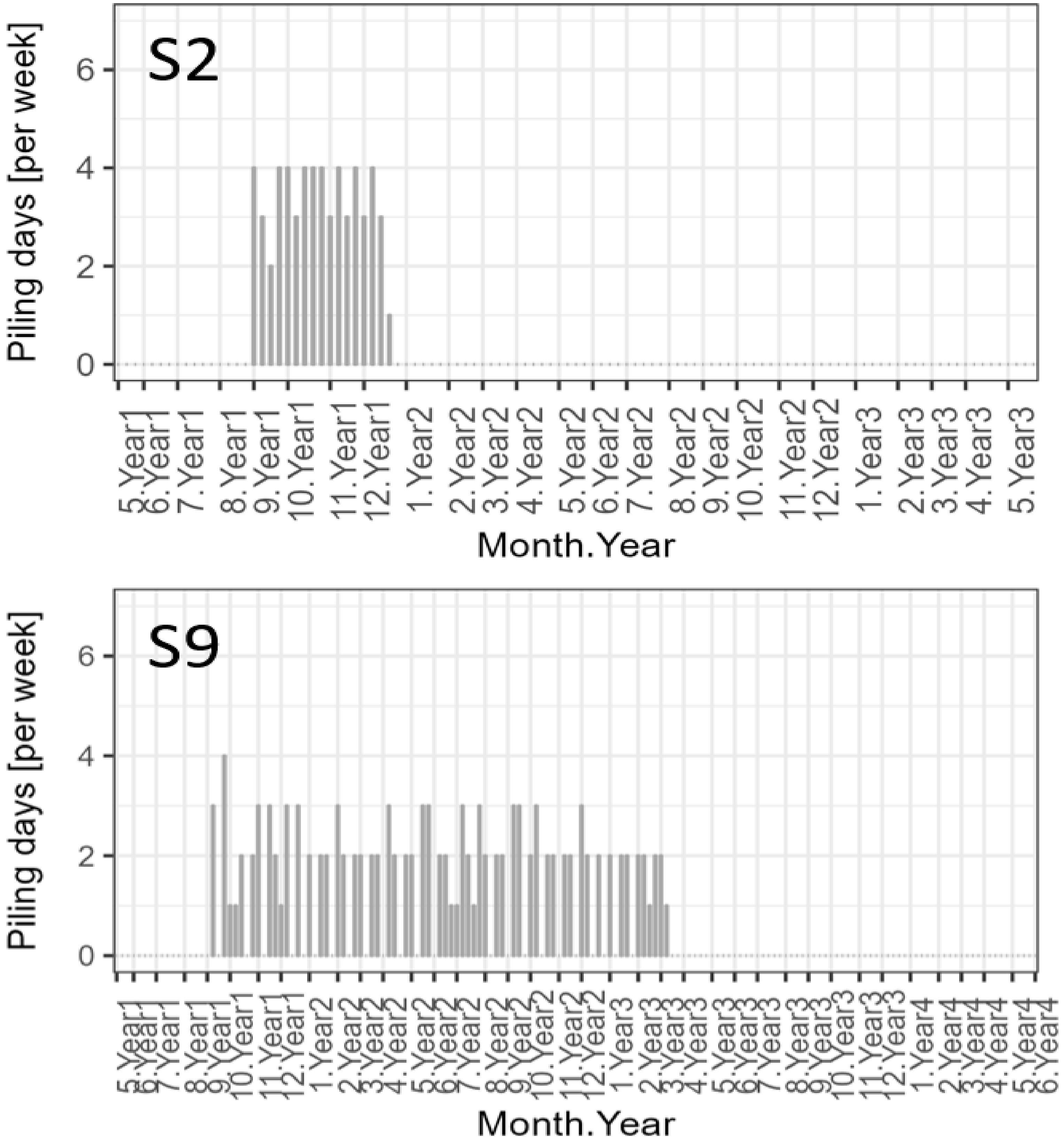

Figure 6 Piling schedules used in the iPCoD modelling.

5.5.64 Table 9 lists the parameters specified in the iPCoD modelling for each species.

Table 9 Parameters used in the iPCoD population modelling.

Parameter	Harbour porpoise	Bottlenose dolphin	Harbour seal	Grey seal
“**pmean**” - Population Size	62,517	496, 1069 or 8326	1,365	6,056
“**Surv[1]**” - Calf/Pup probability of survival	0.8455	0.87	0.4	0.222
“**Surv[7]**” – Juvenile probability of survival	0.85	0.94	0.78	0.94
“**Surv[13]**” – Adult probability of survival	0.925	0.94	0.92	0.94
“**Fertility**” – Fecundity rate	0.34	0.245	0.85	0.84
“**age1**” – Age at which a calf or pup becomes independent of its mother	1	2	1	1
“**age2**” – Age at which an average female gives birth to her first calf	5	9	4	6
“**pile_years**” – Number of piling years	1 for monopiles, 3 for jacket pin- piles			
“**vulnmean**” – Proportion of population which is classed as vulnerable (0 = 0%; 1 = 100%)	c(1)	c(1)	c(1)	c(1)
“**days**” – Number of days of residual disturbance	0	0	0	0
“**prop_days_dist** “ – Proportion of disturbed animals that experience the number of days of residual disturbance (0 = 0%; 1 = 100%)	1	1	1	1
“**other_days**” – The number of remaining individuals that will experience "other days" of residual disturbance	0	0	0	0
“**pilesx1**” – Number of piling operations to be modelled	1	1	1	1
“**vulnpile[1,]**” - matrix indicating which columns of piling.file are to be combined to predict the effects of piling on each vulnerable component of the population	c(1)	c(1)	c(1)	c(1)
“**seasons**” i.e., is the number of individuals predicted to be disturbed different per season or the same throughout the year. Where seasons = 1, the number of disturbed individuals on each day of piling is the same throughout the year	1	1	1	1
“**Avoid**” – shall disturbed animals avoid all piling operations when experiencing residual disturbance? FALSE = no.	FALSE	FALSE	FALSE	FALSE
“**Day1**” - Decide if PTS can occur on any day (default) or only on the first occasion that an individual is disturbed. FALSE = vulnerable on each day of piling.	FALSE	FALSE	FALSE	FALSE
“**years**” – number of years set for modelling simulation.	25	25	25	25
“**z**” – density dependence.	0	0	0	0

5.6 Receiving environment

5.6.1 The data available (see Marine Mammal Technical Baseline) have confirmed the likely presence of harbour porpoise, bottlenose dolphin, common dolphin, minke whale, harbour porpoise, grey seal and harbour seal in the marine mammal survey area and, therefore, these species are considered within the quantitative impact assessment. The most robust and relevant density estimates within each MU were determined for each receptor.

5.6.2 The data review within the Marine Mammal Technical Baseline confirms that no Risso's dolphins were sighted during the site-specific surveys (2019-2021), nor were they recorded in the IWDG surveys of the east coast of Ireland or sighted in SCANS II block O, with only very low numbers in SCANS III block E, SCANS-IV block CS-D, and in the ObSERVE surveys for stratum 5. Risso's dolphins are therefore scoped out of the impact assessment.

Table 10 Marine mammal MU and density estimates (#/km^2) utilised for quantitative impact assessment.

Species	MU	MU population size	MU reference	Density (#/km^2)	Density reference
Harbour porpoise	Celtic and Irish Seas	62,517	IAMMWG (2023)	0.2076[16]	Dublin site-specific surveys: Chudzinska and Burt (2021)
				Grid cell specific	SCANS III density surface: Lacey *et al.* (2022)
				Grid cell specific	Irish Sea density surface: Evans and Waggitt (2023)
				0.2803	SCANS IV block CS-D (Gilles *et al.*, 2023)
Bottlenose dolphin	Irish Sea	1,069[17]	Lacey *et al.* (2022)	Grid cell specific	SCANS III density surface: Lacey *et al.* (2022)
		496[18]	Evans and Waggitt (2023)	Grid cell specific	Irish Sea density surface: Evans and Waggitt (2023)
		8,326[19]	SCANS IV (Gilles *et al.*, 2023)	0.2352	SCANS IV Block CS-D (Gilles *et al.*, 2023)
Common dolphin	Celtic and Greater	102,656	IAMMWG (2023)	Grid cell specific	SCANS III density surface: Lacey *et al.* (2022)
				Grid cell specific	Irish Sea density surface: Evans and Waggitt (2023)

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[16] This density estimate is specific to the survey area, and thus is not as suitable for assessing wide scale disturbance impacts that extend beyond the survey area (i.e., this density estimate isn't applicable throughout the entire Irish Sea)

[17] When summing the grid cells within the Irish Sea, the SCANS III density surface estimates there to be 1,069 bottlenose dolphins in the Irish Sea; this is incompatible with the current Irish Sea MU population size of 293 dolphins (IAMMWG, 2023).

[18] When summing the grid cells within the Irish Sea, the Irish Sea density surface from Evans & Waggitt (2023) estimates there to be 496 bottlenose dolphins in the Irish Sea; this is incompatible with the current Irish Sea MU population size of 293 dolphins (IAMMWG, 2023).

[19] Given the high SCANS IV density estimates for bottlenose dolphins in the Irish Sea, they are incompatible with the current Irish Sea MU population size of 293 dolphins (IAMMWG, 2023). Therefore, it is not possible to use this density estimate in a quantitative impact assessment unless the Irish Sea MU abundance estimate is assumed to be 8,326 instead of 293.

Species	MU	MU population size	MU reference	Density (#/km²)	Density reference
	North Seas			0.0272	SCANS IV Block CS-D (Gilles *et al.*, 2023)
Minke whale	Celtic and Greater North Seas	20,118	IAMMWG (2023)	0.01581[20]	Dublin surveys: Chudzinska and Burt (2021)
				Grid cell specific	SCANS III density surface: Lacey *et al.* (2022)
				Grid cell specific	Irish Sea density surface: Evans and Waggitt (2023)
				0.0137	SCANS IV Block CS-D (Gilles *et al.*, 2023)
Grey seal	East RoI and N Ireland	6,056	Scaled from count data (Morris and Duck, 2019, SCOS, 2023)	Grid cell specific (average density across cells within the array area and Offshore ECC = 0.048 seals/km²)	Carter *et al.* (2020), Carter *et al.* (2022)
Harbour seal	East RoI and N Ireland	1,365	Scaled from count data (Morris and Duck, 2019, SCOS, 2023)	Grid cell specific (average density across cells within the array area and Offshore ECC = 0.017 seals/km²)	Carter *et al.* (2020), Carter *et al.* (2022)

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[20] Not suitable for wide scale disturbance impacts that extend beyond the survey area

Harbour porpoise

5.6.3 Harbour porpoise within the Celtic and Irish Seas MU have an estimated abundance of 62,517 (95% CI[21]: 48,324 – 80,877, Coefficient of Variation (CV[22]): 0.13) (estimated using data from SCANS III and ObSERVE) (IAMMWG, 2023). They were the most commonly sighted marine mammal during the site-specific surveys, with an estimated density of 0.2076 porpoise/km^2. Previous baseline surveys of the area also found harbour porpoise to be the most commonly sighted species. Harbour porpoise within the Celtic and Irish Seas MU harbour porpoise were found to have a widespread distribution. There are several SACs designated in the MU which list harbour porpoise as a qualifying feature, including the Rockabill to Dalkey Island SAC located closest to the project site. In the summer of 2021 (Aug-Sept), boat-based line transect surveys were conducted within the Rockabill to Dalkey Island SAC to estimate density and abundance. The density estimates for each survey had an overall pooled density of 0.83 ± 0.14 porpoises/km^2 (Berrow *et al.*, 2021). Given the range of density estimates available and the different areas covered by the density estimates, a range of relevant density estimates have been taken forward to the quantitative impact assessment. These include: the site-specific survey estimate (not suitable for wide scale disturbance impacts), the SCANS IV uniform density estimate, the SCANS III density surface estimate and the Irish Sea density surface.

Bottlenose dolphin

5.6.4 Bottlenose dolphin within the Irish Sea MU have an estimated abundance of 293 dolphins (95% CI: 108 – 793, CV: 0.54) estimated using data from SCANS III and ObSERVE (IAMMWG, 2023). However, it's important to note that given the high density estimates for bottlenose dolphins in the Irish Sea in the SCANS III density surface, the Irish Sea density surface and the SCANS IV blocks, these density surfaces are incompatible with the current Irish Sea MU population size of 293 dolphins as reported in the IAMMWG (2023).

5.6.5 During site specific surveys, four groups of bottlenose dolphins sightings occurred, confirming their presence within the study area, but there were not enough sightings to calculate a density estimate. A greater abundance has been recorded in the wider region, predominantly on the south and west coasts of Ireland (Rogan *et al.*, 2018).

5.6.6 Previous research has found a high degree of site fidelity for bottlenose dolphins in Ireland's coastal populations (Nykänen *et al.*, 2018, Nykänen *et al.*, 2020). However, studies have also found that they travel large distances, both within Ireland (O'Brien *et al.*, 2009) as well further afield with evidence of movement from the Atlantic to the North Sea (Robinson *et al.*, 2012), including the East of Scotland[23] suggesting confirmation of individual exchange between previously considered discrete populations in the UK and Ireland. A range of density estimates have been taken forward to the quantitative impact assessment (see Marine Mammal Technical Baseline for full details). These include the SCANS IV uniform density estimate, the SCANS III density surface and the Irish Sea density surface.

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[21] Confidence Interval: the 95% confidence interval is a range of values that you can be 95% confident contains the true mean of the population.

[22] Coefficient of Variation: statistical measure of the relative dispersion of data around the mean.

[23] https://www.abdn.ac.uk/lighthouse/blog/international-sightings/

Common dolphin

5.6.7 A single MU is implemented for common dolphin: Celtic and Greater North Seas. It is estimated that the MU comprises 102,656 common dolphin (95% CI: 58,932 – 178,822, CV: 0.29) (estimated using data from SCANS III and ObSERVE) (IAMMWG, 2023). Common dolphins are the most frequently recorded dolphin species in Irish waters, occurring in group sizes ranging from a few individuals to over a thousand individuals in the open sea. They have a wide distribution and occur in both coastal and offshore waters off Ireland (NPWS, 2019). Sightings made during the site-specific surveys confirm their presence, but, as there were only five groups observed during site-specific surveys, insufficient data was available for a localised density estimate in the vicinity of the proposed development. A range of density estimates have been taken forward to the quantitative impact assessment (see Marine Mammal Technical Baseline for full details). These include the SCANS IV uniform density estimate, the SCANS III density surface and the Irish Sea density surface.

Minke whales

5.6.8 Minke whale abundance is also analysed within the Celtic and Greater North Seas MU and is estimated at 20,118 (95% CI: 14,061 – 28,786, CV: 0.18) (estimated using data from SCANS III and ObSERVE) (IAMMWG, 2023). Data shows minke whales have patchy distribution within the Irish Sea (Baines and Evans, 2012). A total of 50 minke whales were sighted during the Dublin Array site-specific surveys, all of which were sighted in the spring/summer months (March to July). This was sufficient data to allow a localised average density of 0.016 minke whale/km^2 to be calculated. A range of density estimates have been taken forward to the quantitative impact assessment (see Marine Mammal Technical Baseline for full details). These include the SCANS IV uniform density estimate, the SCANS III density surface and the Irish Sea density surface.

Grey seals

5.6.9 For grey seals, the offshore infrastructure is located within the East Ireland (EI) region of the RoI but is also relatively close to the Northern Ireland MU. The relevant reference population against which to assess the impacts of the proposed development is thus a combination of the east regions of RoI (East and South-East Ireland as per Morris and Duck (2019)) and the North West & Northern Ireland (NWNI) MU due to the potential for wide-ranging impacts across each of these MUs, combined with the wide-ranging behaviour of grey seals.

5.6.10 The total August counts for the East region (418), South-east region (556) and the Northern Ireland MU (549) can be scaled by the estimated proportion of animals hauled-out at the time of the survey (25.15%, 95% CI 21.45% - 29.07%) (SCOS, 2022) to provide an estimate of the total population (hauled-out and at-sea at the time of the count). The combined count totals 1,523 grey seals with a resulting population estimate of 6,056 grey seals in the reference population (95% CI: 5,239 – 7,100). Site-specific surveys resulted in 14 grey seal sightings, confirming their presence within the study area Whilst there have been several studies on grey seal abundance and distribution at haul-outs around Ireland, there is a lack of at-sea density estimates due to a lack of telemetry data in Irish waters. However, telemetry data for grey seals tagged in UK waters have shown connectivity between the east coast of the RoI, Northern Ireland, Wales, Southwest England and the southwest coast of Scotland, meaning any impacts on this MU could have further reaching effects.

Harbour seals

5.6.11 Harbour seals occur throughout Irish waters in estuarine, coastal and fully marine areas. For this impact assessment, harbour seals have been assessed within the East region of RoI MU, and the Northern Ireland MU due to the potential for wide-ranging impacts across each of these MUs. MU size has been estimated as a proportion of the haul-out count for the region (72% of the population are expected to be hauled-out during the August survey, 95% CI: 54% - 88%). The total August counts for the East region (131), South-east region (34) and the Northern Ireland MU (818) can be scaled by the estimated proportion of animals hauled-out at the time of the survey (0.72, 95% CI 0.54 – 0.88) (Lonergan *et al*. 2013). The combined count totals 983 harbour seals with a resulting population estimate of 1,365 harbour seals in the reference population (95% CI: 1,117 – 1,820).

5.6.12 No definite harbour seal sightings were made during site specific surveys (although there were two sightings of seals where species could not be confirmed) or during IWDG surveys (see Marine Mammal Technical Baseline) covering the study area. There have been no harbour seal tagging studies conducted in the RoI to date, and no connectivity found between and tagging studies conducted in Northern Ireland. Harbour seals are known to be present at the Lambay Island SAC which is located within 20 km from the offshore infrastructure. As this is within the typical foraging range of harbour seals (40-50 km from their haul-out sites, SCOS, 2019), it is, therefore, anticipated that there will be harbour seals in the vicinity of the offshore infrastructure of Dublin Array.

Designated sites

5.6.13 The desk-based review identified a number of marine mammal species protected under national and international legislation that have potential to be present within the marine mammal study area. These are discussed in full in Section 3 of the Marine Mammal Technical Baseline report.

5.6.14 Of the species having the potential to occur within the study area, four are listed as Annex II species under the EU Habitats Directive: harbour porpoise, bottlenose dolphin, grey seal and harbour seal. These species all utilise marine habitats during certain life-stages, though the migratory and offshore ranging behaviours of these species are generally not well-known.

5.6.15 European sites with one of the Annex II species listed as qualifying interests which are within the MUs for those species are assessed within the Supporting Information for Screening of Appropriate Assessment (SISAA) (Part 4: Habitats Directive Assessment, Volume 3 Supporting Information Screening for Appropriate Assessment) and/or NIS (Part 4: Habitats Directive Assessments, Volume 4: NIS) where applicable. As such, this chapter aims to avoid repetition of the assessments contained within the NIS Screening and NIS.

5.7 Future receiving environment

5.7.1 It is challenging to predict the future trajectories of marine mammal populations. There is no appropriate monitoring at the right temporal or spatial scales to really understand the baseline dynamics of some marine mammal populations, including all cetacean species included in this assessment.

5.7.2 All marine mammal receptors were assessed as having an overall Favourable conservation status in Irish waters, with grey seal showing an increasing population trend (NPWS, 2019).

5.7.3 The receiving environment is expected to continue to change as a result of global trends such as climate change. The potential impacts of climate change on marine mammals has previously been reviewed and synthesised by Evans and Bjørge (2013), but they concluded that this topic remains poorly understood. Since then, numerous studies have, and are being undertaken to understand the potential impacts of climate change on marine mammals. Building upon the work by Evans and Bjørge (2013), Martin *et al*. (2023) provided a further review on climate change impacts on marine mammals around the UK and Ireland, highlighting for marine mammals, impacts are likely to present themselves in the form of geographic range shifts (Kaschner *et al.*, 2011, Nøttestad *et al.*, 2015, Ramp *et al.*, 2015, Williamson *et al.*, 2021) resulting from a reduction of suitable habitats; changes to predator-prey dynamics and thus, food-web alterations (Nøttestad *et al.*, 2015, Ramp *et al.*, 2015); and increased potential for prevalence of disease amongst marine mammal populations through the introduction of novel diseases (Blanchet *et al.*, 2021, SCOS, 2022). Whilst Martin *et al*. (2023) provides an overview of what is, and what could happen to marine mammal populations around the UK and Ireland, the review does not go into the specifics for each of the species discussed in this baseline report and thus there still remains some uncertainty around the potential impacts of climate change.

5.8 Defining the sensitivity of the baseline

5.8.1 The sensitivity for the receptors for each potential effect, using the criteria outlined in section 5.4, are presented in sections 5.13 to 5.15. Literature reviews have been conducted to assess the potential impacts of underwater noise on marine mammals, the sensitivity of each species to PTS-onset and behavioural disturbance from pile driving.

5.9 Uncertainties and technical difficulties encountered

5.9.1 There are uncertainties relating to the underwater noise modelling and impact assessment. Broadly, these relate to predicting exposure of animals to underwater noise, predicting the response of animals to underwater noise and predicting potential population consequences of disturbance from underwater noise. Further detail of such uncertainty is set out below.

PTS-onset assumptions

5.9.2 There are no empirical data on the threshold for auditory injury in the form of PTS onset for marine mammals, as to test this would be inhumane. Therefore, PTS onset thresholds are estimated based on extrapolating from TTS onset thresholds. For pulsed noise, such as piling, NOAA have set the onset of TTS at the lowest level that exceeds natural recorded variation in hearing sensitivity (6 dB), and assumes that PTS occurs from exposures resulting in 40 dB or more of TTS measured approximately four minutes after exposure (NMFS, 2018).

Proportion impacted

5.9.3 It is important to note that it is expected that only 18-19% of animals are predicted to actually experience PTS at the PTS-onset threshold level. This was the approach adopted by Donovan *et al.* (2017) to develop their dose response function implemented into the SAFESIMM (Statistical Algorithms For Estimating the Sonar Influence on Marine Megafauna) model, based on the data presented in Finneran *et al.* (2005). Therefore, where PTS-onset ranges are provided, it is not expected that all individuals within that range will experience PTS. Therefore, the number of animals predicted to be within PTS-onset ranges are precautionary, since they assume that all animals are impacted.

Exposure to noise

5.9.4 There are uncertainties relating to the ability to predict the exposure of animals to underwater noise, as well as in predicting the response to that exposure. These uncertainties relate to a number of factors: The ability to predict the level of noise that animals are exposed to, particularly over long periods of time; the ability to predict the numbers of animals affected, and the ability to predict the individual and ultimately population consequences of exposure to noise. These are explored in further detail in the paragraphs below.

5.9.5 The propagation of underwater noise is relatively well understood and modelled using standard methods. However, there are uncertainties regarding the amount of noise actually produced by each pulse at source and how the pulse characteristics change with distance from the source. There are also uncertainties regarding the position of receptors in relation to received levels of noise, particularly over time, and understanding how the position of receptors in the water column (i.e., depth of animal) may affect received level. Noise monitoring is not always carried out at distances relevant to the ranges predicted for effects on marine mammals, so effects at greater distances remain un-validated in terms of actual received levels. The extent to which ambient noise and other anthropogenic sources of noise (e.g. from commercial, fishing and recreational vessels etc) may mask signals from the offshore wind farm construction are not specifically addressed. The dose-response functions for porpoise include behavioural responses at noise levels down to 120 dB SEL_{ss} which may be indistinguishable from ambient noise at the ranges these levels are predicted, and therefore may over-estimate the number of animals responding.

Cumulative PTS

5.9.6 The cumulative sound exposure level (SEL_{cum}) is energy based and is a measure of the accumulated sound energy an animal is exposed to over an exposure period. An animal is considered to be at risk of experiencing “cumulative PTS” if the SEL_{cum} exceeds the energy-based threshold. The calculation of SEL_{cum} is undertaken with frequency-weighted sound levels, using species group-specific weighting functions to reflect the hearing sensitivity of each functional hearing group. To assess the risk of cumulative PTS, it is necessary to make assumptions on how animals may respond to noise exposure, since any displacement of the animal relative to the noise source will affect the sound levels received. For this assessment, it was assumed that animals would flee from the pile foundation at the onset of piling. A fleeing animal model was therefore used to determine the cumulative PTS impact ranges, to determine the minimum distance to the pile site at which an animal can start to flee, without the risk of experiencing cumulative PTS.

5.9.7 There is much more uncertainty associated with the prediction of the cumulative PTS impact ranges than with those for the instantaneous PTS. One reason is that the sound levels an animal receives, and which are cumulated over a whole piling sequence, are difficult to predict over such long periods of time, as a result of uncertainties about the animal’s (responsive) movement in terms of its changing distance to the sound source and the related speed, and its position in the water column.

5.9.8 Another reason is that the prediction of the onset of PTS (which is assumed to be at the SEL_{cum} threshold values provided by Southall *et al.* (2019)) is determined with the assumptions that:

- the amount of sound energy an animal is exposed to within 24 hours will have the same effect on its auditory system, regardless of whether it is received all at once (i.e., with a single bout of sound) or in several smaller doses spread over a longer period (called the equal-energy hypothesis); and
- the sound keeps its impulsive character, regardless of the distance to the sound source.

5.9.9 However, in practice:

- there is a recovery of a threshold shift caused by the sound energy if the dose is applied in several smaller doses with breaks in between (e.g., between pulses during pile driving or in piling breaks) leading to an onset of PTS at a higher energy level than assumed with the given SEL_{cum} threshold; and

- pulsed sound loses its impulsive characteristics while propagating away from the sound source, resulting in a slower shift of an animal's hearing threshold than would be predicted for an impulsive sound. The changes in noise characteristics with distance generally result in exposures becoming less physiologically damaging with increasing distance as sharp transient peaks become less prominent (Southall *et al.*, 2007).

5.9.10 Both assumptions, therefore, lead to a conservative determination of the impact ranges and are discussed in further detail in the sections below.

Equal energy hypothesis

5.9.11 The equal-energy hypothesis assumes that exposures of equal energy are assumed to produce equal amounts of noise-induced threshold shift, regardless of how the energy is distributed over time however, a continuous and an intermittent noise exposure of the same SEL will produce different levels of TTS (Ward, 1997). However, Finneran (2015) showed that several marine mammal studies have demonstrated that the temporal pattern of the exposure does in fact affect the resulting threshold shift (e.g. Kastak *et al.*, 2005, Mooney *et al.*, 2009, Finneran *et al.*, 2010, Kastelein *et al.*, 2013). Intermittent noise allows for some recovery of the threshold shift in between exposures, and therefore recovery can occur in the gaps between individual pile strikes and in the breaks in piling activity, resulting in a lower overall threshold shift, compared to continuous exposure at the same SEL. Therefore, the equal energy hypothesis assumption behind the SEL_{cum} threshold is not valid, and as such, models will overestimate the level of threshold shift experienced from intermittent noise exposures. The degree to which the threshold shift is over-estimated is explored in detail below.

5.9.12 Kastelein *et al.* (2014) showed that a porpoise experienced a 6-8 dB lower TTS when exposed to sound with a duty cycle of 25% compared to a continuous sound. Kastelein *et al.* (2015) also showed for a 100% duty cycle (continuous noise), PTS-onset is predicted to be reached at a SEL_{cum} of 196 dB re 1 μPa^2s, but for a 10% duty cycle, the 40 dB hearing threshold shift is predicted to be reached at a SEL_{cum} of 206 dB re 1 μPa^2s (thus resulting in a 10 dB re 1 μPa^2s difference in the threshold).

5.9.13 For the pile driving at Dublin Array, the initial soft-start has been modelled to start at 2 blows per minute for the first 5 minutes, increasing to 20 blows per minute for 30 minutes. Assuming a signal duration of around 0.5 seconds for a pile strike, the initial soft-start will be a 1.7% duty cycle (0.5 second pulse followed by 29.5 seconds of silence) and second part of the soft start will be a 16.7% duty cycle (0.5 second pulse followed by 2.5 seconds of silence). In the study of Kastelein *et al.* (2014), the reduction in TTS at a duty cycle of 25% is 5.5-8.3 dB. This means, if the same SEL elicits a ≥5.5 dB lower TTS at 25% duty cycle compared to 100% duty cycle, to elicit the same TTS as a sound of 100% duty cycle, a ≥2.4 dB[24] higher SEL is needed. The threshold at which PTS-onset is likely is therefore, expected to be a minimum of 2.4 dB higher than the PTS-onset threshold proposed by Southall *et al.* (2019) and used in the current assessment. Therefore, accounting for recovery in hearing between pulses by increasing the PTS-onset threshold by 2 or 3 dB would significantly decrease the predicted PTS-onset impact ranges.

5.9.14 The approach to modelling cumulative PTS is in development. Therefore, this impact assessment will present the cumulative PTS impact ranges using the current Southall et al. (2019) PTS-onset impact threshold without accounting for recovery between pulses.

Impulsive characteristics

5.9.15 Southall *et al.* (2019) assumed that an animal's hearing threshold will shift by 2.3 dB per dB SEL received from an impulsive sound, but only 1.6 dB per dB SEL when the sound received is non impulsive. The PTS onset threshold for non-impulsive sound is, therefore, higher than for impulsive sound, as more energy is needed to cause PTS. Consequently, an animal subject to both types of sound will be at risk of PTS at an SEL_{cum} that lies somewhere between the PTS onset thresholds of impulsive and non-impulsive sound.

5.9.16 Southall *et al.* (2019) acknowledges that as a result of propagation effects, the sound signal of certain sound sources (e.g. impact piling) loses its impulsive characteristics and could potentially be characterised as non-impulsive beyond a certain distance. The changes in noise characteristics with distance generally result in exposures becoming less physiologically damaging (Southall *et al.*, 2007).

5.9.17 Hastie *et al.* (2019) estimated the transition from impulsive to non-impulsive characteristics of impact piling noise during the installation of offshore wind turbine foundations at the Wash and in the Moray Firth. They showed that the noise signal experienced a high degree of change in its impulsive characteristics with increasing distance. Based on this data it is expected that the probability of a signal being defined as "impulsive" (using the criteria of rise time being less than 25 ms) reduces to only 20% between ~2 and 5 km from the source.

5.9.18 Martin *et al.* (2020) investigated the sound emission of different sound sources (including piling) to test techniques for distinguishing between the sound being impulsive or non-impulsive. They suggested the use of kurtosis[25] to further investigate the impulsiveness of sound. Martin *et al.* (2020) argued that:

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[24] Calculated as: 5.5 dB divided by 2.3, based on the assumption that an animal's hearing threshold will shift by 2.3 dB per dB SEL received from an impulsive sound, as per Southall et al. (2019).

[25] Kurtosis is a measure of the asymmetry of a probability distribution of a real-valued variable.

- Kurtosis of 0-3 = continuous sinusoidal signal (non-impulsive);
- Kurtosis of 3-40 = transition from non-impulsive to impulsive sound; and
- Kurtosis of 40 = fully impulsive (based on data from Hamernik *et al.* (2007)).

5.9.19 The results from Martin *et al.* (2020) shows (for unweighted and LF-C weighted sound) that piling sound loses its impulsiveness with increasing distance from the piling site - the kurtosis value decreases with increasing distance and therefore the sound loses its harmful impulsive characteristics.

5.9.20 Southall (2021) points out that "*at present there are no properly designed, comparative studies evaluating TTS for any marine mammal species with various noise types, using a range of impulsive metrics to determine either the best metric or to define an explicit threshold with which to delineate impulsiveness*". Southall (2021) also notes that '*it should be recognized that the use of impulsive exposure criteria for receivers at greater ranges (tens of kilometers) is almost certainly an overly precautionary interpretation of existing criteria'*.

5.9.21 Most recently, as a part of the range dependent nature of impulsive noise (RaDIN) project, Matei *et al.* (2024) modelled four metrics of impulsiveness and found that impulsiveness of pile driving noise decreased as it travelled further away from the source. Although a decrease in impulsiveness was noted within the first five kilometres from the piling location for all metrics, the authors caveat that this is not equivalent to a range at which these sounds are no longer impulsive (Matei *et al.*, 2024).

5.9.22 Considering that an increasing proportion of the sound emitted during a piling sequence will become less impulsive (and thereby less harmful) while propagating away from the sound source, and this effect starts at ranges below 5 km in all above mentioned examples, any impact range estimated beyond this distance should be considered as an unrealistic over-estimate, especially when they result in very large distances.

5.9.23 For the purpose of presenting a precautionary assessment, the quantitative impact assessment for marine mammals is based on fully impulsive thresholds, but the potential for overestimation should be noted.

Animal depth

5.9.24 Empirical data on SEL_{ss} levels recorded during piling construction at the Lincs offshore wind farm have been compared to estimates obtained using the Aquarius pile driving model[26] (Whyte *et al.*, 2020b). This has demonstrated that measured recordings of SEL_{ss} levels made at 1 m depth were all lower than the model predicted single-strike sound exposure levels for the shallowest depth bin[27] (2.5 m). In contrast, measurements made at 9 m depth were much closer to the model predicted single-strike sound exposure levels. This highlights the limitations of modelling exposure using depth averaged sound levels, as the acoustic model can overpredict exposure at the surface. This is important to note since animals may conduct shorter and shallower dives when fleeing (e.g. van Beest *et al.*, 2018).

Cumulative PTS Conclusion

5.9.25 Given the above, SMRU Consulting considers that the calculated SEL_{cum} PTS-onset impact ranges are highly precautionary and that the true extent of effects (impact ranges and numbers of animals experiencing PTS) will likely be considerably less than that assessed here.

Density

5.9.26 There are uncertainties relating to the ability to predict the responses of animals to underwater noise and the number of animals potentially exposed to levels of noise that may cause an impact is uncertain. Given the high spatial and temporal variation in marine mammal abundance and distribution in any particular area of the sea, it is difficult to predict how many animals may be present within the range of noise impacts. All methods for determining at sea abundance and distribution suffer from a range of biases and uncertainties.

Predicting response

5.9.27 In addition, there are limited empirical data available to inform predictions of the extent to which animals may experience auditory damage or display responses to noise. The current methods for prediction of behavioural responses are based on received sound levels, but it is likely that factors other than noise levels alone will also influence the probability of response and the strength of response (e.g., previous experience, behavioural and physiological context, proximity to activities, characteristics of the sound other than level, such as duty cycle and pulse characteristics). However, at present, it is impossible to adequately take these factors into account in a predictive sense. This assessment makes use of the monitoring work that has been carried out during the construction of the Beatrice offshore wind farm (Graham *et al.*, 2015, Graham *et al.*, 2016, Graham *et al.*, 2017a) and therefore uses the most recent information on disturbance to harbour porpoise as a result of pile driving noise.

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[26] From more information on the Aquarius model see: de Jong, C., Binnerts, B., Prior, M., Colin, M., Ainslie, M., Mulder, I., and Hartstra, I. (2019). “Wozep – WP2: update of the Aquarius models for marine pile driving sound predictions,” TNO Rep. (2018), number R11671, The Hague, Netherlands, p. 94. Retrieved from https://www.noordzeeloket.nl/publish/pages/160801/update_aquarius_models_pile_driving_sound_predeictions_tno_2019.pdf

[27] Reference to ‘bin’ here refers to a statistical bin, whereby numbers of continuous values are grouped into a smaller number of ‘bins’.

5.9.28 There is also a lack of information on how observed effects (e.g. short-term displacement around impact piling activities) manifest themselves in terms of effects on individual fitness, and ultimately population dynamics (see the section 5.9.27 above on marine mammal sensitivity to disturbance and the recent expert elicitation conducted for harbour porpoise and both seal species) in order to attempt to quantify the amount of disturbance required before vital rates are impacted.

Duration of impact

5.9.29 The duration of disturbance is another uncertainty. Studies at Horns Rev 2 demonstrated that porpoises returned to the area between one and three days after piling (Brandt *et al.*, 2011) and monitoring at the Dan Tysk wind farm as part of the Disturbance Effects on the Harbour Porpoise Population in the North Sea (DEPONS) project found return times of around 12 hours (van Beest *et al.*, 2015). Two studies at Alpha Ventus demonstrated, using aerial surveys, that the return of porpoises was about 18 hours after piling (Dähne *et al.*, 2013). A recent study of porpoise response at the Gemini wind farm in the Netherlands, also part of the DEPONS project, found that local population densities recovered between two and six hours after piling (Nabe-Nielsen *et al.*, 2018). An analysis of data collected at the first seven offshore wind farms in Germany has shown that harbour porpoise detections were reduced between one and two days after piling (Brandt *et al.*, 2018).

5.9.30 Analysis of data from monitoring of marine mammal activity during piling of jacket pile foundations at Beatrice offshore wind farm (Graham *et al.*, 2017b, Graham *et al.*, 2019) provides evidence that harbour porpoise were displaced during pile driving but return after cessation of piling, with a reduced extent of disturbance over the duration of the construction period. This suggests that the assumptions adopted in the current assessment are precautionary as animals are predicted to remain disturbed at the same level for the entire duration of the pile driving phase of construction.

Population Modelling Limitations and Assumptions

5.9.31 There is a lack of empirical data on the way in which changes in behaviour and hearing sensitivity may affect the ability of individual marine mammals to survive and reproduce. Therefore, in the absence of empirical data, the iPCoD framework uses the results of an expert elicitation process conducted according to the protocol described in Donovan *et al*. (2016) to predict the effects of disturbance and PTS on survival and reproductive rate. The process generates a set of statistical distributions for these effects and then simulations are conducted using values randomly selected from these distributions that represent the opinions of a “virtual” expert. This process is repeated many 100s of times to capture the uncertainty among experts.

5.9.32 There are several precautions built into the iPCoD model and this means that the results are considered to be highly precautionary and likely over-estimate the true population level effects as discussed in the next section. These include:

- The fact that the model assumes minke whales and bottlenose dolphins will not forage for 24 hours after being disturbed,

- The lack of density dependence in the model (meaning the population will not respond to any reduction in population size), and
- The level of environmental and demographic stochasticity in the model (see section 5.9.36).

Duration of disturbance: minke whales and bottlenose dolphins

5.9.33 The iPCoD model for minke whale and bottlenose dolphin disturbance was last updated following the expert elicitation in 2013 (Harwood *et al.*, 2014a). When this expert elicitation was conducted, the experts provided responses on the assumption that a disturbed individual would not forage for 24 hours. However, the most recent expert elicitation in 2018 highlighted that this was an unrealistic assumption for harbour porpoises (generally considered to be more responsive than minke whales and bottlenose dolphins), and thus the iPCoD model for harbour porpoise was amended to assume that disturbance resulted in six hours of non-foraging time (Booth *et al.*, 2019). Unfortunately, neither minke whale nor bottlenose dolphins were included in the updated expert elicitation for disturbance, and thus the iPCoD model still assumes 24 hours of non-foraging time for both minke whales and bottlenose dolphins. This is unrealistic considering what we now know about marine mammal behavioural responses to pile driving. A recent study estimated energetic costs associated with disturbance from sonar, where it was assumed that one hour of feeding cessation was classified as a mild response, two hours of feeding cessation was classified as a strong response and eight hours of feeding cessation was classified as an extreme response (Czapanskiy *et al.*, 2021). Assuming 24 hours of feeding cessation for both minke whales and bottlenose dolphins in the iPCoD model is significantly beyond that which is considered to be an extreme response and is therefore considered to be unrealistic and will over-estimate the true disturbance levels expected from the offshore development.

Lack of density dependence

5.9.34 Density dependence is described as *"the process whereby demographic rates change in response to changes in population density, resulting in an increase in the population growth rate when density decreases and a decrease in that growth rate when density increases"* (Harwood et al., 2014a). The iPCoD scenario run assumes no density dependence, since there is insufficient data to parameterise this relationship. Essentially, what this means is that there is no ability for the modelled impacted population to increase in size back up to carrying capacity following disturbance. It is possible that populations with a positive growth rate (i.e. an increasing population) will continue to increase in the absence of disturbance.

5.9.35 At a recent expert elicitation, conducted for the purpose of modelling population impacts of the Deepwater Horizon oil spill (Schwacke et al., 2021), experts agreed that there would likely be a concave density dependence on fertility, which means that in reality, it would be expected that the impacted population would recover to carrying capacity (which is assumed to be equal to the size of un-impacted population – i.e., it is assumed the un-impacted population is at carrying capacity) rather than continuing at a stable trajectory that is smaller than that of the un-impacted population. Note that in the iPCoD model, for stable populations, carrying capacity is assumed to be equal to the size of un-impacted population – i.e., it is assumed the un-impacted population is at carrying capacity.

Environmental and demographic stochasticity

5.9.36 The iPCoD model attempts to model some of the sources of uncertainty inherent in the calculation of the potential effects of disturbance on marine mammal population. This includes demographic stochasticity and environmental variation. Environmental variation is defined as *"the variation in demographic rates among years as a result of changes in environmental conditions"* (Harwood *et al.*, 2014a). Demographic stochasticity is defined as *"variation among individuals in their realised vital rates as a result of random processes"* (Harwood *et al.*, 2014a).

5.9.37 The iPCoD protocol describes this in further detail: *"Demographic stochasticity is caused by the fact that, even if survival and fertility rates are constant, the number of animals in a population that die and give birth will vary from year to year because of chance events. Demographic stochasticity has its greatest effect on the dynamics of relatively small populations, and we have incorporated it in models for all situations where the estimated population within an MU is less than 3000 individuals. One consequence of demographic stochasticity is that two otherwise identical populations that experience exactly the same sequence of environmental conditions will follow slightly different trajectories over time. As a result, it is possible for a "lucky" population that experiences disturbance effects to increase, whereas an identical undisturbed but "unlucky" population may decrease"* (Harwood et al., 2014a).

5.9.38 This is clearly evidenced in the outputs of iPCoD where the un-impacted (baseline) population size varies greatly between iterations, not as a result of disturbance but simply as a result of environmental and demographic stochasticity. In the example provided in Figure 7, after 25 years of simulation, the unimpacted population size varies between 176 (lower 2.5%) and 418 (upper 97.5%). Thus, the change in population size resulting from the impact of disturbance is significantly smaller than that driven by the environmental and demographic stochasticity in the model.

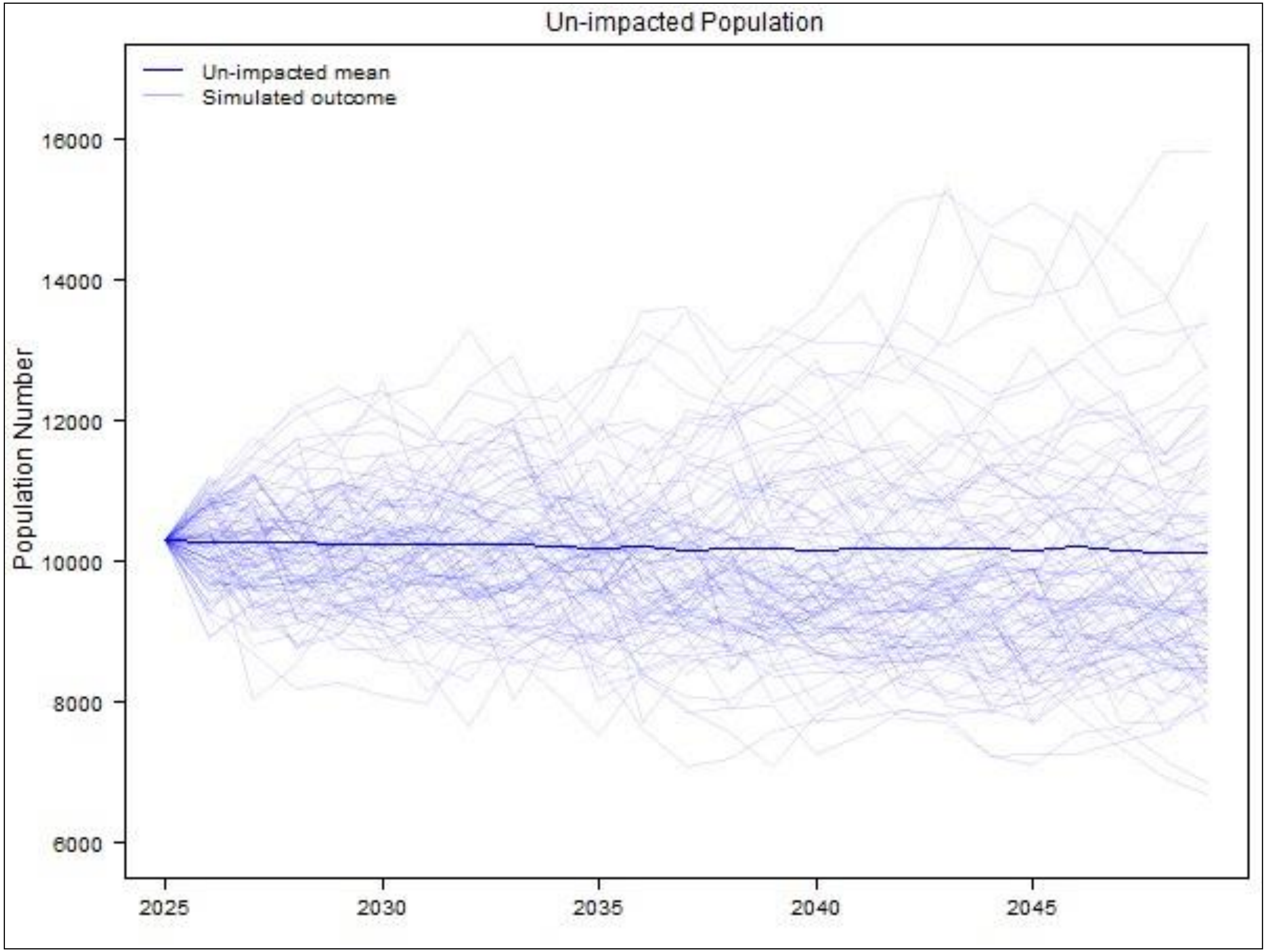

Figure 7 Simulated un-impacted (baseline) population size over the 25 years modelled

Summary

5.9.39 All of the precautions built into the iPCoD model mean that the results are considered to be highly precautionary. Despite these limitations and uncertainties, this assessment has been carried out according to best practice and using the best available scientific information.

5.9.40 In addition to this, it is noted that iPCoD is not available for common dolphins.

5.10 Scope of the assessment

5.10.1 The Department of the Environment, Climate and Communications (DCCAE[28]) 2017 guidelines identify the potential impacts relevant to offshore renewable energy projects and have been used to inform the scope of the assessment for marine mammals. The impacts that will be assessed are detailed in Table 11.

Table 11 Potential impacts considered within the marine mammal ecology assessment

Potential impact/ change	Impact
Construction	
Auditory injury as a result of geophysical survey	Impact 1
Behavioural disturbance from geophysical surveys	Impact 2
PTS onset from UXO clearance	Impact 3
Behavioural disturbance from UXO clearance	Impact 4
Auditory injury as a result of foundation piling activity	Impact 5
Behavioral displacement and disturbance from foundation piling activity	Impact 6
Other construction activities	Impact 7
Vessel collision risk	Impact 8
Increases in suspended sediment concentrations	Impact 9
Changes in prey availability and distribution	Impact 10
Operation and maintenance	
Disturbance from vessel noise	Impact 11
Vessel collision risk	Impact 12
Increases in suspended sediment concentrations	Impact 13
Changes in prey availability and distribution.	Impact 14
Decommissioning	
Disturbance (including dredging, trenching and vessel noise)	Impact 15
Vessel collision risk	Impact 16
Increases in suspended sediment concentrations	Impact 17
Changes in prey availability and distribution	Impact 18

Impacts scoped out of the assessment

5.10.2 A number of impacts are proposed to be scoped out of the assessment for marine mammals as they are considered to have no potential for significant effect. These impacts are outlined below, together with the justification for scoping them out:

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[28] Now the Dept of Environment, Climate and Comms. DHLPG now Dept of Housing, Local Government and Heritage

- TTS (construction, operation and decommissioning);
- Operational noise (operation);
- Accidental pollution and contamination (construction, operation and decommissioning);
- Electromagnetic field (EMF; operation); and
- Disturbance of haul-out sites (construction).

TTS (construction, operation and decommissioning)

5.10.3 Exposure to loud sounds can result in a reduction in hearing sensitivity. This reduction in sensitivity (threshold shift) can be permanent or temporary. Reductions in hearing sensitivity may affect an animal's ability to forage, avoid predation and communicate but the TTS onset ranges alone do not allow assessment of the magnitude or significance of the likely consequences for individuals and ultimately populations of the predicted extent over which any TTS might occur. The magnitude of the consequence is likely to be related to the duration and magnitude of the TTS. However, the current TTS onset thresholds are inappropriate to determine a biologically significant level of TTS. It is asserted that any effects of TTS, as currently defined, are captured in the period that marine mammals exposed to pile driving noise are predicted to be disturbed. Therefore, a reduction in individual foraging capability as a result of exposure to pile driving noise will be included in the assessment and potential reductions in fitness as a result of noise exposure will be sufficiently captured by the assessment of disturbance.

5.10.4 TTS is, by definition, temporary, and the duration of effect at the threshold for TTS onset is likely to be short and therefore unlikely to cause any major consequences for an animal. An impact range which encompasses such a large variation in the predicted effect on individuals is extremely difficult to interpret in terms of the potential consequences for individuals. It is important to bear in mind that the quantification of the spatial extent over which any impact is predicted to occur in the environmental assessment process, is done so in order to inform an assessment of the potential magnitude and significance of an impact. Because the TTS thresholds are not intended to indicate a level of impact of concern per se but are used to enable the prediction of where PTS might occur, they should not be used for the basis of any assessment of impact significance.

5.10.5 Since there are no thresholds to determine a biologically significant effect from TTS and given that disturbance will be included in a detailed quantitative assessment (Section 5.13), the impact of TTS on marine mammals is scoped out of assessment.

Operational noise (operation)

5.10.6 The Marine Management Organisation[29] (2014) review of post-consent monitoring at offshore wind farms found that available data on the operational noise, from the UK and abroad, in general showed that underwater noise levels from operational wind turbines are low and the spatial extent of the potential impact of the operational wind turbine noise on marine receptors is generally estimated to be small, with behavioural response only likely at ranges close to the wind turbine. This is supported by several published studies which provide evidence that marine mammals are not displaced from operational wind farms.

5.10.7 At the Horns Rev and Nysted OWFs in Denmark, long-term monitoring showed that both harbour porpoise and harbour seals were sighted regularly within the operational OWFs, and within two years of operation, the populations had returned to levels that were comparable with the wider area (Diederichs *et al.*, 2008). Similarly, a monitoring programme at the Egmond aan Zee OWF in the Netherlands reported that significantly more porpoise activity was recorded within the OWF compared to the reference area during the operational phase (Scheidat *et al.*, 2011). Other studies at Dutch and Danish OWFs (Lindeboom *et al.*, 2011) also suggest that harbour porpoise may be attracted to increased foraging opportunities (see Impact 14: Changes in prey availability and distribution (O&M)) within operating offshore wind farms. In addition, tagging work by Russell *et al*. (2014) found that some tagged harbour and grey seals demonstrated grid-like movement patterns as these animals moved between individual wind turbine generators (WTGs), strongly suggestive of these structures being used for foraging.

5.10.8 Other reviews have also concluded that operational wind farm noise will have negligible effects (Madsen *et al.*, 2006, Teilmann *et al.*, 2006a, Teilmann *et al.*, 2006b, CEFAS, 2010, Scheidat *et al.*, 2012). Tougaard *et al.* (2020) highlight that wind turbine noise could be expected to be significant in areas with low natural ambient noise and low levels of ship traffic; however, given the levels of vessel traffic recorded in the area (see the NRA), this is not considered to be the case at for the proposed development. Therefore, this impact has been scoped out of the assessment.

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[29] The Marine Management Organisation (MMO) is a department in the UK Government created in 2009 by the Marine and Coastal Access Act. The MMO's purpose is to: "*protect and enhance our precious marine environment, and support UK economic growth by enabling sustainable marine activities and development*". https://www.gov.uk/government/organisations/marine-management-organisation/about

Accidental pollution and contamination (construction, operation and decommissioning)

5.10.9 The impact of pollution including accidental spills and contaminant releases associated with the construction of infrastructure and use of supply/service vessels has the potential to lead to direct mortality of marine mammals or a reduction in prey availability, either of which may affect species' survival rates. Substances such as grease, oil, fuel, anti-fouling paints and grouting materials may be accidentally released or spilt into the marine environment. The Applicant is committed and legally bound to prevent pollution and due diligence throughout all construction, O&M and decommissioning activities under the Sea Pollution Acts and associated SIs which give effect to MARPOL Convention obligations. This commitment ensures the implementation of appropriate avoidance and/or preventative measures and serves as mitigation against this type of pollution incident. The Applicant will implement the following, in line with the Sea Pollution Act 1991 and MARPOL convention and other similar binding rules and obligations imposed on ship owners and operators by inter alia the International Maritime Organisation as relevant:

- Marine Pollution Contingency Plan to cover accidental spills, potential contaminant release and include key emergency contact details (e.g., the Irish Coast Guard (IRCG) and will comply with the National Maritime Oil/ HNS Spill Contingency Plan (IRCG, 2020). Measures include Storage of all chemicals in secure designated areas with impermeable bunding (up to 110% of the volume); and double skinning of pipes and tanks containing hazardous materials to avoid contamination.

5.10.10 With the implementation of these preventative measures within an appropriate Project Environmental Management Plan (PEMP), it is expected that mortality is considered very unlikely to occur, and a major incident that may impact any species at a population level is also considered very unlikely. Therefore, this impact has been scoped out of the assessment.

EMF (operation)

5.10.11 Based on the data available to date, there is no evidence of EMFs related to marine renewable devices (e.g., offshore wind turbines, tidal turbines, wave energy) having any impact (either positive or negative) on marine mammals (Copping, 2018). There is no evidence that seals can detect or respond to EMF, however, some species of cetaceans may be able to detect variations in magnetic fields (Normandeau *et al.*, 2011). To date, the only marine mammal known to show any response to EMF is the Guiana dolphin (*Sotalia guianensis*) which has been shown to possess an electroreceptive system, which uses the vibrissal crypts on their rostrum to detect electrical stimuli similar to those generated by small to medium sized fish (Czech-Damal *et al.*, 2013). None of the marine mammals included in this assessment are considered to be sensitive to EMF.

5.10.12 Given that marine mammals are known to closely associate with offshore wind farm structures, it is predicted that the significance for this impact would be Imperceptible, and therefore this impact is scoped out of assessment.

Disturbance of haul-out sites (construction)

5.10.13 There are no significant grey or harbour seal haul-outs sites in the vicinity of the landfall or O&M sites based on the haul-out data utilised in the count surveys and provided in the Marine Mammal Technical Baseline. There is also no evidence from the at-sea and total usage maps or the available telemetry data that grey seals or harbour seals use the landfall area in any significant numbers. It is not expected that landfall activities during construction will impact seal haul-outs, therefore this impact is scoped out of assessment.

5.11 Key parameters for assessment

5.11.1 As set out in the Application for Opinion under Section 287B of the Planning and Development Act 2000, flexibility is being sought where details or groups of details may not be confirmed at the time of the Planning Application. In summary, and as subsequently set out in the ABP Opinion on Flexibility (detailed within Volume 2, Chapter 3: EIA Methodology) the flexibility being sought relates to those details or groups of details associated with the following components (in summary - see further detail in see Project Description Chapter):

- WTG (model – dimensions and number);
- OSP (dimensions);
- Array layout;
- Foundation type (WTG and OSP; types and dimensions and scour protection techniques); and
- Offshore cables (IAC and ECC; length and layout).

5.11.2 To ensure a robust, coherent, and transparent assessment of the proposed Dublin Array project for which development consent is being sought under section 291 of the Planning Act, the Applicant has identified and defined a Maximum Design Option (MDO) and Alternative Design Option(s) (ADO) for each environmental topic/receptor. The MDO and ADO have been assessed in the EIAR to determine the full range and magnitude of effects, providing certainty that any option within the specified parameters will not give rise to environmental effects more significant than those associated with the MDO. The extent of significant effects is therefore defined and certain, notwithstanding that not all details of the proposed development are confirmed in the application.

5.11.3 The range of parameters relating to the infrastructure and technology design allow for a range of options in terms of construction methods and practices, which are fully assessed in the EIAR. These options are described in the project description and are detailed in the MDO and ADO tables within each offshore chapter of the EIAR. This ensures that all aspects of the proposed Dublin Array project are appropriately identified, described and comprehensively environmentally assessed.

5.11.4 With respect to project design features where flexibility is not being sought, such as trenchless cable installation techniques at the landfall, the MDO and alternative design option(s) are the same (as there is no alternative). With respect to the range of normal construction practises that are intrinsic to installation of the development, such as the nature and extent of protection for offshore cables and the design of cable crossings, but which cannot be finally determined until after consent has been secured and detailed design is completed, the parameters relevant to the receptor being assessed are quantified, assigned and assessed as a maximum and alternative, as informed by the potential for impact upon that receptor. In the event of a favourable decision on the Planning Application they will be agreed prior to the commencement of the relevant part of the development by way of compliance with a standard ‘matters of detail’ planning condition (see Volume 2, Chapter 2: Consents, Legislation, Policy and Guidance). Throughout, an explanation and justification is provided for the MDO and alternative(s) within the relevant tables, as it relates the details or groups of details where statutory design flexibility is being sought, and wider construction practises where flexibility is provided by way of planning compliance condition.

Table 12 Maximum and Alternative Design Options assessed

Maximum design option	Alternative design options	Justification
Construction		
Impact 1: Auditory injury as a result of geophysical surveys		
Pre and post construction surveys will be undertaken using a combination of DP and anchored vessels across the array area and offshore ECC. The same surveys will be required for Option A: 50 WTG, Option B: 45 WTG, and Option C: 39 WTGs. Surveys may require the use of the following equipment: - Multi-Beam Echo Sounder (MBES) - Side Scan Sonar (SSS) - Sub Bottom Profiler (SBP) - 2D / 3D UHR Seismic reflection profiling - Seismic refraction - Ultra-short Baseline (USBL) - underwater positioning - Drop-Down Video (DDV) - Magnetometer (MAG) - Passive measurement - Additional survey activities may also be required including Remotely Operated Vehicle (ROV) or diver inspections of cable routes and identified seabed anomalies.	Alternative options include the potential for varying spatial areas requiring survey, however all survey operations of this type will include the equipment listed in the maximum design option, and will take place using a combination of DP and anchored vessels across the array area and offshore ECC. Note that the same surveys will be required for Option A: 50 WTG, Option B: 45 WTG, and Option C: 39 WTGs.	The maximum design option presents the greatest potential for PTS from geophysical surveys as it includes all possible survey equipment and the greatest spatial area over which the surveys will be completed.
Impact 2: Behavioural disturbance from geophysical surveys		
As above. See: Impact 1: PTS from geophysical surveys		
Impact 3: PTS-onset from UXO clearance		
A detailed UXO survey will be completed prior to construction. The type, size (net explosive quantities (NEQ)) and number of possible detonations and duration of UXO clearance operations is not known at this stage. Data acquired to date and pUXO assessment indicates a low likelihood of UXO to be present. The MDO is for up to four high order detonations in the assessment, which could take place anywhere within the array area, offshore ECC and wider temporary occupation area. Only one detonation will take place at any one time. For all detonations standard mitigation will be applied (bubble curtain or other suitable alternative). Confirmation of the most appropriate mitigation to be applied will be dependent on the consideration of further site-specific data (including, but not limited to; ground conditions, sea conditions, location of UXO, status of UXO).	As for the MDO, the type, size and number of possible detonations and duration of UXO clearance operations is not known at this stage. Data acquired to date and pUXO assessment indicates a low likelihood of UXO to be present. The alternative design option for UXO disposal involve avoidance of any targets by project routing and micrositing of infrastructure, relocation of UXO to a safe area within the development boundary or in situ detonation using low order. The Alternative Design Option (ADO) will be for up to four low order detonations in the assessment, which could take place anywhere within the array area, offshore ECC and wider temporary occupation area. Only one detonation will take place at any one time. For all detonations standard mitigation will be applied (bubble curtain or other suitable alternative). Confirmation of the most appropriate mitigation to be applied will be dependent on the consideration of further site-specific data (including, but not limited to; ground conditions, sea conditions, location of UXO, status of UXO).	The maximum design option presents the greatest potential for PTS from UXO detonations as it involves use of high order detonation which results in the greatest impact range for marine mammals and consequently greater number of animals predicted to experience PTS.
Impact 4: Behavioural disturbance from UXO clearance		
As above. See Impact 3: PTS from UXO		
Impact 5: Auditory injury as a result of foundation piling activity		
Offshore construction programme Construction period lasting a maximum of **30 months**.	**Offshore construction programme** Construction period lasting a minimum of **18 months** or a mean of **24 months**	For underwater noise from impact piling, the MDO presented is based on the maximum spatial extent of noise propagation generated by largest pile diameter and blow energy imparted on the pile and the longest duration of

Maximum design option	Alternative design options	Justification
Spatial MDO: **WTG Monopiles** - Max pile diameter: 13 m - Max hammer energy: 6,372 kJ - One monopile foundation installed in a 24-hour period OR WTG pin-piles - Max pile diameter: 5.75 m - Max hammer energy: 4,695 kJ - Four pin-piles installed in a 24-hour period	**Spatial MDO**: Foundation installation using alternative methods such as drilled piles and suction-installed buckets piles would result in lower underwater noise levels compared to impact pile driving.	piling. In line with the modelling, the piling scenario with the largest noise impact ranges represents the maximum design scenario. The maximum number of piled foundations would represent the temporal maximum design scenario for disturbance from impact piling. The maximum predicted impact range for underwater noise for piled foundations would represent the spatial maximum design scenario for disturbance.
Temporal MDO: **WTG pin piles** - Max pile diameter: 5.75 m - Max hammer energy: 4,695 kJ - Max 4 piles installed per day (12 hours active piling time per 24 hours)	**Temporal MDO:** Alternative turbine sizes will result in fewer WTGs installed resulting in fewer piling days compared to the MDO	
Other structures - One offshore platforms - Max hammer energy: 4,695 kJ	As for MDO	
Impact 6: Behavioural displacement and disturbance from foundation piling activity		
As above. See Impact 5: Auditory injury as a result of foundation piling activity		
Impact 7: Other construction activities		
Other construction noise: Noise emitted from construction vessels and arising during construction activities (e.g., cable laying, dredging, rock placement and trenching), consistent with the longest construction programme of 30 months on site and MDO for greatest area of seabed preparation as detailed in the Physical processes chapter. **Construction Vessels:** Up to **three** large installation vessels and associated support craft operating simultaneously with a total of **66** vessels on site at any time. Up to **813** round trips to port from construction vessels and an additional **1,825** round trips from small vessels such as CTVs during construction period.	**Other construction noise**: Noise emitted from construction vessels and arising during construction activities (e.g., cable laying, dredging, rock placement and trenching), consistent with the shortest construction programme of 18 months on site and alternative design options for smallest area of seabed preparation as detailed in the Physical processes chapter. Up to **three** large installation vessels and associated support craft operating simultaneously with a total of **51** vessels on site at any time Up to **774** round trips to port from construction vessels and an additional **538** round trips from small vessels such as CTVs during construction period.	The maximum numbers of vessels and associated vessel movements represents the maximum potential for disturbance from other construction activity. Other construction activities identified were modelled using predicted source levels using a simple modelling approach based on measurement data from Subacoustech Environmental's underwater noise measurement database, the MDO correlates with the activities that generate the loudest noise and/or activities are in operation for the longest period of time.
Impact 8: Vessel collision risk (construction)		
Full build out of the array area Option C: 39 WTGs and one OSP **Two** export cable circuits, with maximum length of **18.35 km** per cable circuit Construction period lasting a maximum of **30 months**	All design option layouts represent similar spatial use of the array area Option A: 50 WTGs and one OSP or Option B: 45 WTGs and one OSP **Two** export cables circuits, with maximum length of **17.95 km** per cable circuit Construction period lasting **18 months**	The maximum numbers of vessels and associated vessel movements represents the maximum potential for collision risk, the larger WTGs will result in the greater number of vessel movements.

Maximum design option	Alternative design options	Justification
Up to **three** large installation vessels and associated support craft operating simultaneously with a total of **66** vessels on site at any time. Up to **813** round trips to port from construction vessels and an additional **1,825** round trips from small vessels such as CTVs during construction period	Up to **three** large installation vessels and associated support craft operating simultaneously with a total of **51** vessels on site at any time Up to **774** round trips to port from construction vessels and an additional **538** round trips from small vessels such as CTVs during construction period.	
Impact 9: Increases in suspended sediment concentrations (construction)		
Assessment is based on the MDO presented in Volume 3, Chapter 1: Marine Geology, Oceanography and Physical Processes, and is in line with modelled outputs that represent the maximum spatial footprint of the effect with the longest duration to return to background levels using trailer suction hopper dredgers.		
Impact 10: Changes in prey availability and distribution (construction)		
Assessment is based on the MDO presented in Volume 3, Chapter 5: Fish and Shellfish Ecology		
Operation and Maintenance		
Impact 11: Disturbance from vessel noise (Operations and Maintenance)		
Operations and Maintenance Vessels: Potential vessels: Operations and Maintenance vessel, SOV, CTV, lift vessel/ jack-up vessel, cable maintenance vessel, auxiliary vessels (e.g. survey vessels, tugs, cargo vessels, passenger vessels, scour replacement vessels etc) **Three** daily CTV trips with the addition of up to **100** vessels trips to support scheduled routine and non-routine maintenance per year.	**Operations and Maintenance Vessels:** Potential vessels: Operations and Maintenance vessel, SOV, CTV, lift vessel/ jack-up vessel, cable maintenance vessel, auxiliary vessels (e.g. survey vessels, tugs, cargo vessels, passenger vessels, scour replacement vessels etc) **2** daily CTV trips with the addition of up to **75** vessels trips to support scheduled routine and non-routine maintenance	The maximum numbers of vessels and associated vessel movements represents the maximum potential for disturbance from vessel noise and collision risk.
Impact 12: Vessel collision risk (Operations and Maintenance)		
As above. See Impact 11: Disturbance from vessel noise		
Impact 13: Increases in suspended sediment concentrations (Operations and Maintenance)		
Maximum amount of suspended sediment released during operational activities and associated duration - see Volume 3, Chapter 1: Marine Geology, Oceanography and Physical Processes.		
Impact 14: Changes in prey availability and distribution (Operations and Maintenance)		
Assessment is based on the MDO presented in Volume 3, Chapter 5: Fish and Shellfish Ecology.		
Decommissioning		
Impact 15: Disturbance (decommissioning)		
Removal of structures is expected to be undertaken as an approximate reverse of the installation process	Decommissioning activities are expected to be the same for all design options. Alternative design options are represented by varying numbers of total structures within the array area (represented by different WTG options), as shown below.	The MDO is the option with the greatest number of WTGs (Option A: 50 WTGs). All alternatives have lower potential for damage to assets and infrastructure during decommissioning. The maximum numbers of vessels and associated vessel movements represents the maximum potential for collision risk.
It is anticipated that piled foundations will be cut at a level just below the seabed Buried cables to be cut and left in situ (but to be determined in consultation with key stakeholders as part of the decommissioning plan and following best practice at the time of decommissioning)	It is anticipated that piled foundations will be cut at a level just below the seabed Buried cables to be cut and left in situ (but to be determined in consultation with key stakeholders as part of the decommissioning plan and following best practice at the time of decommissioning)	
Scour and cable protection left in situ	Scour and cable protection will be removed	
Decommissioning activities lasting approximately three years for both onshore and offshore works.	Decommissioning activities lasting approximately three years for both onshore and offshore works.	
Removal of foundations: - Option A: Up to 50 WTGs; and - One OSP.	Removal of foundations: - Option B: Up to 45 WTGs and one OSP; or Option C: Up to 39 WTGs; and one OSP.	

Maximum design option	Alternative design options	Justification
Landfall infrastructure will be left in situ where considered appropriate. Any requirements for decommissioning at the landfall will be agreed with statutory consultees; and It is likely judged that cable removal will bring about further environmental impacts. At present it is therefore proposed that the cables will be left in situ, but this will be reviewed over the design life of the project. **Decommissioning Vessels:** Up to 813 round trips to port vessels and an additional 1825 round trips from small vessels such as CTVs.	Landfall infrastructure will be left in situ where considered appropriate. Any requirements for decommissioning at the landfall will be agreed with statutory consultees; and It is likely judged that cable removal will bring about further environmental impacts. At present it is therefore proposed that the cables will be left in situ, but this will be reviewed over the design life of the project. **Decommissioning Vessels:** Up to 774 round trips to port and an additional 538 round trips from small vessels such as CTVs.	
Impact 16: Vessel collision risk (decommissioning)		
As above. See Impact 15: Disturbance from decommissioning activities		
Impact 17: Increases in suspended sediment concentrations (decommissioning)		
As above. See Impact 15: Disturbance from decommissioning activities		
Impact 18: Changes in prey availability and distribution (decommissioning)		
As above. See Impact 15: Disturbance from decommissioning activities		

5.12 Project Design Features and Avoidance or Preventative Measures

5.12.1 As outlined within the EIA Methodology Chapter (Volume 2, Chapter 3) and in accordance with the EPA Guidelines (2022), this EIAR describes the following:

- Project Design Features: These are features of the Dublin Array project that were selected as part of the iterative design process, which are demonstrated to avoid and prevent significant adverse effects on the environment in relation to marine mammals. These are presented within Table 13 .

- Other Avoidance and Preventative Measures: These are measures that were identified throughout the early development phase of the Dublin Array project, also to avoid and prevent likely significant effects, which go beyond design features. These measures were incorporated in as constituent elements of the project, they are referenced in the Project Description Chapter of this EIAR and they form part of the project for which development consent is being sought. These measures are distinct from design features and are found within our suite of management plans. These are also presented within Table 13 .

- Additional Mitigation: These are measures that were introduced to the Dublin Array project after a likely significant effect was identified during the EIA assessment process. These measures either mitigate against the identified significant adverse effect or reduce the significance of the residual effect on the environment.

5.12.2 All measures are secured within Volume 8, Chapter 2: Schedule of Commitments.

Table 13 Project design features and other avoidance and preventative measures relating to marine mammals

Project design feature / other avoidance or preventative measure	Where secured
Impact piling of a single pile will occur at any one time, i.e. no simultaneous impact piling will occur.	Outlined within the Project Description Chapter
The Applicant commits to the implementation of at-source noise abatement methods (e.g. bubble curtains, casings, resonators) to reduce the source level of the underwater noise from pile driving by at least 10 decibels (dB).	Outlined within the Project Description Chapter with further details relevant to marine mammals within the MMMP

Project design feature / other avoidance or preventative measure	Where secured
Procedures for impact piling, will include: ▪ Implementation of a 1000 m mitigation zone; ▪ Pre-piling Marine Mammal Observer (MMO) watches; ▪ pre-piling Passive Acoustic Monitoring (PAM) (if required to supplement the MMO); ▪ Acoustic Deterrent Device (ADD), as an additional mitigation tool prior to the start of piling activities at night; ▪ Soft start procedure; and ▪ Breaks in piling procedure.	Outlined within the MMMP. The MMMP has been developed to comply with all relevant guidance, specifically NPWS, (2014); DAHG (2014[30]); IWDG (2020).
Procedures for geophysical surveys using 3D UHRS (sparker) equipment, will include: ▪ Implementation of a 1000 m mitigation zone; ▪ Pre-shooting (in relation to survey start) Marine Mammal Observer (MMO) watches; ▪ Delay of operations if marine mammals detected for at least 30 mins; ▪ Soft start procedure; ▪ Line changes longer than 40 minutes will be stopped with a pre watch of 30 mins, followed by soft start to resume; ▪ Breaks in operation of between 5-10 mins will prompt a MMO watch.	Outlined within the MMMP. The MMMP has been developed to have regard to all relevant guidance, specifically NPWS, (2014); DAHG (2014); IWDG (2020)
Procedures for UXO detonation will include: ▪ Implementation of a mitigation zone of 1000 m; ▪ Pre-detonation MMO and PAM; ▪ Soft start charges for high order clearance; ▪ Use of bubble curtains for high clearance UXO; and ▪ Post detonation searches.	Outlined within the MMMP. The MMMP has been developed to comply with all relevant guidance, specifically NPWS, (2014); DAHG (2014); IDWG (2020)

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[30] At the time of publication updates to this guidance are still pending.

Project design feature / other avoidance or preventative measure	Where secured
Applicant will implement the following, in line with the Sea Pollution Act 1991 and MARPOL convention and other similar binding rules and obligations imposed on ship owners and operators by inter alia the International Maritime Organisation as relevant: Marine Pollution Contingency Plan to cover accidental spills, potential contaminant release and include key emergency contact details (e.g., the Irish Coast Guard (IRCG) and will comply with the National Maritime Oil/ HNS Spill Contingency Plan (IRCG, 2020). Measures include Storage of all chemicals in secure designated areas with impermeable bunding (up to 110% of the volume); and double skinning of pipes and tanks containing hazardous materials to avoid contamination.	The PEMP includes measures outlined within the Marine Pollution Contingency Plan compliant with relevant legal obligations
Waste management and disposal arrangements - the developer will commit to the disposal of sewage and other waste in a manner which complies with all regulatory requirements, including but not limited to the IMO MARPOL requirements	The PEMP includes measures outlined within the Marine Pollution Contingency Plan compliant with relevant legal obligations
A code of conduct will be implemented by all vessel operators when encountering marine species. In addition, vessel movements to and from construction sites and ports will, where feasible, follow existing routes.	The PEMP incorporates all measures within an environmental Vessel Management Plan
Navigational safety measures including: ▪ Compliance with COLREGs ▪ Marine coordination; ▪ Temporary lighting and marking; ▪ Operational lighting and marking; ▪ Use of guard vessels; ▪ Advisory safe passing distances; ▪ Charting; ▪ Emergency Response Cooperation Planning.	Measures contained within the Vessel Management Plan designed to prevent any risks of collision or disruption to other craft, all measures will ensure compliance with the Convention on the International Regulations for Preventing Collisions at Sea (COLREGS) (International Maritime Organization (IMO), 1972/77)

5.13 Environmental Assessment: Construction phase

5.13.1 The potential environmental impacts arising from the construction of the offshore infrastructure are listed in Table 12 along with the MDO against which each construction phase impact has been assessed. A description of the potential impact on marine mammal receptors caused by each impact under consideration is given below.

Impact 1: Auditory injury as a result of geophysical surveys

5.13.2 A series of pre-construction and post-construction surveys will be undertaken in the array area and along the ECC. The purpose of these surveys will be to further characterise the seabed conditions and morphology, determine soil design parameters and identify any potential obstructions or hazards to the construction works as well as furthering understanding of baseline metocean conditions.

5.13.3 Geophysical surveys are non-intrusive[31] and will utilise towed equipment such as side scan sonar, sub bottom profiler, multibeam echosounder and magnetometer to gather detailed information on the bathymetry, seabed sediments, geology, and anthropogenic features (e.g., existing seabed infrastructure, unexploded ordinance (UXO)) that may exist across the offshore development area. Remotely Operated Vehicles (ROV) may also be used for further identification of findings from the geophysical surveys. Details on each of the aforementioned geophysical survey equipment are outlined below:

- Multi-Beam Echo Sounder (MBES): MBES is used to acquire detailed seabed topography and water depth by emitting a fan shaped swath of acoustic energy (sound waves) along a survey transect. The sound waves are reflected from the seabed to enable high resolution seafloor mapping. The MBES can be either hull- or ROV-mounted.

- Side Scan Sonar (SSS): SSS utilises conical or fan-shaped pulses of sounds directed at the seafloor to provide information on the surface of the seabed through analysis of reflected sound.

- Sub Bottom Profiler (SBP): The SBP is a type of geophysical survey tool that uses low-frequency or high frequency sounds (pings) to identify acoustic impedance of the sub-surface geology and to identify transitions from one stratigraphic sequence to another. Sound sources that produce lower frequency pulses can penetrate through and be reflected by subsurface sediments (low-resolution data), whilst higher frequency pulses achieve higher resolution images but do not penetrate the subsurface sediments. A shallow 3D Sub-Bottom Imaging System (SBI) is a type of SBP and provides a real-time 3D view of the sub-seabed via multiple 5 m wide data swaths that penetrate the seabed up to 8 m. The SBI uses a frequency modulated signal to identify buried objects, anomalies, geohazards, and stratigraphy to a 10 cm resolution. SBIs are typically deployed on an ROV or towfish, close to the seabed, and operate at a much lower source level than sub-bottom profilers.

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[31] Non-intrusive means that there is no direct impact on the seabed.

- Ultra-short Baseline (USBL): A USBL system is used to obtain accurate equipment positioning during sampling activities. This system consists of a transceiver mounted under the vessel, and a transponder on deployed equipment. The transceiver transmits an acoustic pulse which is detected by the transponder, followed by a reply of an acoustic pulse from the transponder. This pulse is detected by the transceiver and the time from transmission of the initial pulse is measured by the USBL system and converted into a range.

- 2D / 3D Ultra-High Resolution Seismic (UHRS) reflection profiling (sparkers): A small seismic source containing a cluster of electrodes. These systems discharge high voltage impulses which heat the surrounding water within which the device is located through the use of electrode tips. The generation of heat and subsequently, steam, results in the emission of an acoustic impulse (Hartley Anderson Ltd, 2020). While sparkers are less directional than other SBPs, the acoustic energy they emit is still focussed towards the sea floor.

- Magnetometer: A magnetometer is used to measure the variation in the earth’s total magnetic field to detect and map ferromagnetic objects on or near the sea floor along the survey’s vessel tracks. Often, two magnetometers are mounted in a gradiometer format to measure the magnetic gradient between the two sensors. As a passive system, the magnetometer does not emit any noise, and is therefore scoped out of assessment.

5.13.4 An essential step in assessing the potential for effects on relevant species is a consideration of their auditory sensitivities. Marine mammal hearing groups and auditory injury criteria from Southall et al. (2019), and corresponding species of relevance to this assessment, are summarised in Table 14 . There are no audiogram data currently available for low frequency cetaceans; therefore, predictions are based on the hearing anatomy for each species and considerations of the frequency range of their vocalisations (sounds produced).

Table 14 Marine mammal hearing groups, estimated hearing range and sensitivity and injury criteria and corresponding species relevant to this assessment (Southall et al., 2019)

Hearing Group	Species	Estimated hearing range	Estimated region of greatest sensitivity†	Estimated peak sensitivity†
Low-frequency (LF) cetaceans	Minke whale	7Hz –35kHz	200Hz–19kHz	-
High-frequency (HF) cetaceans	Bottlenose dolphin Common dolphin	150Hz–160kHz	8.8–110kHz	58kHz
Very high-frequency (VHF) cetacean	Harbour porpoise	275Hz–160kHz	12–140kHz	105kHz

Hearing Group	Species	Estimated hearing range	Estimated region of greatest sensitivity†	Estimated peak sensitivity†
Phocid carnivores in water (PCW)	Harbour seal Grey seal	50Hz–86kHz	1.9–30kHz	13kHz

†Region of greatest sensitivity represents low-frequency (F1) and high-frequency (F2) inflection points, while peak sensitivity is the frequency at which the lowest threshold was measured (T0) (Southall et al., 2019).

Prior to an evaluation in relation to each item of equipment which may be used in the geophysical surveys, the overlap between typical survey equipment operating characteristics and marine mammal functional hearing capability is considered in Table 15 . Table 15 presents typical values for geophysical surveys for large offshore wind farms, but equipment specific values will vary between different survey contractors. Where there is no overlap between hearing capability and functional hearing, there is no potential for disturbance effects to occur. High magnitude pressure waves may result in physiological damage to organs regardless of hearing range overlap, i.e. blast trauma from underwater explosions; however, the acoustic signals from high frequency geophysical sources (e.g. MBES, SSS) which are above the hearing range of marine mammals are not impulsive enough to have the potential to result in hearing injury or other harm through such a mechanism.

Table 15 Comparison of typical noise emitting survey equipment operating characteristics and overlap with the estimated hearing range of different marine mammal functional hearing groups

Equipment	Estimated source pressure level (dB re 1µPa)	Expected Sound Frequency	LF	HF	VHF	PCW
MBES	210–240dB re 1µPa (SPL_{peak}) for multiple beams* (Lurton and Deruiter, 2011) 197dB re 1µPa (SPL_{peak}) for a single beam at an operational frequency of 200 kHz (Risch *et al.*, 2017)	200–400kHz (Hartley Anderson Ltd, 2020)	Above all hearing ranges			
SSS	210dB re 1µPa (SPL_{peak}) (Crocker and Fratantonio, 2016, Crocker *et al.*, 2019)	300 and 900kHz (Crocker and Fratantonio, 2016, Crocker *et al.*, 2019)	Above all hearing ranges			
SBP	210–220dB re 1µPa (SPL_{peak}) (Hartley Anderson Ltd, 2020)	Frequency selectable. Typically 2–15kHz with a peak frequency of 3.5kHz (Hartley Anderson Ltd, 2020)	Yes	Yes	Yes	Yes
USBL	187 – 206 dB re 1 µPa (SPLRMS) (Jiménez-Arranz et al. 2020)	19 – 34 kHz (Jiménez-Arranz et al. 2020)	Yes	Yes	Yes	Yes
UHRS (sparker)	200 – 226 dB re 1 µPa (Hartley Anderson Ltd, 2020)	100 Hz to 5 kHz, and average approx. 1.5 kHz (Hartley Anderson Ltd, 2020)	Yes	Yes	Yes	Yes

*The higher the frequency of operation, the lower the source level tends to be.

Magnitude

MBES and SSS

5.13.5 DAHG (2014) do not advise that mitigation measures apply to this type of equipment unless surveys are taking place within bays, inlets or estuaries and within 1,500m of the entrance of enclosed bays/inlets/estuaries. Similarly JNCC (2017) do not advise that mitigation to avoid injury from use of MBES is necessary in shallow (<200 m) waters where the MBES used are of high frequencies (as they are planned to be here). EPS Guidance for use of SSS states that *"this type of survey is of a short-term nature and results in a negligible risk of an injury or disturbance offence (under the Regulations)."* An equivalent conclusion was reached by DECC (2011). Furthermore, a recent comprehensive assessment of the characteristics of acoustic survey sources proposed that MBES and SSS should be considered de minimis in terms of being unlikely to result in PTS to marine mammals (Ruppel *et al.*, 2022). The extent and duration of the impact (underwater noise during MBES and SSS) is expected to be localised and short-term. As discussed in Ruppel et al. (2022), the effect is unlikely to occur due to radiated power, exposure duration and number of pings exceeding the injury threshold. As the consequence, it is anticipated that no animals will experience injury and therefore the impact will not alter respective population trajectories. Therefore, the risk of injury from MBES and SSS to all marine mammals is concluded to be of negligible (adverse) magnitude.

SBP

5.13.6 DAHG (2014) do not advise that mitigation measures apply to this type of equipment unless surveys are taking place within bays, inlets or estuaries and within 1,500m of the entrance of enclosed bays/inlets/estuaries.

5.13.7 For dolphins, the source levels of SBP equipment are below the PTS-onset thresholds. As such, there is no risk of PTS onset to any dolphin species from the use of this equipment and the magnitude of impact is assessed as negligible (adverse).

5.13.8 For harbour porpoise, the predicted SBP source levels exceed the PTS-onset threshold and as such, the use of this equipment has the potential to cause PTS. However, results for SBPs have indicated that PTS onset is likely to arise between 17–23m from the use of this equipment at source levels of 267dB re 1 µPa (SPL_{peak}) (BEIS, 2020). This source level is considerably louder than those likely to be used within the offshore development area and as such, impacts which could adapt behaviour so that individual survival and reproduction rates may be affected are unlikely. It is also suggested that SBPs used in high-resolution geophysical surveys have a very low potential for injury (BEIS, 2019a).

5.13.9 For <u>seals and minke whales</u>, only the upper limits of predicted sources levels are predicted to exceed the PTS-onset thresholds. Whilst it is possible that the use of this equipment could operate at source levels below the PTS-onset thresholds for these species, at this stage of the proposed development it is difficult to determine whether that will be the case. As such, if this equipment operates within their upper source level limits, there is the potential to adapt behaviour so that individual survival and reproduction rates may be affected. Acoustic signals from SBPs have shown slightly greater propagation from sources generating low frequencies (<10kHz), whilst some of the highest frequency sources (>50kHz) were only weakly detectable or undetected by recording equipment located a few hundred metres from the source (Halvorsen and Heaney, 2018). However, noise modelling for pipeline surveys have previously indicated PTS-onset in minke whales within 5 m of the source when SBP pingers operate with a sound source of 220dB re 1 µPa (SPL_{peak}) (Shell, 2017), and ~10m for seals (BEIS, 2019b).

USBL

5.13.10 USBL are not explicitly listed within the DAHG (2014) guidance, however, although an active sound source, operates at frequencies and source levels with a very limited range.

5.13.11 The source levels of USBL equipment are below the PTS-onset thresholds for <u>minke whales, dolphins and seals</u>. While theoretical source levels for USBL exceed the PTS threshold for <u>harbour porpoise</u> by a few dB, noise levels would drop to below the threshold within 10 m of the source and so pose a negligible risk of injury.

5.13.12 While there is potential for USBL to be operated at a theoretical source level which exceeds the minimum threshold for instantaneous injury in a relevant marine mammal species (harbour porpoise; 202 dB) by up to 4 dB, such noise levels are unlikely to be realised. The NMFS has previously determined that USBL was unlikely to lead to incidental take[32] and identified only Level B harassment threshold as something that could be potentially exceeded (NMFS, 2020). Pace *et al.* (2021) reported noise levels for a USBL operating at 25-40 kHz attached to a SSS operating at a dual 300/600 kHz frequency, the latter being above the recording capabilities of the noise loggers used. The effective source level was estimated as 184 dB re 1 μPa^2 @1 m (SPL_{rms}). At 100 m distance, broadband received levels in the 20-30 kHz band were 147.9 dB re 1 μPa^2 (SPL_{rms}). When the USBL was active, the combined source was detectable above background noise at the maximum recording distance of 2 km; however, at a distance of c. 1 km from the source, broadband received levels were ≤ 140 dB re 1 μPa^2 (SPL_{peak}), ≤ 130 dB re 1 μPa^2 (SPL_{peak}), and application of VHF cetacean (harbour porpoise) frequency weighting indicated noise levels of < 120 dB re 1 μPa^2 (SPL_{rms}, VHF frequency-weighted).

5.13.13 These results illustrate no potential for instantaneous PTS-onset from the USBL source tested. As such, the extent and duration of the impact (underwater noise during USBL) is expected to be localised and short-term. The effect is unlikely to occur. As a consequence, the population trajectory of harbour porpoise will not be altered. Therefore, the magnitude of auditory injury from USBL has been assessed as Negligible for harbour porpoise.

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[32] In the US, take is defined under the Marine Mammal Protection Act (MMPA) as "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal". Unintentional “take” is therefore, in this case, to cause injury of marine mammals incidental to specified activities.

UHRS (sparker)

5.13.14 The source levels of UHRS equipment are below the PTS-onset thresholds for dolphin species (see the Underwater noise assessment). As such, there is no risk of auditory injury (PTS) onset to any dolphin species from the use of this equipment and therefore the magnitude of auditory injury from UHRS for dolphin species is assessed as Negligible.

5.13.15 For harbour porpoise, minke whale and seals, the predicted UHRS source levels exceed the PTS-onset threshold and as such, the use of this equipment has the potential to cause PTS. The extent and duration of the impact (underwater noise during UHRS) is expected to be localised and short-term. The effect is unlikely to occur, but in case it does, it will be at a low frequency. As the consequence, although it cannot be excluded that the impact could affect a small proportion of the respective populations, the population trajectories will not be altered. Therefore, the magnitude of auditory injury from UHRS has been assessed as Low for harbour porpoise, minke whale and seals. This will be reduced to Negligible magnitude given the project design features and avoidance measures identified within the MMMP for geophysical surveys when using UHRS (sparker) equipment.

Summary

5.13.16 Noting the project design features and avoidance measures identified within the MMMP for geophysical surveys when using UHRS (sparker) equipment, particularly the pre-survey MMO watch to ensure the area is free of marine mammals prior to the survey commencing, the risk of PTS is negligible. This commitment is in line with the advice provided in (DAHG, 2014).

Table 16 Determination of magnitude for marine mammals for auditory injury from geophysical surveys

Definition	MDO	ADO
Extent	Negligible – The effect is expected in a very low proportion of the population as PTS-onset impact ranges are very small. Additionally, a pre-survey MMO watch will ensure the area is free of marine mammals prior to any UHRS (sparker) surveys commencing (see Table 13).	For geophysical surveys the MDO and ADO are aligned
Duration	High – PTS is a permanent effect on the hearing sensitivity.	For geophysical surveys the MDO and ADO are aligned
Frequency	Low – surveys will occur over 2-3 years, in two campaigns pre- and post-construction.	For geophysical surveys the MDO and ADO are aligned
Probability	Negligible - The effect is highly unlikely to occur as the pre-survey MMO watch prior to any UHRS (sparker) surveys commencing will ensure the area is free of marine mammals prior to the survey commencing (Table 13)Table 13	For geophysical surveys the MDO and ADO are aligned
Consequence	Negligible - No potential for any changes in the individual reproductive success or survival therefore no changes to the population size or trajectory.	For geophysical surveys the MDO and ADO are aligned

Definition	MDO	ADO
Overall magnitude	*The potential magnitude of PTS-onset for marine mammals is rated as Negligible.*	*The potential magnitude of PTS-onset for marine mammals is rated as Negligible.*

Sensitivity

MBES and SSS

5.13.17 The operational frequency of MBES and SSS sound sources (200 to 400 kHz and 300 to 900 kHz, respectively) is far above that of greatest hearing sensitivity for both porpoise (275 Hz to 160 kHz (peak sensitivity: 105 kHz)) and seals (50 Hz to 86 kHz (peak sensitivity: 13 kHz)). As there is no overlap between the hearing ranges of these species and the expected sound frequency of equipment, there is expected to be no reduction in the hearing abilities of either species. For dolphin species and minke whales, the operational frequency of MBES & SSS (200 to 400 kHz) is far above that of the hearing range for dolphins (150 Hz to 160 kHz) and minke whales (7 Hz to 35 kHz). As such, the expected sound frequency does not overlap with the functional hearing range of these species and hence there is no potential to affect the hearing abilities of dolphins and minke whale. As such, all marine mammals are assessed as having a Negligible sensitivity to auditory injury (PTS-onset) from MBES and SSS.

SBP

5.13.18 While harbour porpoise and seal hearing ranges are between 275 Hz to 160 kHz, their peak sensitivity falls at 105 kHz and 13 kHz, respectively. The operational frequencies of SBP (2 to 15 kHz with peak at 3.5 kHz) typically operate below that at which harbour porpoise and seals are most sensitive to auditory impact. Therefore, porpoise and seal sensitivity to PTS at this frequency is expected to be minimal. The operational frequency of SBP (2 to 15 kHz with peak at 3.5 kHz) overlaps within the hearing range for dolphins (150 Hz to 160 kHz) and minke whales (7 Hz to 35 kHz). Although the operable sound frequencies of SBP overlap with the hearing range, when the equipment is emitting higher frequency sounds, the source level tends to be lower(Lurton and Deruiter, 2011), and thus is less likely to exceed the PTS-onset threshold. At the PTS-onset threshold, a 6 dB elevation of the hearing threshold somewhere within the SPB frequency range (2 to 15 kHz) is likely to affect only a small region of minke whale and dolphin hearing, which is unlikely to result in changes to vital rates. As such, all marine mammals are assessed as having a Low sensitivity to auditory injury (PTS-onset) from SBP.

USBL

5.13.19 The operational frequencies of USBL (19 to 34 kHz) typically operate above that at which minke whale are most sensitive to auditory impact (200Hz to 19kHz). Therefore, whilst there is a risk of auditory injury, this risk is expected to be minimal. Additionally, the expected operable sound frequencies of USBL overlap with hearing ranges of harbour porpoise, dolphin and seal species and thus, there is a risk of injury if individuals are close enough to the sound source. Sound frequencies of USBL are outside estimated peak sensitivity for all species (Table 8). At the PTS-onset threshold, a 6 dB elevation of the hearing threshold somewhere within the USBL frequency range is likely to affect only a small region of the animal's hearing, which is unlikely to result in changes to vital rates. As such, all marine mammals are assessed as having a Low sensitivity to auditory injury (PTS-onset) from USBL.

UHRS (sparker)

5.13.20 The operational frequencies of UHRS (100 Hz to 5 kHz) typically operate below that at which harbour porpoise and dolphin species are most sensitive to auditory impact (Table 17). Therefore, whilst there is a risk of auditory injury, this risk is expected to be minimal.

5.13.21 The expected operable sound frequencies of UHRS overlap with hearing ranges of minke whale, and seal species and thus, there is a risk of injury if individuals are close enough to the sound source. Sound frequencies of UHRS are outside estimated peak sensitivity for all species (Table 17). At the PTS-onset threshold, a 6 dB elevation of the hearing threshold somewhere within the UHRS frequency range is likely to affect only a small region of the animal's hearing, which is unlikely to result in changes to vital rates. As such, all marine mammals are assessed as having a Low sensitivity to auditory injury (PTS-onset) from UHRS.

Table 17 Determination of sensitivity for marine mammals to auditory injury (PTS) from geophysical surveys

Marine mammals	Justification
Context	**MBES and SSS:** ▪ there is no potential to affect the hearing abilities. **SBP/USBL/UHRS:** ▪ **Adaptability:** high - Marine mammals have a wide hearing range and it is expected that a small decline in hearing sensitivity at a specific frequency would not affect their ability to forage and communicate. ▪ **Tolerance:** high - At the PTS-onset threshold, a 6 dB elevation of the hearing threshold somewhere within the SPB frequency range (2-15 kHz) is likely to affect only a small region of hearing, which is unlikely to result in changes to vital rates. ▪ **Recoverability:** None. PTS is a permanent change in the hearing threshold.
Value	All cetaceans are categorised as European Protected Species. Therefore, they have a high value. Seals are categorized as Annex II under the EU Habitats Directive. Therefore, they have a high value.
Overall sensitivity	*MBES & SSS: The sensitivity of all marine mammals is rated as Negligible.* *SBP/USBL/UHRS: The sensitivity of all marine mammals is rated as Low.*

5.13.22 In summary, there is a very low risk of PTS during geophysical surveys. When considering the measures set out within Table 13 (particularly the use of pre-survey MMO), the magnitude of PTS is negligible. The sensitivity of all marine mammals is assessed as Low. Therefore, the significance of effect of auditory injury (PTS-onset) occurring as a result of preconstruction geophysical surveys is **imperceptible**, which is not significant in EIA terms.

5.13.23 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Residual effect assessment

Auditory injury from geophysical surveys is not significant in EIA terms. Therefore, no additional mitigation to that already identified in Table 13 are considered necessary. Therefore, ***no significant adverse residual effects*** *have been predicted in respect of marine mammals.*

Impact 2: Behavioural disturbance from geophysical surveys

Magnitude

MBES and SSS

5.13.24 As the sound levels emitted from MBES and SSS are above 200kHz and therefore above the hearing frequency range of all marine mammals likely to be present in the region, the magnitude of impact is assessed as Negligible.

SBP

5.13.25 JNCC et al. (2010) EPS Guidance concluded that the use of SBPs could cause localised short-term impacts on behaviour such as avoidance. However, it is unlikely that any disturbance from SBPs would result in any changes to the favourable conservation status of any species. SBPs are highly directional, with noise levels outside of the main beam considerably lower and therefore with limited horizontal propagation of noise levels. Any response will likely be temporary; for example, evidence from Thompson et al. (2013) suggests that short-term disturbance caused by a commercial two-dimensional seismic survey (a much louder noise source (peak-to-peak source levels estimated to be 242–253 dB re 1µPa at 1 m) than SBP) does not lead to long-term displacement of harbour porpoises. Assessment guidance from JNCC for noise disturbance against conservation objectives of SACs designated for harbour porpoise recommends a 5 km EDR for high resolution geophysical surveys, based on SBP sources (JNCC, 2020). This gives an assumed worst case daily disturbance footprint of 256 km^2 considering this is a moving sound source (IAMMWG, 2023). BEIS (2020) published noise modelling based on the maximum source levels and bandwidths obtained from a range of SBPs. The study indicated potential for harbour porpoise to be disturbed over a distance of 2.5 km. The report concluded that there was a low risk of harbour porpoise being physically disturbed by SBPs. The same is assumed for all marine mammal species and thus the magnitude of impact is assessed as Low (adverse).

USBL & UHRS (sparker)

5.13.26 As presented for auditory injury, a sound source verification exercise carried out by Pace et al. (2021) showed that the potential for behavioural disturbance within a limited spatial extent (i.e. a few hundred metres). It is possible that the UHRS may be audible to marine mammals and therefore their use may have the potential to cause disturbance. The majority of acoustic energy will be directed at the seabed rather than being emitted horizontally which reduces the impacts of noise emissions on nearby marine mammals. UHRS is designed to have a highly focused beam that aims directly at the seabed, meaning there is limited horizontal transmission of noise. The magnitude of impact is assessed as Low (adverse).

Table 18 Determination of magnitude for marine mammals for disturbance from geophysical surveys

Definition	MDO	ADO
Extent	**MBES and SSS:** - Negligible: sound levels are above the hearing frequency range of all marine mammals. No animals are expected to be disturbed. **SBP/USBL/UHRS:** - Low: The effect is expected in a very low proportion of the population, disturbance impact range will be very small, highly localised and highly directional.	For geophysical surveys the MDO and ADO are aligned
Duration	Negligible - The impact is anticipated to be brief, with short-term and temporary behavioural effects only.	For geophysical surveys the MDO and ADO are aligned
Frequency	Low – surveys will occur over 2-3 years, in two campaigns pre- and post-construction.	For geophysical surveys the MDO and ADO are aligned
Probability	Low - effect is unlikely to occur.	For geophysical surveys the MDO and ADO are aligned
Consequence	Negligible - Very short term, recoverable effect on the behaviour and/or distribution in a very small proportion of the population. No potential for any changes in the individual reproductive success or survival therefore no changes to the population size or trajectory.	For geophysical surveys the MDO and ADO are aligned
Overall magnitude	**MBES & SSS:** The potential magnitude of disturbance for marine mammals is rated as Negligible. **SBP/UHRS/USBL:** The potential magnitude of disturbance for marine mammals is rated as Low.	**MBES & SSS:** The potential magnitude of disturbance for marine mammals is rated as Negligible. **SBP/UHRS/USBL:** The potential magnitude of disturbance for marine mammals is rated as Low.

Sensitivity

MBES or SSS

5.13.27 As indicated in Table 15 there is no potential for disturbance effects to occur through use of MBES or SSS, as the sound levels emitted are above 200kHz and therefore above the hearing frequency range of the marine mammals likely to be present in the region. The sensitivity of all marine mammals to disturbance from MBES and / or SSS is therefore assessed as Negligible.

SBP/USBL/UHRS

5.13.28 As indicated in Table 15 , the expected sound frequency for SBP falls within the functional hearing range for all relevant marine mammal species and, therefore, has the potential to result in disturbance effects. JNCC *et al.* (2010) EPS Guidance concludes that the use of SBPs in geophysical surveys “*could, in a few cases, cause localised short-term impacts on behaviour such as avoidance.*”

5.13.29 The expected sound frequency for the USBL and UHRS falls within the functional hearing range for all relevant marine mammal species and, therefore, has the potential to result in disturbance effects (Table 15). Although the UHRS is a sparker system and is likely to cause greater disturbance, it is designed to have a highly focused beam that aims directly at the seabed, meaning there is limited horizontal transmission of noise. For both, USBL and UHRS, disturbance is likely to be of a very localised spatial extent which is unlikely to extend much beyond that of temporary avoidance associated with the concurrent presence of the survey vessel(s).

5.13.30 The behavioural disturbance due to SBP, USBL and UHRS is unlikely to cause change in individual reproduction and survival rates. As such, the sensitivity of marine mammals to disturbance from SBP, USBL and UHRS equipment is assessed as Low.

Table 19 Determination of sensitivity for marine mammals to disturbance from geophysical surveys

Marine mammals	Justification
Context	**MBES and SSS:** sound levels are above the hearing frequency range of all marine mammals. **SBP/USBL/UHRS:** any impact is expected to be temporary which is not expected to result in changes to vital rates.
Value	All cetaceans are categorised as European Protected Species. Therefore, they have a high value. Seals are categorized as Annex II under the EU Habitats Directive. Therefore, they have a high value.
Overall sensitivity	***MBES & SSSS:*** *The sensitivity of all marine mammals is rated as Negligible.* ***SBP/USBL/UHRS:*** *The sensitivity of all marine mammals is rated as Low.*

5.13.31 As the sensitivity of all marine mammals to disturbance from MBES and SSS equipment has been assessed as negligible, and the magnitude of impact has been assessed as negligible (adverse), the significance of the effect is assessed as **Imperceptible** (not significant).

5.13.32 As the sensitivity of all marine mammals to disturbance from SBP/USBL/UHRS equipment has been assessed as low, and the magnitude of impact has been assessed as low, the significance of the effect is assessed as **Slight adverse** (not significant).

5.13.33 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Residual effect assessment

Behavioural displacement and disturbance from geophysical surveys is not significant in EIA terms. Therefore, no additional mitigation to that already identified in Table 13 are considered necessary. Therefore, ***no significant adverse residual effects*** *have been predicted in respect of marine mammals.*

Impact 3: PTS-onset from UXO clearance

5.13.34 A detailed UXO survey will be completed prior to construction. The type, size (net explosive quantities (NEQ)) and number of possible detonations and duration of UXO clearance operations is not known at this stage. Data acquired to date and UXO assessment indicates a low likelihood of UXO to be present.

5.13.35 If UXO are found, a risk assessment will be undertaken and items of UXO will either be avoided, removed or detonated *in situ*. Recent advancements in the available methods for UXO clearance mean that high-order detonation may be avoided. The methods of UXO clearance considered will include:

- Avoidance through micro-siting of infrastructure (e.g. cable routing);
- Relocation of UXO to a safe area within the development boundary;
- In situ detonation of UXO – low order;
- In situ detonation of UXO – high order (considered as a last resort only).

5.13.36 For the purposes of assessment, it has been assumed within the MDO that a maximum of four high order UXO detonations will be required.

5.13.37 Low order is the preferred clearance method and will be attempted on all suitable UXO. The low order technique uses a user filled shaped-charge to create a plasma-jet, which causes a build-up of pressure within the UXO target, leading to a burst of the UXO casing, disrupting the contents by introducing heat to ignite the explosive fill to rapidly burn.

5.13.38 High order detonation will be used in the following scenarios, and only as a last resort:

- When low order disposal has been unsuccessful;
- When it is deemed unsafe to attempt a low order detonation; or
- In circumstances when expert opinion advises that high order disposal is required (i.e., where munitions are damaged).

5.13.39 A high order detonation is achieved by placing a donor charge adjacent to the UXO target. The preferred method of deployment is by ROV. The detonation produces a high-speed shockwave which sets off the main charge within the UXO target, in effect destroying the UXO target.

5.13.40 For high order clearance a bubble curtain will be deployed. Where a bubble curtain is required, works will wait until conditions are favourable for the deployment of the bubble curtain abatement system, prior to the clearance activity proceeding.

5.13.41 A UXO detonation is defined as a single pulse and, as such, both the SEL_{ss} and SPL_{peak} metrics have been assessed in Table 20. As a result, animal fleeing assumptions do not apply to the values presented. Whilst the bubble curtain abatement system is assumed as an avoidance / preventative measure for the purposes of the assessment, it is recognised that the noise produced by the detonation of explosives is affected by several different elements and therefore a precautionary approach has been taken whereby the underwater noise propagation estimates do not include the addition of a bubble curtain.

Magnitude

Low-order clearance

5.13.42 The maximum PTS-onset impact range from low-order clearance is 0.99 km (Table 20). For harbour porpoise, the PTS-onset impact range for low-order clearance means that a maximum of one single porpoise may experience PTS. For all other species, no individuals are predicted to experience PTS.

High-order clearance

5.13.43 For high-order clearance of a 525 kg UXO (+ donor) the maximum PTS-onset impact range is 13 km for harbour porpoise, resulting in impact to up to 149 individual porpoise. For minke whales, the maximum PTS-onset range for high-order clearance of a 525 kg UXO (+ donor) is 9.5 km, resulting in impact to up to 4 individual whales. For seals, the maximum PTS-onset range for high-order clearance of a 525 kg UXO (+ donor) is 2.5 km, resulting in impact to up to 1 grey seal and <1 harbour seal. For dolphins, the maximum PTS-onset range for high-order clearance of a 525 kg UXO (+ donor) is 0.73 km, resulting in impact to up to <1 dolphin.

5.13.44 A bubble curtain will be deployed in the event that high-order detonation is required. Therefore, the magnitude of the impact of auditory injury from high-order UXO clearance, considering the application of project design features and other avoidance and preventative measures, is assessed as **Negligible** (adverse).

Table 20 Summary of the source level and impact ranges (km) for various UXO charge sizes using the impulsive criteria from Southall *et al.* (2019) (without bubble curtain)

Charge weight	Source level	VHF	HF	LF	PCW
Weighted SEL PTS-onset impact ranges (km)					
Low order (0.25 kg)	215.2	0.08	<0.05	0.23	<0.05
25 kg + donor	228.0	0.57	<0.05	2.20	<0.05
55 kg + donor	230.1	0.74	<0.05	3.20	<0.05
120 kg + donor	232.3	0.95	<0.05	4.70	0.07
240 kg + donor	234.2	1.10	<0.05	6.50	0.10
525 kg + donor	236.4	1.40	0.05	9.50	0.13
Unweighted SPL_{peak} PTS-onset impact ranges (km)					
Low order (0.25 kg)	269.8	0.99	0.06	0.17	0.19
25 kg + donor	284.9	4.60	0.26	0.81	0.90
55 kg + donor	287.5	6.00	0.34	1.00	1.10
120 kg + donor	290.0	7.70	0.45	1.30	1.50
240 kg + donor	292.3	9.80	0.56	1.70	1.90
525 kg	294.8	13.00	0.73	2.20	2.50

Table 21 Estimated number of marine mammals potentially at risk of auditory injury (PTS) from UXO clearance (without bubble curtain)

	Harbour porpoise		**Bottlenose dolphin**	**Common dolphin**	**Minke whale**		**Grey seal**	**Harbour seal**
Density (#/km^2)	**0.2076 Site surveys**	**0.2803 SCANS IV**	**0.2352 SCANS IV**	**0.0272 SCANS IV**	**0.01581 Site surveys**	**0.0137 SCANS IV**	**0.048**	**0.017**
Weighted SEL PTS-onset								
Low order (0.25 kg)	0	0	0	0	0	0	0	0
25 kg + donor	0	0	0	0	0	0	0	0
55 kg + donor	0	0	0	0	1	0	0	0
120 kg + donor	1	1	0	0	1	1	0	0
240 kg + donor	1	1	0	0	2	2	0	0
525 kg + donor	1	2	0	0	4	4	0	0
Unweighted SPL$_{peak}$ PTS-onset								
Low order (0.25 kg)	1	1	0	0	0	0	0	0
25 kg + donor	14	19	0	0	0	0	0	0
55 kg + donor	23	32	0	0	0	0	0	0
120 kg + donor	39	52	0	0	0	0	0	0
240 kg + donor	63	85	0	0	0	0	1	0
525 kg + donor	110	149	0	0	0	0	1	0

Table 22 Determination of magnitude for marine mammals for auditory injury (PTS) from UXO clearance

Definition	MDO	ADO
Extent	Negligible – The effect is expected in a low proportion of the population given the commitment to to deploying a bubble curtain in the event that high-order detonation is required (see Table 13).	For UXO clearance, the MDO and ADO are aligned.
Duration	High - since PTS is a permanent change in hearing sensitivity.	For UXO clearance, the MDO and ADO are aligned.
Frequency	Negligible - The effect is anticipated to occur on a maximum of 4 days (noting that the proposed development involves a construction approach of a maximum of one UXO being cleared per day).	For UXO clearance, the MDO and ADO are aligned.
Probability	Negligible - given the commitment to to deploying a bubble curtain in the event that high-order detonation is required (see Table 13).	For UXO clearance, the MDO and ADO are aligned.
Consequence	Negligible - No potential for the any changes in the individual reproductive success or survival therefore no changes to the population size or trajectory given the commitment to to deploying a bubble curtain in the event that high-order detonation is required (see Table 13).	For UXO clearance, the MDO and ADO are aligned.
Overall magnitude	*The potential magnitude of PTS from UXO clearance for all marine mammals is rated as Negligible.*	*The potential magnitude of PTS from UXO clearance for all marine mammals is rated as Negligible.*

Sensitivity

5.13.45 Most of the acoustic energy produced by a high-order detonation is below a few hundred Hz, decreasing on average by about SEL 10 dB per decade above 100 Hz, and there is a pronounced drop-off in energy levels above ~5-10 kHz (von Benda-Beckmann *et al.*, 2015, Salomons *et al.*, 2021). Therefore, the primary acoustic energy from a high-order UXO detonation is below the region of greatest sensitivity for most marine mammal species considered here (porpoise, dolphins and seals) (Southall *et al.*, 2019). If PTS were to occur within this low frequency range, it would be unlikely to result in any significant impact to vital rates of porpoise, dolphins and seals. Therefore, porpoise, dolphins and seals have been assessed as having a Low sensitivity to PTS from UXO clearance.

5.13.46 Recent acoustic characterisation of UXO clearance noise has shown that there is more energy at lower frequencies (<100 Hz) than previously assumed (Robinson *et al.*, 2022). Given the lower frequency components of the sound produced by UXO clearance, it is more precautionary to assess minke whales as having a Medium sensitivity to PTS from UXO clearance.

Table 23 Determination of sensitivity for marine mammals to auditory injury (PTS) from UXO clearance

Marine mammals	Justification
Context	**Adaptability:** Marine mammals have a wide hearing range and it is expected that a small decline in hearing sensitivity at a specific frequency would not affect their ability to forage and communicate. **Tolerance (minke whale):** Given the lower frequency components of the sound produced by UXO clearance, it is expected that minke whales would be less tolerant than other marine mammal species as their hearing is more sensitive to lower frequencies. **Tolerance (others):** Most of the acoustic energy produced by a high-order detonation is below a few hundred Hz. If PTS were to occur within this low frequency range, it would be unlikely to result in any significant impact to vital rates of porpoise, dolphins and seals. **Recoverability:** None. PTS is a permanent change in the hearing threshold.
Value	All cetaceans are categorised as European Protected Species. Therefore, they have a high value. Seals are categorized as Annex II under the EU Habitats Directive. Therefore, they have a high value.
Overall sensitivity	*The sensitivity of minke whales is rated as Medium.* *The sensitivity of all other marine mammals is rated as Low.*

5.13.47 The maximum magnitude of the impact has been assessed as **Negligible** given the commitment to deploying a bubble curtain in the event that high-order detonation is required, with the maximum sensitivity of the receptors being **Medium**. Therefore, the significance of effect of auditory injury (PTS) from UXO clearance is **Negligible**, which is not significant in EIA terms.

5.13.48 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Table 24 Summary of the marine mammal assessment for auditory injury (PTS) from UXO clearance

Species	Magnitude	Sensitivity	Impact Significance
Harbour porpoise	Negligible (with inclusion of bubble curtain for high-order clearance) (Table 13)	Low	Not significant
Bottlenose dolphin	Negligible (with inclusion of bubble curtain for high-order clearance) (Table 13)	Low	Not significant
Common dolphin	Negligible (with inclusion of bubble curtain for high-order clearance) (Table 13)	Low	Not significant

Species	Magnitude	Sensitivity	Impact Significance
Minke whale	Negligible (with inclusion of bubble curtain for high-order clearance) (Table 13)	Medium	Not significant
Harbour seal	Negligible (with inclusion of bubble curtain for high-order clearance) (Table 13)	Low	Not significant
Grey seal	Negligible (with inclusion of bubble curtain for high-order clearance) (Table 13)	Low	Not significant

Residual effect assessment

The significance of effect of auditory injury (PTS-onset) from UXO clearance is not significant in EIA terms. Therefore, no additional mitigation to that already identified in Table 13 are considered necessary. Therefore, ***no significant adverse residual effects*** *have been predicted in respect of marine mammals.*

Impact 4: Behavioural disturbance from UXO clearance

Magnitude

Low-order clearance

5.13.49 Using the 5 km EDR approach, the greatest estimated disturbance occurs for bottlenose dolphins, where 18 dolphins are predicted to be disturbed (0.22% MU) (Table 25). This is considered to be a low magnitude given the proportion of the population impacted. For all other species, the proportion of the population impacted is negligible.

5.13.50 Using TTS as a proxy for disturbance for low-order clearance, there is predicted to be no disturbance to bottlenose dolphins, common dolphins, grey seals or harbour seals. For harbour porpoise, a maximum of three individuals are predicted to experience disturbance, and for minke whales up to one individual is predicted to experience disturbance (Table 26 and Table 27). Given that UXO clearance is expected to occur on up to 4 days (noting that the proposed development involves a construction approach of a maximum of one UXO being cleared per day) at the most, this is of negligible magnitude.

Table 25 Estimated number of marine mammals potentially at risk of disturbance during low-order UXO clearance (assuming an impact area of 78.5 km^2)

Species	Density (#/km^2)	# Impacted	MU	% MU	Magnitude
Harbour porpoise	0.2076 Site surveys	16	62,517	0.03%	Negligible
	0.2803 SCANS IV	22		0.04%	Negligible
Bottlenose dolphin	0.2352 SCANS IV	18	8,326	0.22%	Low
Common dolphin	0.0272 SCANS IV	2	102,656	0.00%	Negligible
Minke whale	0.01581 Site surveys	1	20,118	0.00%	Negligible

Species	Density (#/km^2)	# Impacted	MU	% MU	Magnitude
	0.0137 SCANS IV	1		0.00%	Negligible
Grey seal	0.048 (average array & ECC)	4	6,056	0.07%	Negligible
Harbour seal	0.017 (average array & ECC)	1	1,365	0.07%	Negligible

Table 26 Disturbance impact ranges for low-order clearance using TTS as a proxy for disturbance and the impulsive criteria from Southall *et al.* (2019)

Charge weight	TTS SPL$_{peak}$				TTS SEL$_{ss}$			
	VHF	HF	LF	PCW	VHF	HF	LF	PCW
Low order (0.25 kg)	1.8 km	100 m	320 m	360 m	750 m	< 50 m	3.2 km	570 m

Table 27 Estimated number of marine mammals potentially at risk of disturbance during low-order UXO clearance using TTS as a proxy for disturbance

Density (#/km^2)	Harbour porpoise		Bottlenose dolphin	Common dolphin	Minke whale		Grey seal	Harbour seal
	0.2076 Site surveys	0.2803 SCANS IV	0.2352 SCANS IV	0.0272 SCANS IV	0.01581 Site surveys	0.0137 SCANS IV	0.048	0.017
Weighted SEL TTS-onset								
Low order	0	0	0	0	1	0	0	0
Unweighted SPL$_{peak}$ TTS-onset								
Low order	2	3	0	0	0	0	0	0

High order clearance

5.13.51 Using the 26 km EDR approach, the greatest estimated disturbance occurs for bottlenose dolphins (500 dolphins, 6.01% MU), harbour seals (36 seals, 2.64% MU) and grey seals (102 seals, 1.68% MU) (Table 28). The proportion of the porpoise, common dolphin and minke whale population disturbed is <1%.

5.13.52 Using TTS as a proxy for disturbance, HF cetaceans (dolphins) have the smallest predicted impact range of <50 m to 530 m for weighted SEL$_{ss}$ noise criteria and 100 m to 1.3 km for unweighted SPL$_{peak}$ noise criteria. Impact ranges for VHF cetaceans (harbour porpoise) are greatest under unweighted SPL$_{peak}$ noise criteria and ranged from 1.8 km to 23 km, whilst for PCW (seals) impact ranges were greatest under a weighted SEL$_{ss}$ scenario and ranged from 570 m to 19 km (smallest to largest charge). LF cetaceans (minke whale) show the greatest impact range under the weighted SEL$_{ss}$ noise criteria, with TTS-onset predicted at 3.2 km to 110 km (smallest to largest charge).

5.13.53 Using TTS as a proxy for disturbance for the maximum charge size high-order clearance, no bottlenose dolphin or common dolphins are predicted to be disturbed (Table 30). For harbour porpoise, the greatest disturbance impact is to 466 individuals, which is 0.75% of the MU. For minke whales up to a maximum of 497 individuals (2.47% MU) are predicted to be subject to TTS at the largest charge weight. The largest impact for seals is predicted to disturb 54 grey seals (0.89% MU) and 19 harbour seals (1.39% MU).

5.13.54 Southall *et al.* (2007) states that the use of TTS as a proxy for disturbance is *"expected to be precautionary because TTS at onset levels is unlikely to last a full diel cycle or to have serious biological consequences during the time TTS persists."*. TTS-onset thresholds are therefore likely to over-estimate the true behavioural response of any number of individuals predicted to be impacted.

Table 28 Estimated number of marine mammals potentially at risk of disturbance during high-order UXO clearance (assuming an impact area of 2,124 km^2) (without bubble curtain)

Species	Density (#/km^2)	# Impacted	MU	% MU	Magnitude
Harbour porpoise	0.2076 Site surveys	441	62,517	0.71%	Low
	0.2803 SCANS IV	595		0.95%	Low
Bottlenose dolphin	0.2352 SCANS IV	500	8,326	6.01%	Medium
Common dolphin	0.0272 SCANS IV	58	102,656	0.06%	Negligible
Minke whale	0.01581 Site surveys	34	20,118	0.17%	Low
	0.0137 SCANS IV	29		0.14%	Low
Grey seal	0.048 (average array & ECC)	102	6,056	1.68%	Medium
Harbour seal	0.017 (average array & ECC)	36	1,365	2.64%	Medium

Table 29 Summary of the disturbance impact ranges for various UXO charge sizes using TTS as a proxy for disturbance and the impulsive criteria from Southall *et al.* (2019) (without bubble curtain)

Charge weight	TTS SPL_{peak}				TTS SEL_{ss}			
	VHF	HF	LF	PCW	VHF	HF	LF	PCW
25 kg + donor	8.5 km	490 m	1.5 km	1.6 km	2.4 km	150 m	29 km	5.2 km
55 kg + donor	11 km	640 m	1.9 km	2.1 km	2.8 km	210 m	41 km	7.5 km
120 kg + donor	14 km	830 m	2.5 km	2.8 km	3.2 km	300 m	57 km	10 km
240 kg + donor	18 km	1.0 km	3.2 km	3.5 km	3.5 km	390 m	76 km	14 km
525 kg + donor	23 km	1.3 km	4.1 km	4.6 km	4.0 km	530 m	100 km	19 km

Table 30 Estimated number of marine mammals (and proportion of MU) potentially at risk of disturbance (using TTS as a proxy) from UXO clearance (without bubble curtain)

Density (#/km²)	**Harbour porpoise**		**Bottlenose dolphin**	**Common dolphin**	**Minke whale**		**Grey seal**	**Harbour seal**
	0.2076 Site surveys	**0.2803 SCANS IV**	**0.2352 SCANS IV**	**0.0272 SCANS IV**	**0.01581 Site surveys**	**0.0137 SCANS IV**	**0.048**	**0.017**
Weighted SEL TTS-onset								
25 kg + donor	4	5	0	0	42	36	4	1
55 kg + donor	5	7	0	0	83	72	8	3
120 kg + donor	7	9	0	0	161	140	15	5
240 kg + donor	8	11	0	0	287	249	30	10
525 kg + donor	10	14	0	0	497 (2.47% MU)	430 (2.14% MU)	54 (0.89% MU)	19 (1.39% MU)
Unweighted SPL_{peak} TTS-onset								
25 kg + donor	47	64	0	0	0	0	0	0
55 kg + donor	79	107	0	0	0	0	1	0
120 kg + donor	128	173	1	0	0	0	1	0
240 kg + donor	211	285	1	0	1	0	2	1
525 kg + donor	345 (0.55% MU)	466 (0.75% MU)	1	0	1	1	3	1

Magnitude summary

5.13.55 For the most likely scenario of low-order clearance, the magnitude score is Low for bottlenose dolphins, and Negligible across all other marine mammals.

5.13.56 For high-order clearance the magnitude score is Low, given the negligible duration, negligible frequency (up to 4 days, noting that the proposed development involves a construction approach of a maximum of one UXO being cleared per day) and the proportion of the MU impacted.

5.13.57 The impact of UXO disturbance is predicted to be of local spatial extent, short term duration and extremely infrequent (only 4 days, noting that the proposed development involves a construction approach of a maximum of one UXO being cleared per day). A suite of measures included in a UXO MMMP will be used to minimise the risk of injury to marine mammals. While not designed to specifically reduce the disturbance impact, the measures set out in the UXO MMMP will result in reduced disturbance impact to marine mammals.

Table 31 Determination of magnitude for marine mammals for disturbance from UXO clearance

Definition	MDO	ADO
Low-order clearance		
Extent	**Bottlenose dolphin:** Low – The effect is expected in a low proportion of the population (max 0.22% MU). **Other species:** negligible - The effect is expected in a very low proportion of the population (<0.1% MU).	For UXO clearance, the MDO and ADO are aligned.
Duration	Negligible - The impact is anticipated to be momentary (seconds to minutes). It is expected that UXO clearance only elicit a startle response and not widespread or prolonged displacement.	For UXO clearance, the MDO and ADO are aligned.
Frequency	Negligible - The impact is anticipated to occur on a maximum of 4 days (noting that the proposed development involves a construction approach of a maximum of one UXO being cleared per day).	For UXO clearance, the MDO and ADO are aligned.
Probability	Medium – while data is lacking, it is expected that marine mammals will be only temporarily displaced by UXO clearance activity	For UXO clearance, the MDO and ADO are aligned.
Consequence	Negligible - Very short term, recoverable effect on the behaviour and/or distribution resulting in no changes to the population size or trajectory.	For UXO clearance, the MDO and ADO are aligned.

Definition	MDO	ADO
Overall magnitude	*The potential magnitude of disturbance from low-order UXO clearance for bottlenose dolphins is rated as Low and for all other marine mammals is rated as Negligible.*	*The potential magnitude of disturbance from low-order UXO clearance for bottlenose dolphins is rated as Low and for all other marine mammals is rated as Negligible.*
High-order clearance		
Extent	**Bottlenose dolphin & seals**: Medium – The effect is expected in a medium proportion of the population (max 6.01% MU impacted from high-order clearance (without bubble curtain)). **Porpoise & minke whale:** Low – The effect is expected in a low proportion of the population (max 2.47% MU impacted impacted from high-order clearance (without bubble curtain)). **Common dolphin:** Negligible – The effect is expected in a very low proportion of the population (0.06% MU impacted from high-order clearance (without bubble curtain)).	For UXO clearance, the MDO and ADO are aligned.
Duration	Negligible - The impact is anticipated to be momentary (seconds to minutes). It is expected that UXO clearance only elicit a startle response and not widespread or prolonged displacement.	For UXO clearance, the MDO and ADO are aligned.
Frequency	Negligible - The impact is anticipated to occur on a maximum of 4 days.	For UXO clearance, the MDO and ADO are aligned.
Probability	Medium – while data is lacking, it is expected that marine mammals will be only temporarily displaced by UXO clearance activity.	For UXO clearance, the MDO and ADO are aligned.
Consequence	Negligible - Very short term, recoverable effect on the behaviour and/or distribution resulting in no changes to the population size or trajectory.	For UXO clearance, the MDO and ADO are aligned.
Overall magnitude	*The potential magnitude of disturbance from high-order UXO clearance is rated as Low.*	*The potential magnitude of disturbance from high-order UXO clearance is rated as Low.*

Sensitivity

5.13.58 It is noted in the JNCC (2020) guidance that, although UXO detonation is considered a loud underwater noise source, *"...a one-off explosion would probably only elicit a startle response and would not cause widespread and prolonged displacement..."*. It is not expected that disturbance from a single UXO detonation would result in any significant impacts, and that disturbance from a single noise event would not be sufficient to result in any changes to the vital rates of individuals. Therefore, the sensitivity of marine mammals for disturbance from UXO clearance is expected to be **Low**, irrespective of the disturbance threshold used in the assessment.

Table 32 Determination of sensitivity for marine mammals to disturbance from UXO clearance

Marine mammals	Justification
Context	A one-off explosion would probably only elicit a startle response and would not cause widespread and prolonged displacement.
Value	All cetaceans are categorised as European Protected Species. Therefore, they have a high value. Seals are categorized as Annex II under the EU Habitats Directive. Therefore, they have a high value.
Overall sensitivity	*The sensitivity of all marine mammals to disturbance from UXO clearance is rated as Low.*

UXO disturbance summary

5.13.59 The maximum magnitude of the impact has been assessed as **Medium adverse** (for bottlenose dolphin, grey and harbour seal), with the maximum sensitivity of the receptors being **Low** (Table 33). Therefore, the significance of disturbance caused by UXO clearance is **Slight adverse** at most which is not significant in EIA terms.

5.13.60 For all other marine mammals, the maximum magnitude of the impact has been assessed as **Low adverse**, with the maximum sensitivity of the receptors being **Low.** Therefore, the significance of disturbance caused by UXO clearance is **Slight adverse** at most which is not significant in EIA terms.

5.13.61 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Table 33 Summary of the marine mammal assessment for disturbance from high-order UXO clearance (without bubble curtain)

Species	Magnitude	Sensitivity	Impact Significance
5 km EDR (low-order)			
Harbour porpoise	Negligible	Low	Not significant
Bottlenose dolphin	Low	Low	Slight (adverse)
Common dolphin	Negligible	Low	Not significant
Minke whale	Negligible	Low	Not significant
Grey seal	Negligible	Low	Not significant
Harbour seal	Negligible	Low	Not significant
TTS as a proxy for disturbance – Low order 0.25 kg			
Harbour porpoise	Negligible	Low	Not significant
Bottlenose dolphin	Negligible	Low	Not significant
Common dolphin	Negligible	Low	Not significant
Minke whale	Negligible	Low	Not significant
Grey seal	Negligible	Low	Not significant
Harbour seal	Negligible	Low	Not significant
26 km EDR (high-order)			
Harbour porpoise	Low	Low	Slight (adverse)
Bottlenose dolphin	Medium	Low	Slight (adverse)
Common dolphin	Negligible	Low	Not significant
Minke whale	Low	Low	Slight (adverse)
Grey seal	Medium	Low	Slight (adverse)
Harbour seal	Medium	Low	Slight (adverse)
TTS as a proxy for disturbance – High order 525 kg			
Harbour porpoise	Low	Low	Slight (adverse)
Bottlenose dolphin	Negligible	Low	Not significant
Common dolphin	Negligible	Low	Not significant
Minke whale	Medium [33]	Low	Slight (adverse)
Grey seal	Low	Low	Slight (adverse)
Harbour seal	Low	Low	Slight (adverse)

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[33] Note: this is based on a hugely unrealistic impact range of 100 km

Residual effect assessment

The significance of effect from disturbance from UXO clearance is not significant in EIA terms. Therefore, no additional mitigation to that already identified in Table 13 are considered necessary. Therefore, ***no significant adverse residual effects*** *have been predicted in respect of marine mammals.*

Impact 5: Auditory injury as a result of foundation piling activity

Magnitude

5.13.62 Table 34 outlines the predicted areas and maximum impact ranges for auditory injury (the onset of PTS) from pile driving for each marine mammal receptor. This includes the prediction of impact for both the NE and the SE modelling locations, for both monopiles and jacket foundations, and with the implementation of at-source noise abatement methods to reduce the source level by at least 10 dB (see measures set out in Table 13).

5.13.63 For harbour porpoise, the maximum instantaneous PTS-onset impact range was 150 m for the installation of a monopile at the NE model location, assuming a hammer energy of 6,372 kJ. For all other species, the maximum instantaneous PTS-onset impact range was <50 m across all scenarios modelled. For all marine mammal receptors, the maximum cumulative PTS-onset impact range was <100 m for all scenarios modelled. This resulted in < 1 individual and <0.01% of the MU impacted for each species across each of the piling scenarios (Table 35).

5.13.64 There is evidence that harbour porpoise detections are reduced in the immediate vicinity of the pile prior to the commencement of piling, as a result of the presence of construction vessels, and thus it is assumed that porpoise are displaced from the immediate vicinity of the pile prior to piling commencing (Brandt *et al.*, 2018, Rose *et al.*, 2019, Benhemma-Le Gall *et al.*, 2021b, Benhemma-Le Gall *et al.*, 2023). In the Moray Firth for the construction of the Beatrice and Moray East offshore wind farms, vessels arrived on site on average 11 to 15 hours before piling commenced and porpoise detections reduced within 5 km of the pile by up to 33% at Beatrice and 13% at Moray East prior to piling (Benhemma-Le Gall *et al.*, 2023). Local scale displacement from the pile prior to piling commencing is also expected for other marine mammal species. Therefore, it is highly unlikely that any marine mammal would be present in the auditory injury (PTS) ranges, and thus no animals are expected to experience PTS. The magnitude of PTS from pile driving is therefore rated as **Negligible** (Table 36).

Table 34 Predicted impact ranges for auditory injury (PTS-onset) from pile driving

Species	Threshold	Metric	NE MP	SE MP	NE PP	SE PP
Harbour porpoise	Instantaneous PTS (SPL_{peak})	Area (km^2)	0.07	0.04	0.06	0.04
		Max Range (m)	150	120	140	110
	Cumulative PTS (SEL_{cum})	Area (km^2)	<0.1	<0.1	<0.1	<0.1
		Max Range (m)	<150	<100	<100	<100
Bottlenose & common dolphin	Instantaneous PTS (SPL_{peak})	Area (km^2)	<0.01	<0.01	<0.01	<0.01
		Max Range (m)	<50	<50	<50	<50
	Cumulative PTS (SEL_{cum})	Area (km^2)	<0.1	<0.1	<0.1	<0.1
		Max Range (m)	<100	<100	<100	<100
Minke whale	Instantaneous PTS (SPL_{peak})	Area (km^2)	<0.01	<0.01	<0.01	<0.01
		Max Range (m)	<50	<50	<50	<50
	Cumulative PTS (SEL_{cum})	Area (km^2)	<0.1	<0.1	<0.1	<0.1
		Max Range (m)	<100	<100	<100	<100
Harbour & grey seal	Instantaneous PTS (SPL_{peak})	Area (km^2)	<0.01	<0.01	<0.01	<0.01
		Max Range (m)	<50	<50	<50	<50
	Cumulative PTS (SEL_{cum})	Area (km^2)	<0.1	<0.1	<0.1	<0.1
		Max Range (m)	<100	<100	<100	<100

Table 35 The predicted auditory impact (instantaneous and cumulative PTS) from piling of monopiles and pin piles

Species	Density (#/km²)	Parameter	Instantaneous PTS		Cumulative PTS	
			NE MP	SE MP	NE PP	SE PP
Harbour porpoise	Site-specific density estimate, Chudzinska and Burt (2021)	# indiv	<1	<1	<1	<1
		% MU	<0.01	<0.01	<0.01	<0.01
	Lacey *et al.* (2022)	# indiv	<1	<1	<1	<1
		% MU	<0.01	<0.01	<0.01	<0.01
	Evans and Waggitt (2023)	# indiv	<1	<1	<1	<1
		% MU	<0.01	<0.01	<0.01	<0.01
	SCANS IV (Gilles *et al.*, 2023)	# indiv	<1	<1	<1	<1
		% MU	<0.01	<0.01	<0.01	<0.01
Bottlenose dolphin	Lacey *et al.* (2022)	# indiv	<1	<1	<1	<1
		% MU (1,069)	<0.01	<0.01	<0.01	<0.01
	Evans and Waggitt (2023)	# indiv	<1	<1	<1	<1
		% MU (496)	<0.01	<0.01	<0.01	<0.01
	SCANS IV (Gilles *et al.*, 2023)	# indiv	<1	<1	<1	<1
		% MU (8,326)	<0.01	<0.01	<0.01	<0.01
Common dolphin	Lacey *et al.* (2022)	# indiv	<1	<1	<1	<1
		% MU	<0.01	<0.01	<0.01	<0.01
	Evans and Waggitt (2023)	# indiv	<1	<1	<1	<1
		% MU	<0.01	<0.01	<0.01	<0.01
	SCANS IV (Gilles *et al.*, 2023)	# indiv	<1	<1	<1	<1
		% MU	<0.01	<0.01	<0.01	<0.01
Minke whale	Site-specific density estimate, Chudzinska and Burt (2021)	# indiv	<1	<1	<1	<1
		% MU	<0.01	<0.01	<0.01	<0.01
	Lacey *et al.* (2022)	# indiv	<1	<1	<1	<1
		% MU	<0.01	<0.01	<0.01	<0.01
	Evans and Waggitt (2023)	# indiv	<1	<1	<1	<1
		% MU	<0.01	<0.01	<0.01	<0.01
	SCANS IV (Gilles *et al.*, 2023)	# indiv	<1	<1	<1	<1
		% MU	<0.01	<0.01	<0.01	<0.01
Grey seal		# indiv	<1	<1	<1	<1

Species	Density (#/km²)	Parameter	Instantaneous PTS		Cumulative PTS	
			NE MP	SE MP	NE PP	SE PP
	Carter *et al.* (2020), Carter *et al.* (2022)	% MU	<0.01	<0.01	<0.01	<0.01
Harbour seal	Carter *et al.* (2020), Carter *et al.* (2022)	# indiv	<1	<1	<1	<1
		% MU	<0.01	<0.01	<0.01	<0.01

Table 36 Determination of magnitude for auditory injury (PTS-onset) from pile driving

Definition	**MDO**	**ADO**
Extent	Negligible - The effect is expected in a very low proportion of the population, when considering the measures set out in Table 13, in particular the implementation of at-source noise abatement methods to reduce the source level by at least 10 dB. Maximum impact range is 150 m impacting <1 individual.	The MDO and ADO are aligned.
Duration	High - since PTS is a permanent change in hearing sensitivity.	The MDO and ADO are aligned.
Frequency	Low - The effect is anticipated to occur frequently throughout construction phase	The ADO will result in less impact as fewer WTGs will be installed resulting in fewer piling days.
Probability	Negligible - The effect is highly unlikely to occur when considering the measures set out in Table 13, in particular the implementation of at-source noise abatement methods to reduce the source level by at least 10 dB.	The MDO and ADO are aligned.
Consequence	Negligible - No potential for the any changes in the individual reproductive success or survival therefore no changes to the population size or trajectory, when considering the measures set out in Table 13, in particular the implementation of at-source noise abatement methods to reduce the source level by at least 10 dB.	The MDO and ADO are aligned.
Overall magnitude	*The potential magnitude of PTS-onset for marine mammals is rated as Negligible.*	*The potential magnitude of PTS-onset for marine mammals is rated as Negligible.*

Sensitivity

Harbour porpoise

5.13.65 The ecological consequences of PTS for marine mammals are uncertain. At an expert elicitation workshop for the interim Population Consequences of Disturbance framework (iPCoD framework), experts in marine mammal hearing[34] discussed the nature, extent and potential consequence of PTS to marine mammal species arising from exposure to repeated low-frequency impulsive noise such as pile driving (Booth and Heinis, 2018). This workshop outlined and collated the best and most recent empirical data available on the effects of PTS on marine mammals. A number of general points came out in discussions as part of the elicitation. These included that PTS did not mean animals were deaf, that the limitations of the ambient noise environment should be considered and that the magnitude and frequency band in which PTS occurs are critical to assessing the effect on vital rates.

5.13.66 Southall *et al.* (2007) defined the onset of TTS as *"being a temporary elevation of a hearing threshold by 6 dB"* (in which the reference pressure for the dB is 1µPa). Although 6 dB of TTS is a somewhat arbitrary definition of onset, it has been adopted largely because 6 dB is a measurable quantity that is typically outside the variability of repeated thresholds measurements. The onset of PTS was defined as a non-recoverable elevation of the hearing threshold of 6 dB, for similar reasons. Based upon TTS growth rates obtained from the scientific literature, it has been assumed that the onset of PTS occurs after TTS has grown to 40 dB. The growth rate of TTS is dependent on the frequency of exposure, but is nevertheless assumed to occur as a function of an exposure that results in 40 dB of TTS, i.e., 40 dB of TTS is assumed to equate to 6 dB of PTS.

5.13.67 For piling noise, most energy is between ~30 – 500 Hz, with a peak usually between 100 – 300Hz and energy extending above 2 kHz (Kastelein *et al.*, 2015a, Kastelein *et al.*, 2016). Studies have shown that exposure to impulsive pile driving noise induces TTS in a relatively narrow frequency band in harbour porpoise and harbour seals (reviewed in Finneran, 2015), with statistically significant TTS occurring at 4 and 8 kHz (Kastelein *et al.*, 2016) and centred at 4 kHz (Kastelein *et al.*, 2012a, Kastelein *et al.*, 2012b, Kastelein *et al.*, 2013b, Kastelein *et al.*, 2017). Therefore, during the expert elicitation, the experts agreed that any threshold shifts as a result of pile driving would manifest themselves in the 2 – 10 kHz range (Kastelein *et al.*, 2017) and that a PTS 'notch' of 6 – 18 dB in a narrow frequency band in the 2 – 10 kHz region is unlikely to significantly affect the fitness of individuals (ability to survive and reproduce).

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[34] Workshop experts included representatives from Woods Hole Oceanographic Institute, Aarhus University, National Marine Mammal Foundation, SEAMRCO, JASCO Applied Sciences, SMRU and University of Aberdeen.

The expert elicitation concluded that:

> *"… the effects of a 6 dB PTS in the 2-10kHz band was unlikely to have a large effect on survival or fertility of the species of interest.*
>
> *… for all species experts indicated that the most likely predicted effect on survival or fertility as a result of 6 dB PTS was likely to be very small (i.e. <5% reduction in survival or fertility).*
>
> *… the defined PTS was likely to have a slightly larger effect on calves/pups and juveniles than on mature females survival or fertility."*

5.13.68 For harbour porpoise, the predicted decline in vital rates from the impact of a 6 dB PTS in the 2-10 kHz band for different percentiles of the elicited probability distribution are provided in Table 37. The data provided in Table 37 should be interpreted as:

- Experts estimated that the median decline in an individual mature female harbour porpoise's survival was 0.01% (due to a 6 dB PTS (a notch a few kHz wide and 6 dB high) occurring somewhere in the hearing between 2-10 kHz) (Figure 8);
- Experts estimated that the median decline in an individual mature female harbour porpoise's fertility was 0.09% (due to a 6 dB PTS (a notch a few kHz wide and 6 dB high) occurring somewhere in the hearing between 2-10 kHz) (Figure 9); and
- Experts estimated that the median decline in an individual harbour porpoise juvenile or dependent calf survival was 0.18% (due to a 6 dB PTS (a notch a few kHz wide and 6 dB high) occurring somewhere in the hearing between 2-10 kHz) (Figure 10).

Table 37 Predicted decline in harbour porpoise vital rates for different percentiles of the elicited probability distribution.

	Percentiles of the elicited probability distribution								
	10%	20%	30%	40%	50%	60%	70%	80%	90%
Adult survival	0	0	0	0.01	0.01	0.03	0.05	0.1	0.23
Fertility	0	0	0.02	0.05	0.09	0.16	0.3	0.7	1.35
Calf/Juvenile survival	0	0	0.02	0.09	0.18	0.31	0.49	0.8	1.46

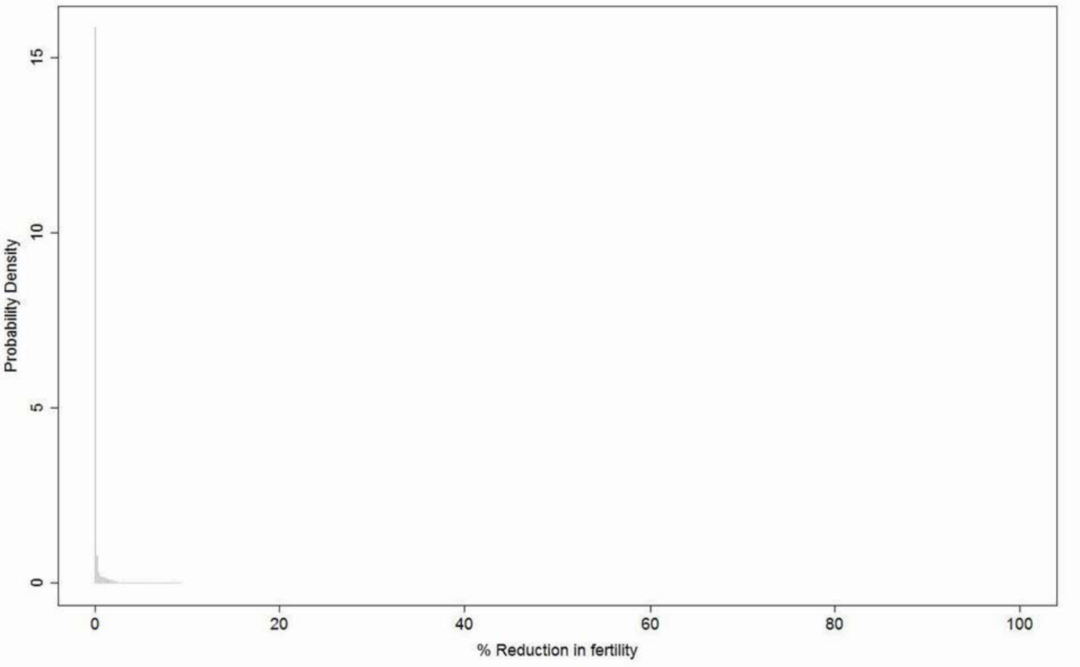

Figure 8 Probability distribution showing the consensus distribution for the effects on fertility of a mature female harbour porpoise as a consequence of a maximum 6 dB of PTS within a 2-10 kHz band (Booth and Heinis, 2018)[35].

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[35] Note - distribution is concentrated in bottom left corner of graph

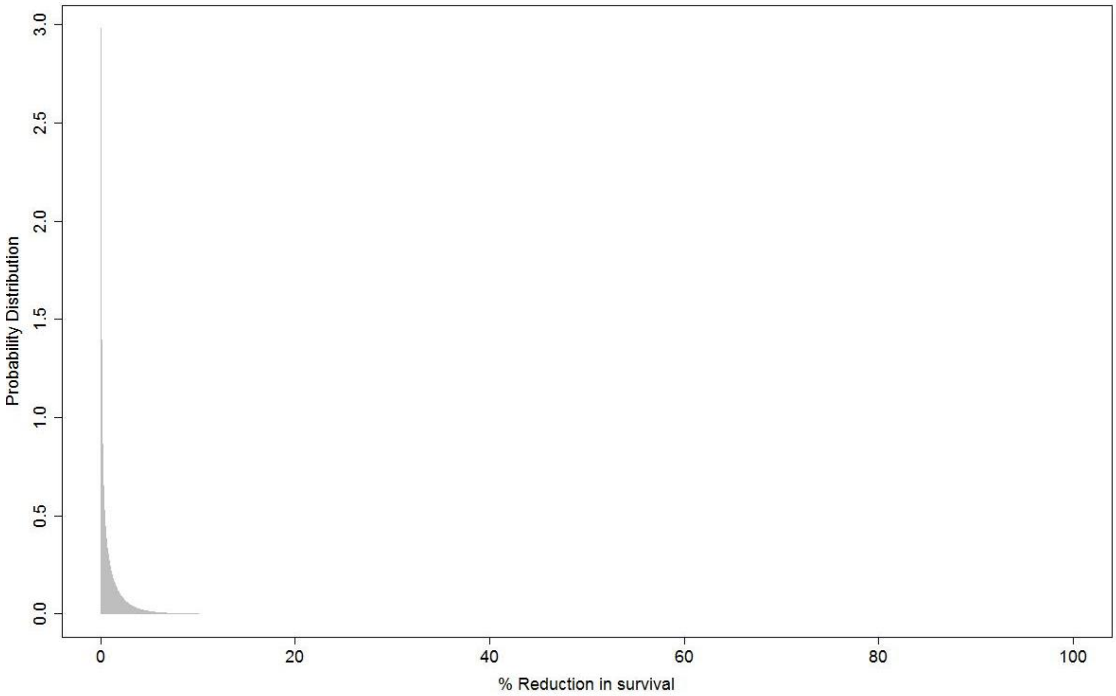


Figure 9 Probability distribution showing the consensus distribution for the effects on survival of a mature female harbour porpoise as a consequence of a maximum 6 dB of PTS within a 2-10 kHz band (Booth and Heinis, 2018).

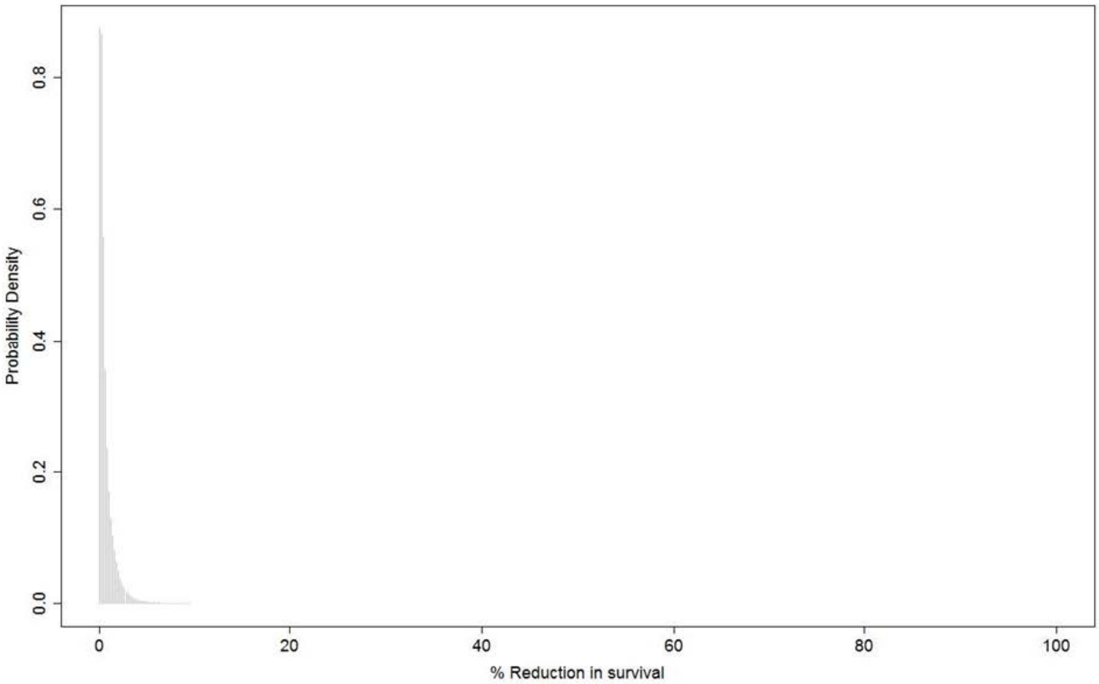


Figure 10 Probability distribution showing the consensus distribution for the effects on survival of juvenile or dependent calf harbour porpoise as a consequence of a maximum 6 dB of PTS within a 2-10 kHz band (Booth and Heinis, 2018).

5.13.69 Whilst PTS is a permanent effect which cannot be recovered from, the best scientific evidence available (Booth and Heinis, 2018) at this time suggests that PTS from piling will not cause a significant impact on either survival or reproductive rates; therefore, harbour porpoise have been assessed as having a **Low** sensitivity to PTS from pile driving.

Bottlenose dolphin

5.13.70 As for harbour porpoise, the ecological consequences of PTS for bottlenose dolphins are uncertain. At the same expert elicitation workshop detailed above in the porpoise section, experts in marine mammal hearing discussed the nature, extent and potential consequence of PTS to bottlenose dolphins arising from exposure to repeated low-frequency impulsive noise such as pile driving (Booth and Heinis, 2018, Fernandez-Betelu *et al.*, 2022). The predicted decline in bottlenose dolphin vital rates from the impact of a 6 dB PTS in the 2-10kHz band for different percentiles of the elicited probability distribution are provided in Table 38. The data provided in Table 38 should be interpreted as:

- Experts estimated that the median decline in an individual mature female bottlenose dolphin's survival was 1.6% (due to a 6 dB PTS (a notch a few kHz wide and 6 dB high) occurring somewhere in the hearing between 2-10 kHz).
- Experts estimated that the median decline in an individual mature female bottlenose dolphin's fertility was 0.43% (due to a 6 dB PTS (a notch a few kHz wide and 6 dB high) occurring somewhere in the hearing between 2-10 kHz).
- Experts estimated that the median decline in an individual bottlenose dolphin juvenile survival was 1.32% (due to a 6 dB PTS (a notch a few kHz wide and 6 dB high) occurring somewhere in the hearing between 2-10 kHz).
- Experts estimated that the median decline in an individual bottlenose dolphin dependent calf survival was 2.96% (due to a 6 dB PTS (a notch a few kHz wide and 6 dB high) occurring somewhere in the hearing between 2-10 kHz).

5.13.71 Whilst PTS is a permanent effect which cannot be recovered from, the best scientific evidence available (Booth and Heinis, 2018) at this time suggests that PTS from piling will not cause a significant impact on either survival or reproductive rates; therefore, bottlenose dolphin have been assessed as having a **Low** sensitivity to PTS from pile driving.

Table 38 Predicted decline in bottlenose dolphin vital rates for different percentiles of the elicited probability distribution.

	Percentiles of the elicited probability distribution								
	10%	20%	30%	40%	50%	60%	70%	80%	90%
Adult survival	0	0.18	0.57	1.04	1.6	2.34	3.39	5.18	10.99
Fertility	0	0.04	0.13	0.26	0.43	0.85	1.66	3.49	6.22
Juvenile survival	0.01	0.11	0.35	0.75	1.32	2.14	3.3	5.19	11.24
Calf survival	0	0.29	0.93	1.77	2.96	4.96	7.81	10.69	14.79

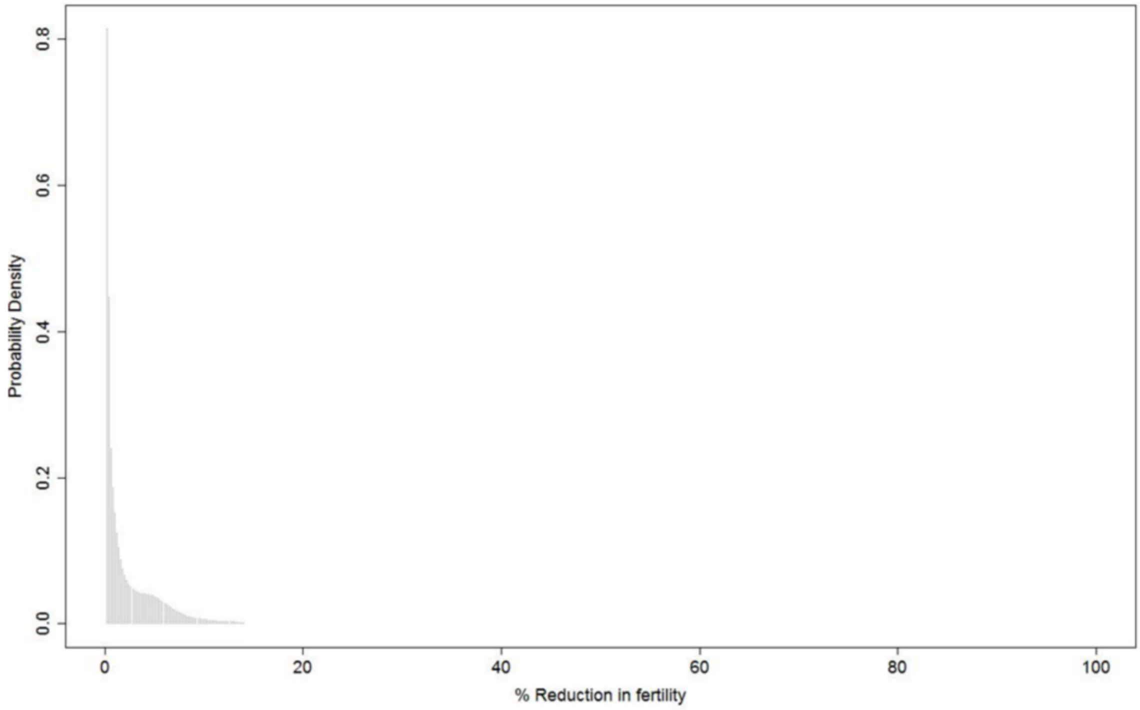


Figure 11 Probability distribution showing the consensus distribution for the effects on fertility of mature female bottlenose dolphin as a consequence of a maximum 6 dB of PTS within a 2-10 kHz band (Booth and Heinis, 2018).

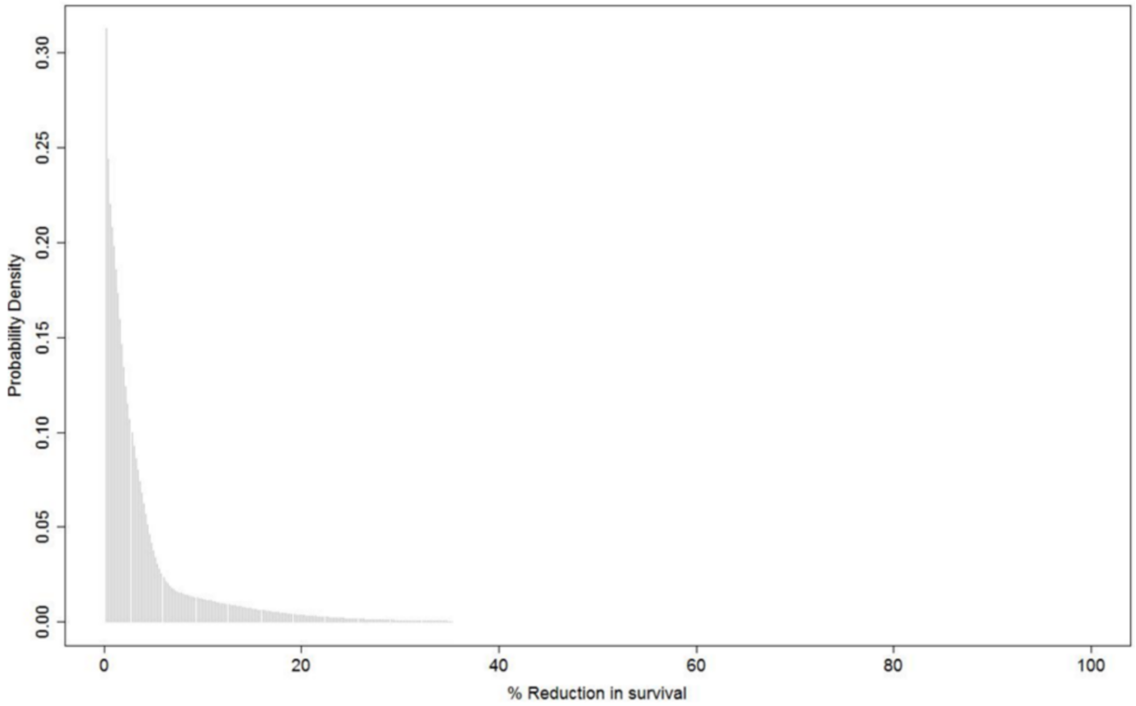


Figure 12 Probability distribution showing the consensus distribution for the effects on survival of mature female bottlenose dolphin as a consequence of a maximum 6 dB of PTS within a 2-10 kHz band (Booth and Heinis, 2018).

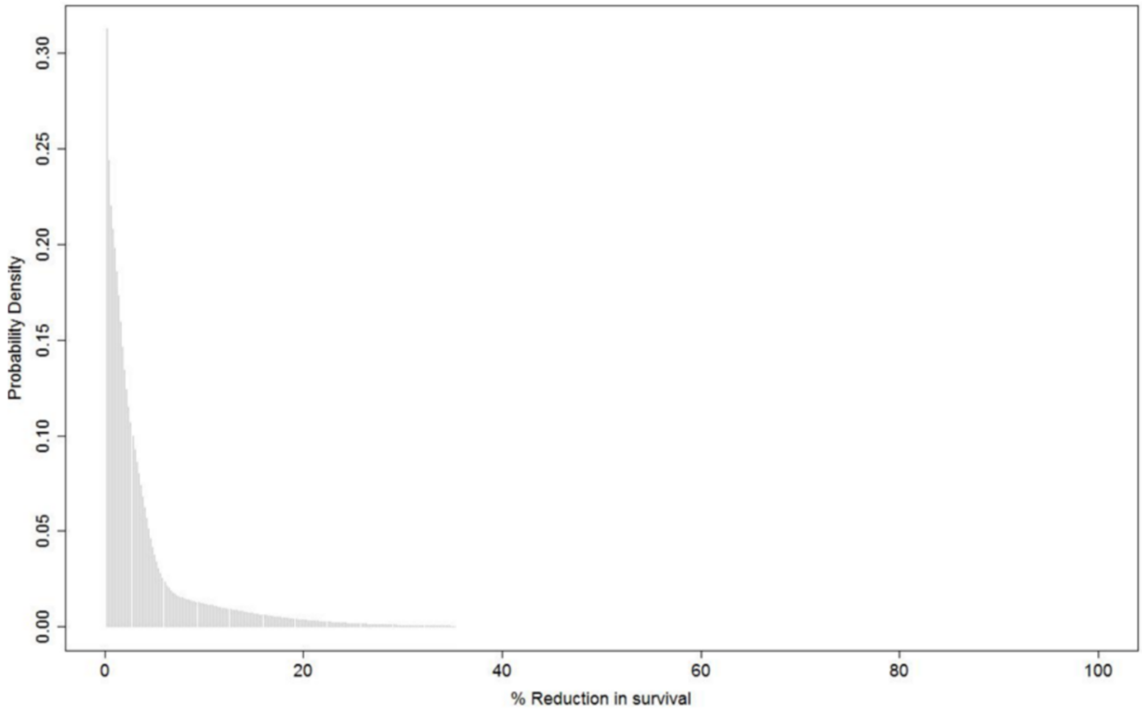


Figure 13 Probability distribution showing the consensus distribution for the effects on survival of juvenile or dependent calf bottlenose dolphin as a consequence of a maximum 6 dB of PTS within a 2-10 kHz band (Booth and Heinis, 2018).

Common dolphin

5.13.72 As common dolphin is also a high frequency cetacean, it is anticipated that the sensitivity of common dolphins to PTS-onset from piling will be the same as that of bottlenose dolphins. Therefore, common dolphins have been assessed as having a **Low** sensitivity to PTS from pile driving.

Minke whale

5.13.73 The PTS expert elicitation report (Booth & Heinis, 2018) provides a summary of the potential effect of piling noise on mammalian hearing and summarises the judgments of 7 world leading experts on marine mammal hearing and noise. The experts agreed that *“it was important to realise that reduced hearing ability does not necessarily mean a less fit animal (i.e. an animal of lower fitness).”* The elicitation included harbour and grey seals – two species with good low frequency hearing. Following a review and discussion of the current literature, experts determined: *“Following exposure to low frequency broadband pulsed noise, TTS was typically observed 1.5 octaves higher than the centre frequency of the exposure sound for seals and porpoise (Kastelein et al. 2012a, Kastelein et al. 2012b, Kastelein et al. 2013a, Finneran 2015). For piling noise and airgun pulses, most energy is between ~30 Hz- 500 Hz, with a peak usually between 100–300Hz and energy extending above 2kHz (e.g. Kastelein et al. 2015a, Kastelein et al. 2016)”*. Based on this, the experts concluded that if piling noise resulted in a threshold shift, that this would manifest in the mammalian ear as a notch in hearing sensitivity somewhere between 2-10kHz. This assessment was not species-specific and was considered to apply to all marine mammals (including minke whales) based on the best available knowledge (TTS studies involving low frequency broadband pulsed noise stimuli).

5.13.74 The low frequency noise produced during piling may be more likely to overlap with the hearing range of low frequency cetacean species such as minke whales. Minke whale communication signals have been demonstrated to be below 2 kHz (Edds-Walton 2000, Mellinger et al. 2000, Gedamke et al. 2001, Risch et al. 2013, Risch et al. 2014). Tubelli et al. (2012) estimated the most sensitive hearing range (the region with thresholds within 40 dB of best sensitivity) to extend from 30-100Hz up to 7.5-25kHz, depending on the specific model used. Ongoing studies to directly estimate the hearing of live minke whales provide initial results suggesting *"minke whales have a much higher frequency limit to their hearing range than previously believed based upon their ear anatomy and the frequencies at which they vocalize."* (Houser, pers comm.)

5.13.75 Booth & Heinis (2018) highlighted that the experts considered that if PTS occurs, this would occur as a notch in hearing loss in a narrow frequency band (occurring somewhere between 2-10kHz). They stressed this was not a loss of hearing across this entire band. Booth & Heinis (2018) also summarise the mechanisms experts considered as to whether PTS could significantly affect vital rates: *"In considering how any PTS could affect vital rates (i.e. probability of survival, probability of fertility), experts discussed the mechanisms by which this could occur. In general, experts noted that where communication has a significant social or reproductive function, that this might be a means by which survival and/or reproduction are affected. Experts noted however that PTS would likely occur over a small frequency range and that much of the energy of communication signals either fell outside the likely range affected by PTS or that the loss of part of the signal would likely not affect detection of the communication signals.".*

5.13.76 Data on minke whale hearing and potential effects of threshold shifts on vital rates are lacking. However, despite this lack of data, given the current understanding of how PTS from piling is expected to manifest in the mammalian ear – and the mechanisms that could lead to an effect on vital rates (census Booth & Heinis, 2018) – it is considered that it is unlikely that vital rates would be altered in a biologically meaningful way as a result of PTS from piling. Therefore, the sensitivity of minke whales to PTS from piling is Low.

Seals

5.13.77 The predicted decline in harbour and grey seals vital rates from the impact of a 6dB PTS in the 2-10 kHz band for different percentiles of the elicited probability distribution are provided in Table 39. The data provided in Table 39 should be interpreted as:

- Experts estimated that the median decline in an individual mature female seal's survival was 0.39% (due to a 6 dB PTS (a notch a few kHz wide and 6 dB high) occurring somewhere in the hearing between 2-10 kHz) (Figure 14).
- Experts estimated that the median decline in an individual mature female seal's fertility was 0.27% (due to a 6 dB PTS (a notch a few kHz wide and 6 dB high) occurring somewhere in the hearing between 2-10 kHz) (Figure 15).
- Experts estimated that the median decline in an individual seal pup/juvenile survival was 0.52% (due to a 6 dB PTS (a notch a few kHz wide and 6 dB high) occurring somewhere in the hearing between 2-10 kHz) (Figure 16).

5.13.78 Whilst PTS is a permanent effect which cannot be recovered from, the evidence does not suggest that PTS from piling will cause a significant impact on either survival or reproductive rates; therefore, both seal species have been assessed as having a **Low** sensitivity to PTS.

Table 39 Predicted decline in harbour and grey seal vital rates for different percentiles of the elicited probability distribution.

	Percentiles of the elicited probability distribution								
	10%	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**
Adult survival	0.02	0.1	0.18	0.27	0.39	0.55	0.78	1.14	1.89
Fertility	0.01	0.02	0.05	0.14	0.27	0.48	0.88	1.48	4.34
Calf survival	0	0.04	0.15	0.32	0.52	0.8	1.21	1.88	3

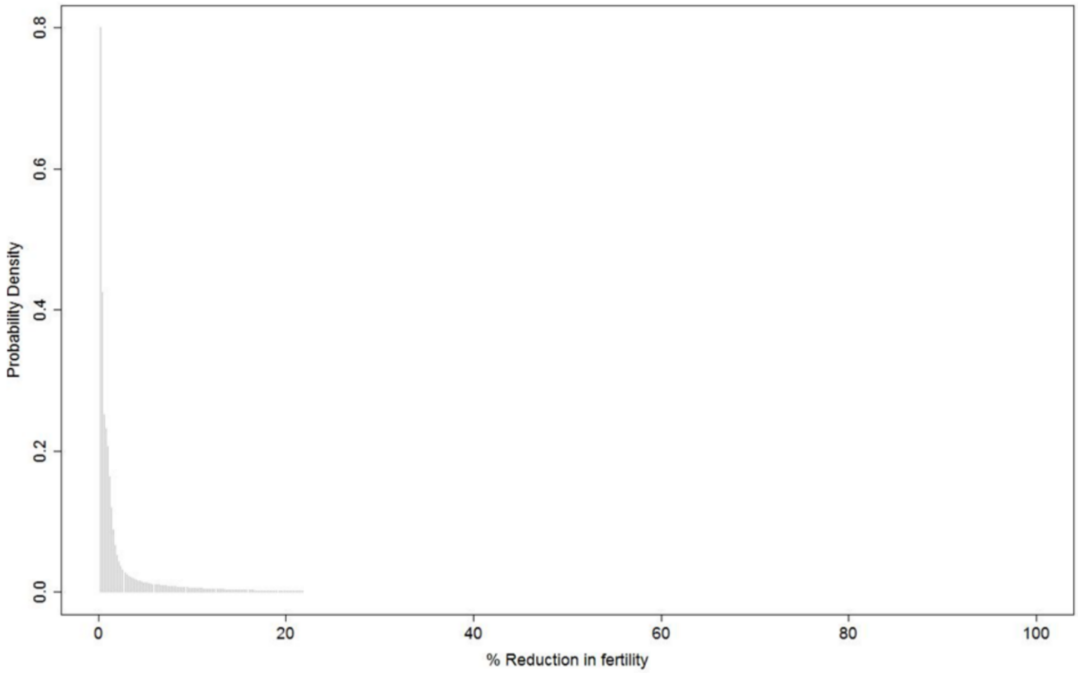


Figure 14 Probability distribution showing the consensus distribution for the effects on fertility of a mature female (harbour or grey) seal as a consequence of a maximum 6 dB of PTS within a 2-10 kHz band (Booth and Heinis, 2018).

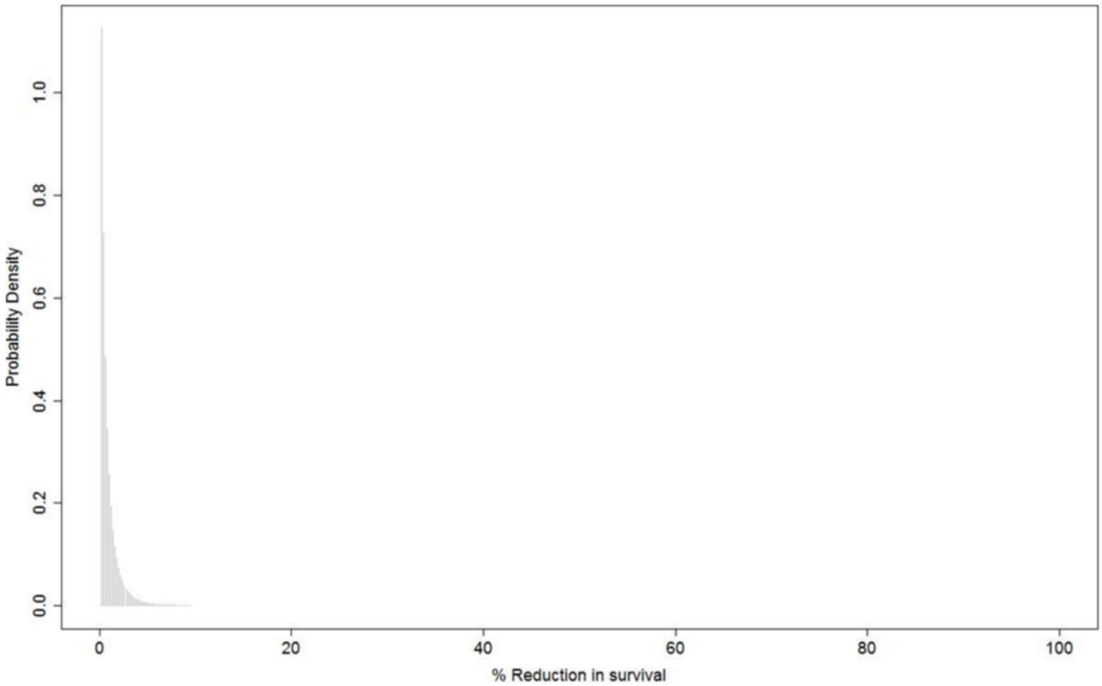


Figure 15 Probability distribution showing the consensus distribution for the effects on survival of a mature female (harbour or grey) seal as a consequence of a maximum 6 dB of PTS within a 2-10 kHz band (Booth and Heinis, 2018).

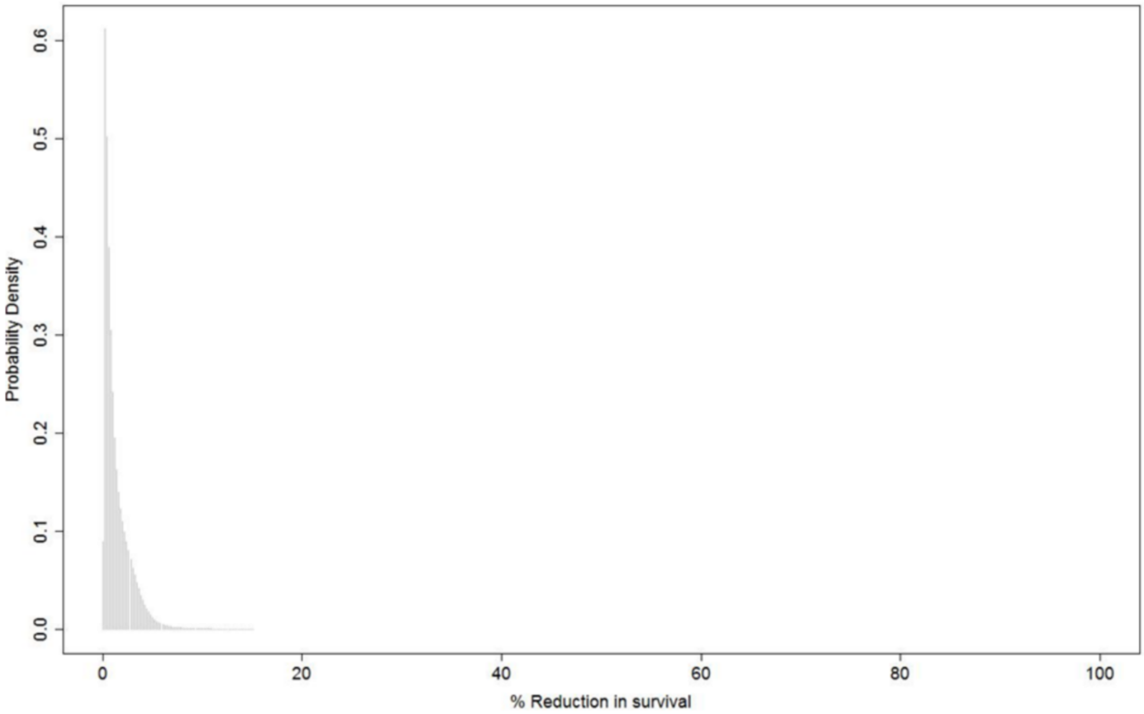


Figure 16 Probability distribution showing the consensus distribution for the effects on survival of juvenile or dependent pup (harbour or grey) seal as a consequence of a maximum 6 dB of PTS within a 2-10 kHz band (Booth and Heinis, 2018).

Table 40 Determination of sensitivity for marine mammals to auditory injury (PTS-onset) from pile driving

All species	Justification
Context	**Adaptability:** Marine mammals have a wide hearing range and it is expected that a small decline in hearing sensitivity at a specific frequency would not affect their ability to forage and communicate. **Tolerance:** Any threshold shifts as a result of pile driving would manifest themselves in the 2 - 10 kHz range (Kastelein *et al.*, 2017) and that a PTS 'notch' of 6 – 18 dB in a narrow frequency band in the 2 - 10 kHz region is unlikely to significantly affect the fitness of individuals (ability to survive and reproduce). **Recoverability:** None. PTS is a permanent change in the hearing threshold.
Value	All cetaceans are categorised as European Protected Species. Therefore, they have a high value. Seals are categorized as Annex II under the EU Habitats Directive. Therefore, they have a high value.
Overall sensitivity	*The potential sensitivity of marine mammals to PTS from pile driving is rated as Low.*

Summary

5.13.79 The magnitude of the impact has been assessed as **Negligible**, with the maximum sensitivity of the receptors being **Low**. Therefore, the significance of effect of auditory injury (PTS-onset) occurring as a result of pile driving activities is **Not significant**, which is not significant in EIA terms.

5.13.80 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Table 41 Summary of the marine mammal assessment for auditory injury (PTS) from piling

Species	Magnitude	Sensitivity	Impact Significance
Harbour porpoise	Negligible with Piling MMMP & NAS (Table 13)	Low	Not significant
Bottlenose dolphin	Negligible with Piling MMMP & NAS (Table 13)	Low	Not significant
Common dolphin	Negligible with Piling MMMP & NAS (Table 13)	Low	Not significant
Minke whale	Negligible with Piling MMMP & NAS (Table 13)	Low	Not significant
Harbour seal	Negligible with Piling MMMP & NAS (Table 13)	Low	Not significant
Grey seal	Negligible with Piling MMMP & NAS (Table 13)	Low	Not significant

Residual effect assessment

PTS-onset from pile driving, and therefore potential for auditory injury, is not significant in EIA terms. Therefore, no additional mitigation to that already identified in Table 13 are considered necessary. Therefore, ***no significant adverse residual effects*** *have been predicted in respect of marine mammals.*

Impact 6: Behavioural displacement and disturbance from foundation piling activity

5.13.81 Table 42 outlines the predicted impact on the number (using the dose-response function) and percentage of each marine mammal receptor which will experience behavioural disturbance as a result of piling activity, assessed within their respective MU.

The potential magnitude of this disturbance based on the dose-response function is presented in Table 42 are discussed below for each receptor. The results using the Level B harassment thresholds for dolphins and minke whales only are presented in Table 43.

Table 42 Predicted impact for disturbance from foundation piling activity using the Graham *et al.* (2017b) dose-response function for all cetaceans and the Whyte *et al.* (2020a) dose-response function for both seal species

Species	Density (#/km^2)	Parameter	NE MP	SE MP	NE PP	SE PP
Harbour porpoise	Site-specific density estimate, Chudzinska and Burt (2021)	# indiv	618	306	576	279
		% MU	0.99	0.49	0.92	0.45
	Lacey *et al.* (2022)	# indiv	736	353	685	322
		% MU	1.18	0.56	1.10	0.52
	Evans and Waggitt (2023)	# indiv	995	507	927	464
		% MU	1.59	0.81	1.48	0.74
	SCANS IV (Gilles *et al.*, 2023)	# indiv	836	413	778	377
		% MU	1.34	0.66	1.24	0.60
Bottlenose dolphin	Lacey *et al.* (2022)	# indiv	77	40	72	36
		% MU (1,069)	7.20	3.74	6.74	3.37
	Evans and Waggitt (2023)	# indiv	8	3	7	2
		% MU (496)	1.61	0.60	1.41	0.40
	SCANS IV (Gilles *et al.*, 2023)	# indiv	699	346	651	316
		% MU (8,326)	8.40	4.16	7.82	3.80
Common dolphin	Lacey *et al.* (2022)	# indiv	71	42	67	39
		% MU	0.07	0.04	0.07	0.04
	Evans and Waggitt (2023)	# indiv	73	24	68	21
		% MU	0.07	0.02	0.07	0.02
	SCANS IV (Gilles *et al.*, 2023)	# indiv	81	40	75	37
		% MU	0.08	0.04	0.07	0.04
Minke whale	Site-specific density estimate, Chudzinska and Burt (2021)	# indiv	47	23	44	21
		% MU	0.23	0.11	0.22	0.10
	Lacey *et al.* (2022)	# indiv	57	26	53	24
		% MU	0.28	0.13	0.26	0.12
	Evans and Waggitt (2023)	# indiv	43	20	40	18
		% MU	0.21	0.10	0.20	0.09
	SCANS IV (Gilles *et al.*, 2023)	# indiv	41	20	38	18
		% MU	0.20	0.10	0.19	0.09

Species	Density (#/km^2)	Parameter	NE MP	SE MP	NE PP	SE PP
Grey seal	Carter *et al.* (2020), Carter *et al.* (2022)	# indiv (95% CI)	177 (17-340)	43 (3-86)	163 (15-315)	39 (3-77)
		% MU (95% CI)	2.92 (0.28-5.61)	0.71 (0.05-1.42)	2.69 (0.25-5.20)	0.64 (0.05-1.27)
Harbour seal	Carter *et al.* (2020), Carter *et al.* (2022)	# indiv (95% CI)	13 (1-25)	12 (0-3)	12 (1-23)	1 (0-3)
		% MU (95% CI)	0.95 (0.07-1.83)	0.88 (0.07-1.68)	0.88 (0.07-1.68)	0.07 (0.0-0.22)

Table 43 Predicted impact for disturbance from foundation piling activity using the Level B harassment threshold

Species	Density (#/km^2)	Parameter	NE MP	SE MP	NE PP	SE PP
Bottlenose dolphin	Lacey *et al.* (2022)	# indiv	11	5	10	4
		% MU (1,069)	1.03	0.47	0.94	0.37
	Evans and Waggitt (2023)	# indiv	0	0	0	0
		% MU (496)	0.00	0.00	0.00	0.00
	SCANS IV (Gilles *et al.*, 2023)	# indiv	85	39	75	33
		% MU (8326)	1.02	0.47	0.90	0.40
Common dolphin	Lacey *et al.* (2022)	# indiv	13	6	12	5
		% MU	0.01	0.01	0.01	<0.01
	Evans and Waggitt (2023)	# indiv	0	0	0	0
		% MU	0.00	0.00	0.00	0.00
	SCANS IV (Gilles *et al.*, 2023)	# indiv	10	4	9	4
		% MU	0.01	<0.01	0.01	<0.01
Minke whale	Site-specific density estimate, Chudzinska and Burt (2021)	# indiv	6	3	5	2
		% MU	0.03	0.01	0.02	0.01
	Lacey *et al.* (2022)	# indiv	7	3	6	2
		% MU	0.03	0.01	0.03	0.01
	Evans and Waggitt (2023)	# indiv	4	1	3	1
		% MU	0.02	<0.01	0.01	<0.01
	SCANS IV (Gilles *et al.*, 2023)	# indiv	5	2	4	2
		% MU	0.02	0.01	0.02	0.01

Harbour porpoise

Magnitude

5.13.82 The number of harbour porpoise predicted to be disturbed was presented for a range of density estimates, including the site-specific density estimate, SCANS III density surface, the Irish Sea density surface and the SCANS IV block densities (Table 41). The highest predicted disturbance impact was 995 porpoise (1.59% MU) for the installation of a monopile at the NE location and 927 porpoise (1.48% MU) for the installation of a pinpile at the NE location.

5.13.83 Figure 19 presents the behavioural disturbance dose-response contours for harbour porpoise during the installation of a monopile at the NE location.

5.13.84 To determine the magnitude of this impact on a population level, iPCoD modelling was conducted. The iPCoD modelling assumed the following:

- Piling scenario S2: 57 piling days impacting 995 harbour porpoise per day (monopiles)
- Piling scenario S9: 125 piling days impacting 927 harbour porpoise per day (pinpiles)

5.13.85 This is highly conservative since the modelling shows that the number of animals impacted at other modelling locations is significantly lower.

5.13.86 The iPCoD results show that the level of disturbance is not sufficient to result in any change at the population level, since the impacted population is predicted to be on the same increasing trajectory as the un-impacted population (monopile: Figure 17 and Table 44; pinpile: Figure 18 and Table 45).

5.13.87 Given the low number of porpoise predicted to be impacted (maximum 995 porpoise from a single piling event) and the proportion of the population this represents (1.39%), coupled with the results of the population modelling, this impact is considered to be of Low Adverse magnitude (Table 46).

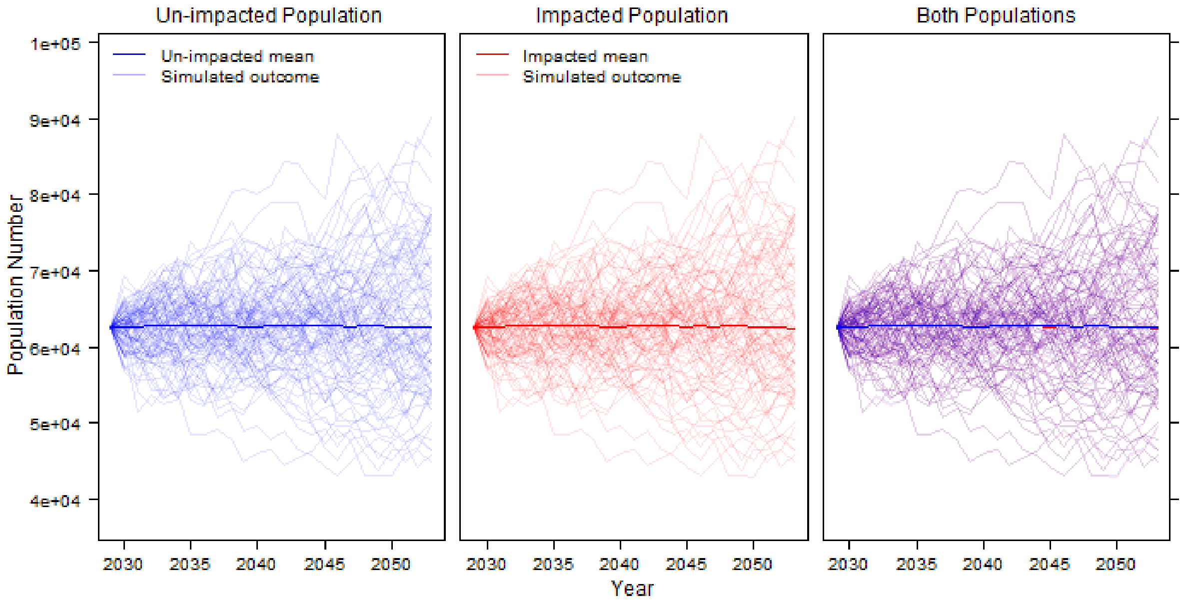


Figure 17 Predicted population trajectories for the un-impacted (baseline) and impacted harbour porpoise iPCoD simulations for monopiles (57 days piling over 1 year), impacting 995 harbour porpoise per day.

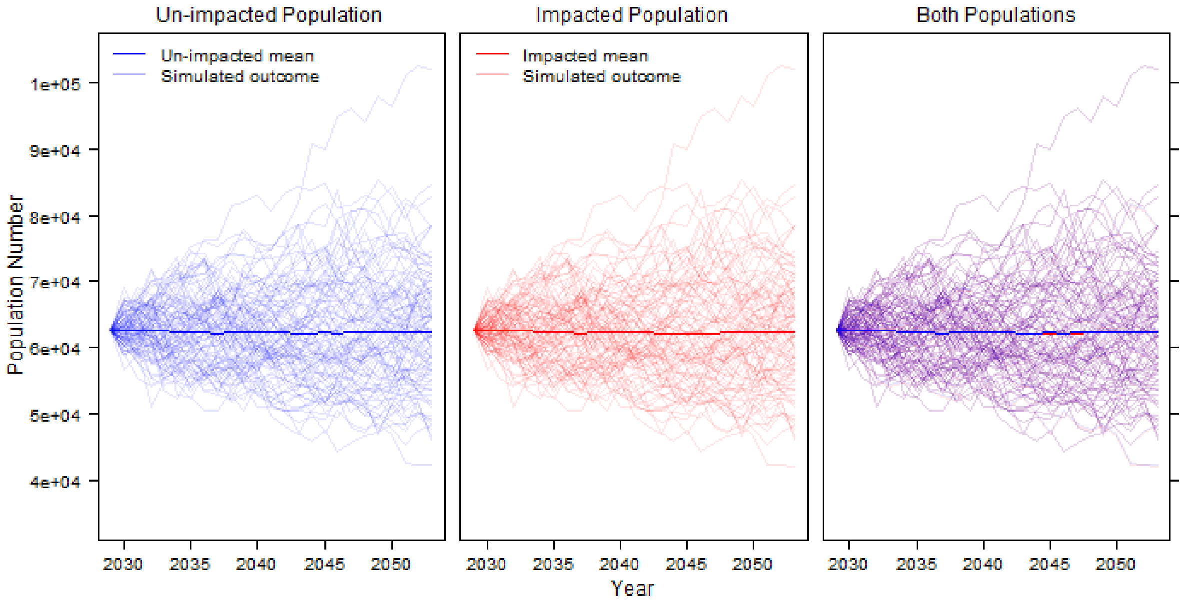


Figure 18 Predicted population trajectories for the un-impacted (baseline) and impacted harbour porpoise iPCoD simulations for pinpiles (125 days piling over 3 years), impacting 927 harbour porpoise per day.

Table 44 Predicted population size for the un-impacted (baseline) and impacted harbour porpoise iPCoD simulations for monopiles (57 days piling over 1 year), impacting 995 harbour porpoise per day. The proportion of the impacted versus unimpacted populations presented as a percentage are presented as the nearest whole percentage.

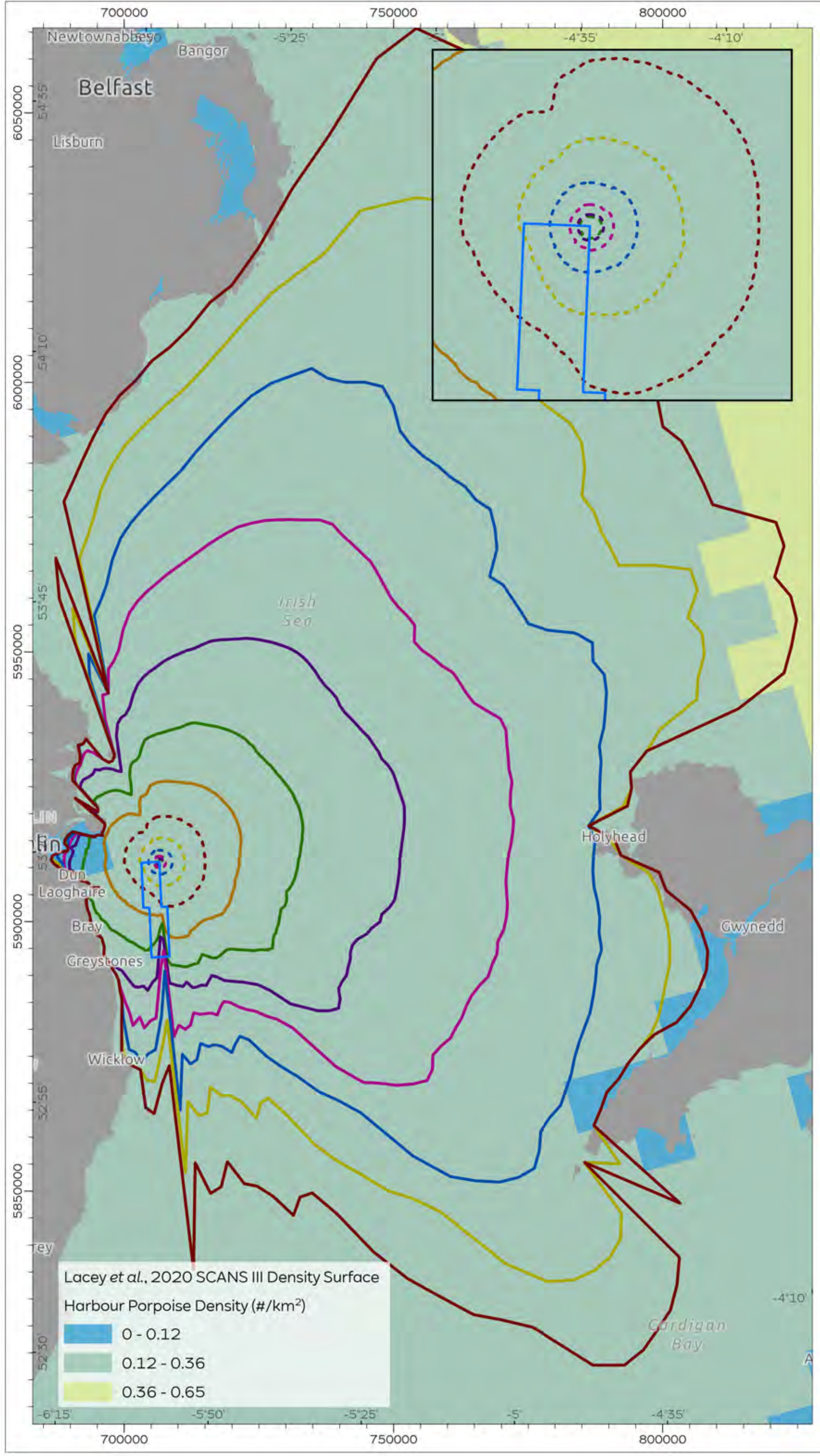
	Unimpacted population mean size	Impacted population mean size	Impacted population size as a proportion of unimpacted
Start year 1 (before piling commences)	62,516	62,516	100%
End year 1 (after piling ends)	62,602	62,602	100%
6 years after piling ends	62,748	62,737	100%
12 years after piling ends	62,732	62,719	100%
18 years after piling ends	62,662	62,649	100%

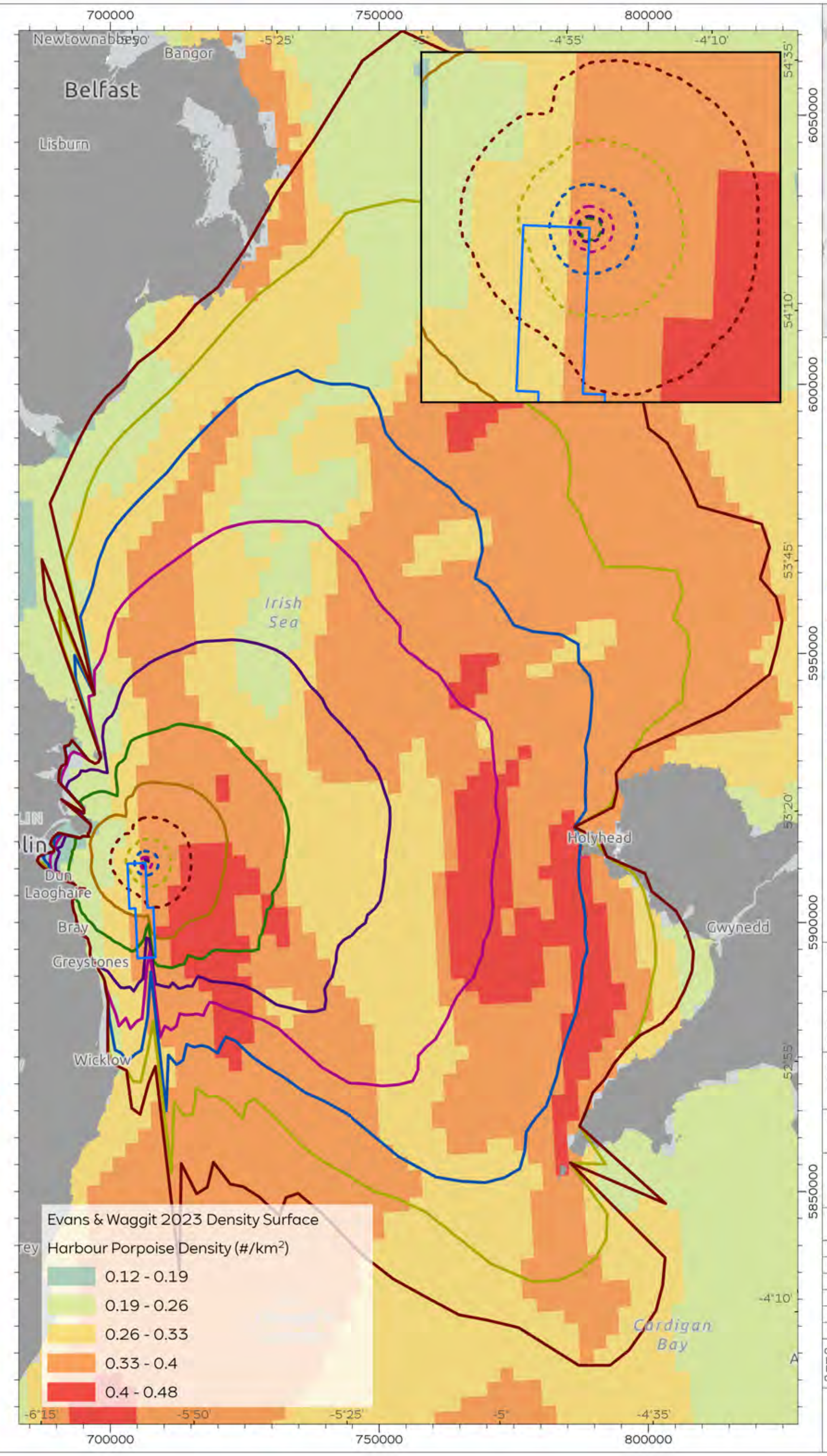
Table 45 Predicted population size for the un-impacted (baseline) and impacted harbour porpoise iPCoD simulations for pinpiles (125 days piling over 3 years), impacting 927 harbour porpoise per day. The proportion of the impacted versus unimpacted populations presented as a percentage are presented as the nearest whole percentage.

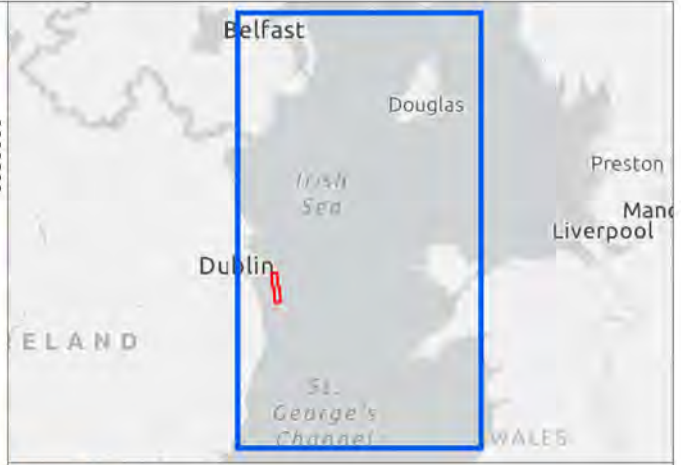
	Unimpacted population mean size	Impacted population mean size	Impacted population size as a proportion of unimpacted
Start year 1 (before piling commences)	62,516	62,516	100%
End year 3 (after piling ends)	62,661	62,661	100%
6 years after piling ends	62,332	62,309	100%
12 years after piling ends	62,332	62,307	100%
18 years after piling ends	62,256	62,231	100%

Table 46 Determination of magnitude for harbour porpoise for disturbance from foundation piling activity

Definition	MDO	ADO
Extent	Low - The effect is expected in a low proportion of the population. Using the Evans and Waggitt (2023) density surface estimate a maximum of 1.59% of the MU is expected to experience disturbance per piling day.	The MDO and ADO are aligned.
Duration	Duration of impact would be temporary to short-term. Active piling time per monopile foundation is a maximum of 3.9 hours. Active piling time for jacket foundations is a maximum of 12 hours for 4 piles per 24 hours. Duration of the effect is Low since evidence shows that animals return to the impacted area between one - three days after piling ceases.	The MDO and ADO are aligned.
Frequency	Low - The impact will occur frequently throughout a relevant project phase (57 days over four months (piling schedule S2) or 125 days over 19 months (piling schedule S9) during the proposed construction activities).	The ADO will result in less impact as fewer WTGs will be installed resulting in fewer piling days.
Probability	High – there are extensive studies on pile driving activities causing disturbance in harbour porpoise.	The MDO and ADO are aligned.
Consequence	Low - Unlikely to cause any population effect (as shown by iPCoD modelling).	The MDO and ADO are aligned.
Overall magnitude	*The potential magnitude for harbour porpoise is rated as Low.*	*The potential magnitude for harbour porpoise is rated as Low.*







Array Area

SELss dB re μPa2 (5dB) NE

—	120
—	125
—	130
—	135
—	140
—	145
—	150
- - -	155
- - -	160
- - -	165
- - -	170
- - -	175
- - -	180

DRAWING STATUS

FINAL

DISCLAIMER

MAP NOTES / DATA SOURCES:

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PROJECT TITLE

Dublin Array

DRAWING TITLE

Behavioural Disturbance Dose-Response Contours (5dB Increments) With Density Surface for Harbour Porpoise

DRAWING NUMBER: **19**

PAGE NUMBER: **1 of 1**

VER	DATE	REMARKS	DRAW	CHEK	APRD
01	2024-04-29	For Issue	GB	BB	SS

0 10 20 30 40 km
0 5 10 15 20 nm

N
GRID NORTH

SCALE 1:1,015,625
PLOT SIZE A3
DATUM WGS 1984
VERTICAL REF LAT
PRJ WGS 1984 UTM Zone 29N

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Dublin Array
Generation for generations
Kish Offshore Wind Limited - Bray Offshore Wind Limited

Sensitivity

5.13.88 Previous studies have shown that harbour porpoises are displaced from the vicinity of piling events. For example, studies at wind farms in the German North Sea have recorded large declines in porpoise detections close to the piling (>90% decline at noise levels above 170 dB) with decreasing effect with increasing distance from the pile (25% decline at noise levels between 145 and 150 dB) (Brandt *et al.* 2016). The detection rates revealed that porpoise were only displaced from the piling area in the short term (one to three days) (Brandt *et al.*, 2011, Dähne *et al.*, 2013, Brandt *et al.*, 2016, Brandt *et al.*, 2018). Harbour porpoise are small cetaceans which makes them vulnerable to heat loss and requires them to maintain a high metabolic rate with little energy remaining for fat storage (e.g. Rojano-Doñate *et al.*, 2018). This makes them vulnerable to starvation if they are unable to obtain sufficient levels of prey intake.

5.13.89 Studies using Digital Acoustic Recording Tags (DTAGs) have shown that porpoise tagged after capture in pound nets foraged on small prey nearly continuously during both the day and the night on their release (Wisniewska *et al.*, 2016). The authors state that porpoise therefore *"operate on an energetic knife edge"* and that they have *"low resilience to disturbance"*. However, there are concerns with the methodologies used in the Wisniewska (2016) paper that bring these conclusions into question. These concerns are summarized in a rebuttal to the original paper by Hoekendijk *et al*. (2018) which call for *"a cautious, critical, and rational assessment of the results and interpretations"*. One of the key issues highlighted is that the porpoise were trapped in a pound net for 24+ hours before tagging and were not allowed to recover from stress and starvation once released. The high levels of foraging observed don't necessarily represent the typical foraging – i.e. they are not necessarily indicative of vulnerability to disturbance. Foraging behaviour after release may in part be a response to being captured and held. It is typical for the initial data recorded from tags to be excluded from analysis as it is not expected to be representative of typical behaviour (e.g. Wright *et al* 2017). Given that the tags on the porpoise in Wisniewska (2016) only recorded for 15-23 hours after tagging, it could be considered that all of the data are impacted by the response to being caught and tagged, and thus none of it is representative of typical behaviour. Wisniewska *et al* (2018) responded to the rebuttal by Hoekendijk *et al*. (2018) by highlighting that it was unknown whether or not the captured porpoise fed while in the pound nets or whether this would have led to elevated stress. They state that the hunger levels of the released porpoise were unknown and that there was no evidence of prolonged response to the tagging circumstances. Further to this, a subsequent paper by Booth (2019) used the Wisniewska *et al* (2016) data combined with additional information on porpoise diet and the energy derived from different prey to highlight that the tagged animals likely were able to consume significant amounts of energy (well in excess of energetic requirements – based on the data available). Booth (2019) disputes the conclusion that porpoise exist on an "energetic knife-edge" as Wisniewska (2016) claim, given that Wisniewska (2016) do not justify this claim in their paper.

5.13.90 The results from Wisniewska *et al*. (2016) could suggest that porpoises have an ability to respond to short-term reductions in food intake, implying a resilience to disturbance. As Hoekendijk *et al*. (2018) argue, this could help explain why porpoises are such an abundant and successful species. It is important to note that the studies providing evidence for the responsiveness of harbour porpoises to piling noise have not provided any evidence for subsequent individual consequences. In this way, responsiveness to disturbance cannot reliably be equated to sensitivity to disturbance and porpoises may well be able to compensate by moving quickly to alternative areas to feed, while at the same time increasing their feeding rates.

5.13.91 Monitoring of harbour porpoise activity at the Beatrice Offshore Wind Farm during pile driving activity has indicated that porpoises were displaced from the immediate vicinity of the pile driving activity – with a 50% probability of response occurring at approximately 7 km (Graham *et al.*, 2019). This monitoring also indicated that the response diminished over the construction period, so that eight months into the construction phase, the range at which there was a 50% probability of response was only 1.3 km. In addition, the study indicated that porpoise activity recovered between pile driving events.

5.13.92 A recent study by Benhemma-Le Gall *et al.* (2021a) provided two key findings in relation to harbour porpoise response to pile driving. Porpoise were not completely displaced from the piling site: detections of clicks (echolocation) and buzzing (associated with prey capture) in the short-range (2 km) did not cease in response to pile driving, and porpoise appeared to compensate: detections of both clicks (echolocation) and buzzing (associated with prey capture) increased above baseline levels with increasing distance from the pile, which suggests that those porpoise that are displaced from the near-field, compensate by increasing foraging activities beyond the impact range (Figure 20). Therefore, porpoise that experience displacement are expected to be able to compensate for the lost foraging opportunities and increased energy expenditure of fleeing.

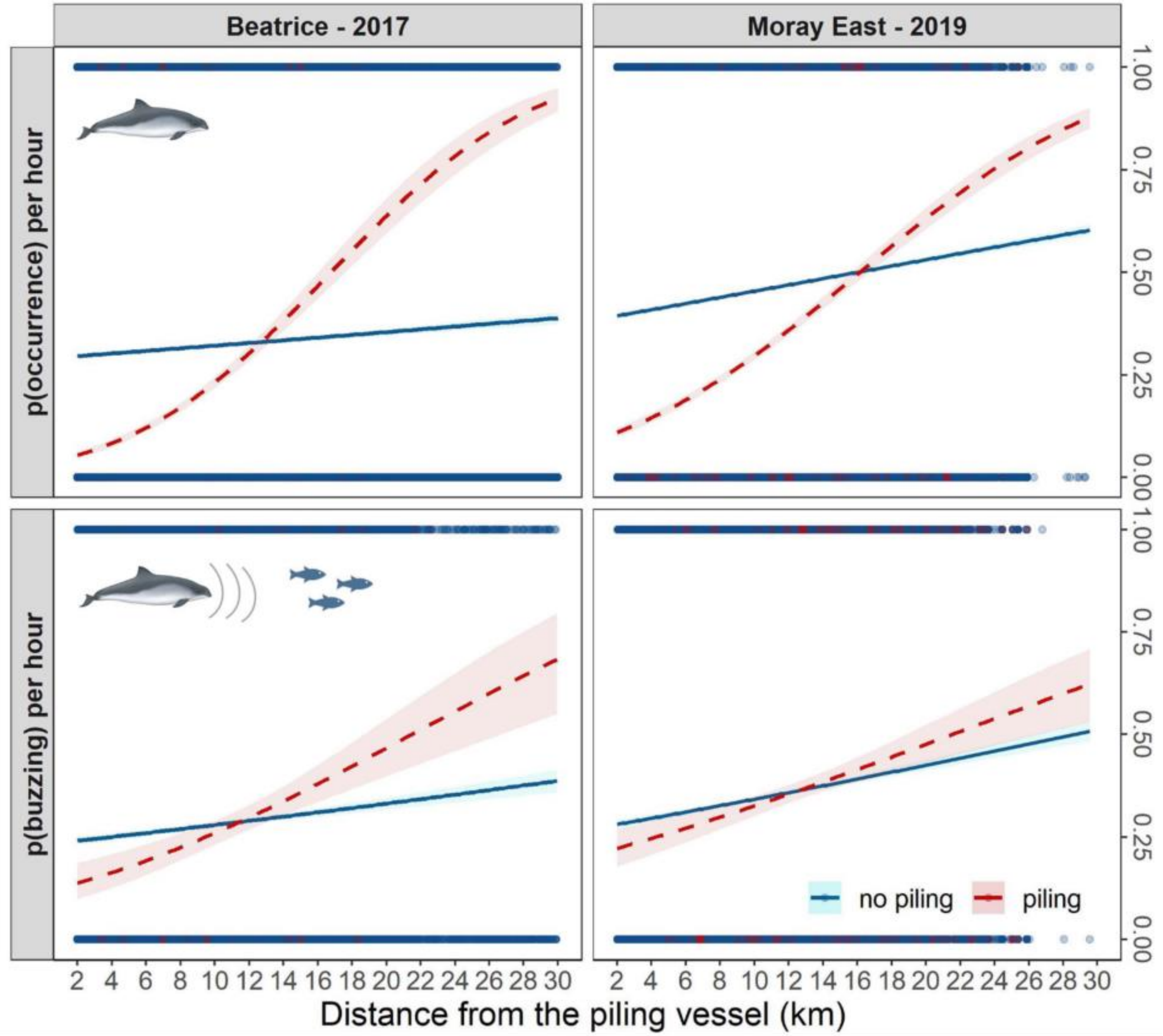


Figure 20 The probability of harbour porpoise occurrence and buzzing activity per hour during (dashed red line) and out with (blue line) pile-driving hours, in relation to distance from the pile-driving vessel at Beatrice (left) and Moray East (right). Obtained from Benhemma-Le Gall *et al.* (2021a).

5.13.93 A study of tagged harbour porpoises has shown large variability between individual responses to an airgun stimulus (van Beest *et al.*, 2018). Of the five porpoises tagged and exposed to airgun pulses at ranges of 420 – 690 m (SEL 135 – 147 dB re 1 µPa^{2}s), one individual showed rapid and directed movements away from the source. Two individuals displayed shorter and shallower dives immediately after exposure and the remaining two animals did not show any quantifiable response. Therefore, there is expected to be a high level of variability in responses from individual harbour porpoises exposed to low frequency broadband pulsed noise (including pile-driving).

5.13.94 At an expert elicitation workshop held in Amsterdam in June 2018, experts in marine mammal physiology, behaviour and energetics discussed the nature, extent and potential consequences of disturbance to harbour porpoise from exposure to low frequency broadband pulsed noise (e.g. pile-driving, airgun pulses) (Booth *et al.*, 2019). Experts were asked to estimate the potential consequences of a six-hour period of zero energy intake, assuming that disturbance from a pile driving event resulted in missed foraging opportunities for this duration. A Dynamic Energy Budget model for harbour porpoise (based on the Dynamic Energy Budget (DEB) model in Hin *et al.*, 2019) was used to aid discussions regarding the potential effects of missed foraging opportunities on survival and reproduction. The model described the way in which the life history processes (growth, reproduction and survival) of a female and her calf depend on the way in which assimilated energy is allocated between different processes and was used during the elicitation to model the effects of energy intake and reserves following simulated disturbance.

5.13.95 The experts agreed that first year calf survival (post-weaning) and fertility were the most likely vital rates to be affected by disturbance, but that juvenile and adult survival were unlikely to be significantly affected as these life-stages were considered to be more robust. Experts agreed that the final third of the year was the most critical for harbour porpoises as they reach the end of the current lactation period and the start of new pregnancies, therefore it was thought that significant impacts on fertility would only occur when animals received repeated exposure throughout the whole year. Experts agreed it would likely take high levels of repeated disturbance to an individual before there was any effect on that individual's fertility (Figure 21 left), and that it was very unlikely an animal would terminate a pregnancy early. The experts agreed that calf survival could be reduced by only a few days of repeated disturbance to a mother/calf pair during early lactation (Figure 21 right); however, it is highly unlikely that the same mother-calf pair would repeatedly return to the area in order to receive these levels of repeated disturbance.

5.13.96 Due to observed responsiveness to piling, their income breeder life history, and the low numbers of days of disturbance expected to affect calf survival, harbour porpoises have been assessed here as having a **Low** sensitivity to disturbance and resulting displacement from foraging grounds (Table 47).

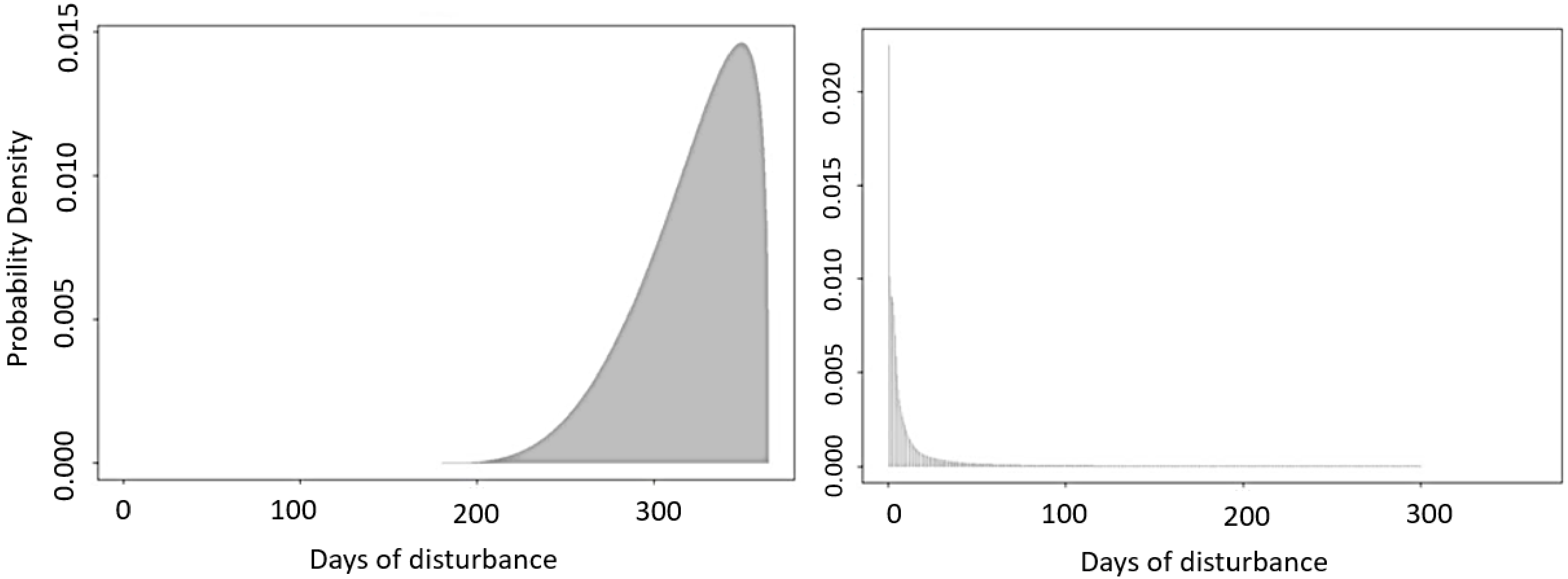


Figure 21 Probability distributions showing the consensus of the expert elicitation for harbour porpoise disturbance from piling (Booth *et al*., 2019). Left: the number of days of disturbance (i.e. days on which an animal does not feed for six hours) a pregnant female could 'tolerate' before it has any effect on fertility. Right: the number of days of disturbance (of six hours zero energy intake) a mother/calf pair could 'tolerate' before it has any effect on survival.

Table 47 Determination of sensitivity for harbour porpoise to disturbance from pile driving

Harbour porpoise	Justification
Context	**Adaptability:** Previous studies have recorded large declines in porpoise detections close to the piling (>90% decline at noise levels above 170 dB) with decreasing effect with increasing distance from the pile (25% decline at noise levels between 145 and 150 dB) (Brandt *et al*. 2016). Monitoring of harbour porpoise at the Beatrice OWF has indicated that porpoises were displaced from the immediate vicinity of the pile driving activity (Graham *et al*., 2019). **Tolerance:** Studies suggest that porpoises have an ability to respond to short term reductions in food intake, implying a resilience to disturbance. Porpoise are expected to be able to compensate for lost foraging and increased energy expenditure by increasing foraging activities beyond the impact site. **Recoverability:** The detection rates revealed that porpoise were only displaced from the piling area in the short term (one to three days) (Brandt *et al.*, 2011, Dähne *et al.*, 2013, Brandt *et al.*, 2016, Brandt *et al.*, 2018). Monitoring of harbour porpoise at the Beatrice OWF indicated that the response diminished over the construction period and that porpoise activity recovered between pile driving events.
Value	Harbour porpoise are categorised as European Protected Species. Therefore, they have a high value.
Overall sensitivity	*The potential sensitivity of harbour porpoise is rated as Low.*

Bottlenose dolphin

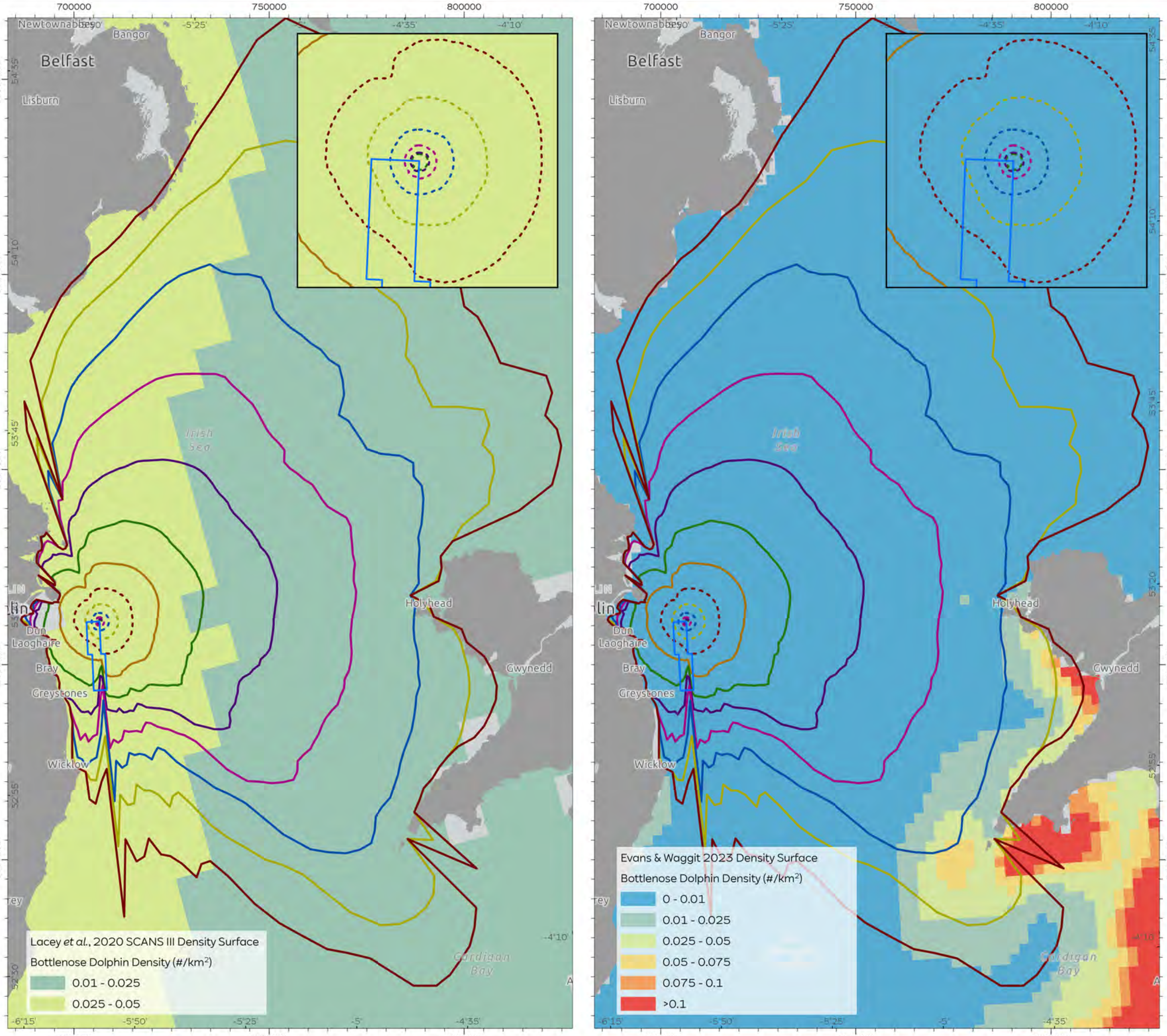
Magnitude: Dose-response

5.13.97 The number of bottlenose dolphins predicted to be disturbed on a single piling day varies drastically depending on the density estimate used:

- **SCANS III density surface** (Lacey *et al.*, 2022): For a single piling location, the highest predicted disturbance impact was 77 dolphins (7.20% MU) for the installation of a monopile at the NE location or 72 dolphins (6.7% MU) for the installation of a pinpile at the NE location. Figure 22 left presents the behavioural disturbance dose-response contours for the installation of a monopile at the NE location.

- Irish Sea density surface (Evans and Waggitt, 2023): For a single piling location, the highest predicted disturbance impact was also 8 dolphins (1.61% MU) for the installation of a monopile at the NE location or 7 dolphins (1.41% MU) for the installation of a pinpile at the NE location. Figure 22 (right) presents the behavioural disturbance dose-response contours for the installation of a monopile at the NE location.

- **SCANS IV block density (Gilles *et al.*, 2023):** For a single piling location, the highest predicted disturbance impact was 699 dolphins (8.40% MU) for the installation of a monopile at the NE location or 651 dolphins (7.82% MU) for the installation of a pinpile at the NE location.



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PROJECT TITLE

Dublin Array

DRAWING TITLE

Behavioural Disturbance Dose-Response Contours (5dB Increments) With Density Surface for Bottlenose Dolphin

DRAWING NUMBER: 22

PAGE NUMBER: 1 of 1

VER	DATE	REMARKS	DRAW	CHEK	APRD
01	2024-04-29	For Issue	GB	BB	SS

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0 5 10 15 20 nm

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GRID NORTH

SCALE 1:1,015,625
PLOT SIZE A3
DATUM WGS 1984
VERTICAL REF LAT
PRJ WGS 1984 UTM Zone 29N

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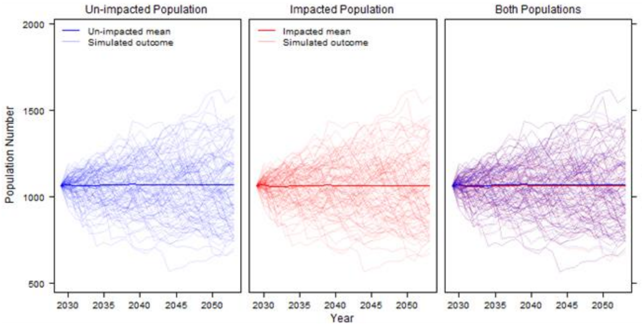
5.13.98 To determine the magnitude of this impact on a population level, iPCoD modelling was conducted. The iPCoD modelling assumed the following:

- Piling scenario S2: 57 piling days impacting 77, 8 or 699 dolphins per day (monopiles).
- Piling scenario S9: 125 piling days impacting 72, 7 or 651 dolphins per day (pinpiles).

5.13.99 The results of the iPCoD modelling shows at most a slight deviation from the baseline resulting from the pile driving disturbance at Dublin Array (Figure 23 and Table 48). Using the SCANS III density surface and the SCANS IV density scenarios, the mean impacted population size decreases very slightly from the mean unimpacted population size initially in response to piling, after which it continues on the same, stable trajectory at 99% of the mean unimpacted population size. It is noted that iPCoD does not currently allow for a density-dependent response, and as such there is no way for the model to allow the impacted population to increase in size to reach the baseline/un-impacted population size (carrying capacity) after the piling disturbance. The impacted population does, however, continue on a stable trajectory in the long-term. Using the Irish Sea density surface scenario, the impacted population remains exactly the same size as the unimpacted population.

5.13.100 The duration of effect is days at most from each piling event, with piling occurring over four months (piling schedule S2 monopiles) or 125 days over 19 months (piling schedule S9 pinpiles) during the proposed construction activities. The results show that temporary changes in behaviour can result in potential reductions to lifetime reproductive success and survival to some individuals, although not enough to affect the population trajectory over a generational scale. This is therefore precautionarily considered to be an impact of Medium Adverse magnitude.



SCANS III surface – Monopile, 77 dolphins/day, 57 piling days

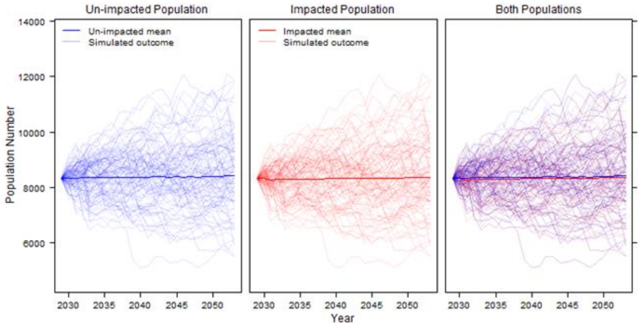
MU: 1,069

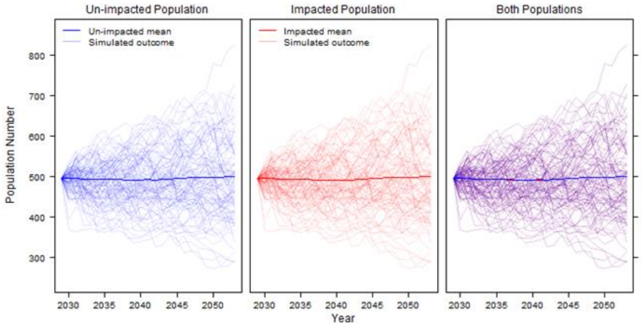
SCANS IV – Monopile, 699 dolphins/day, 57 piling days

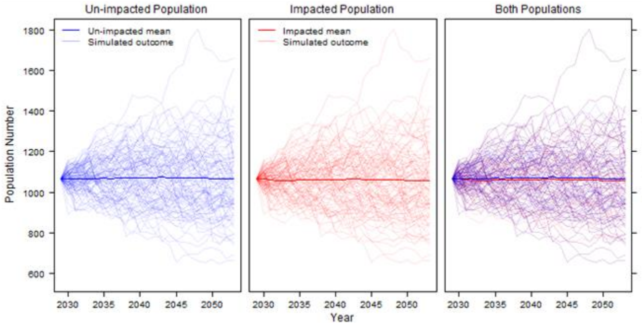
MU: 1,069

Irish Sea Density Surface – Monopile, 8 dolphins/day, 57 piling days

MU: 1,069







SCANS III surface – Pin piles, 72 dolphins/day, 125 piling days

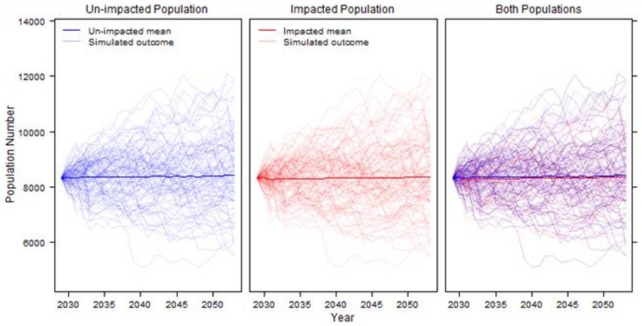
MU: 1,069

SCANS IV – Pin piles, 651 dolphins/day, 125 piling days

MU: 1,069

Irish Sea Density Surface– Pin piles, 7 dolphins/day, 125 piling days

MU: 1,069



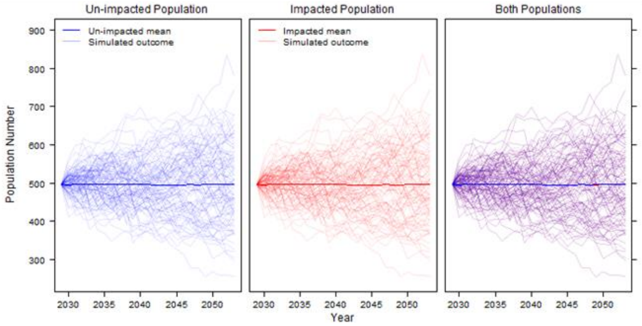


Figure 23 Predicted population trajectories for the unimpacted (baseline) and impacted bottlenose dolphin iPCoD simulations, using the results for the dose-response function and the three density estimates and MU sizes.

Table 48 Predicted population size for the unimpacted (baseline) and impacted bottlenose dolphin iPCoD simulations, using the results for the dose-response function and the three density estimates and MU sizes.

Monopiles (57 piling days in one year)						
Scenario		Start (before piling starts)	End (after piling ends)	6 yrs after piling ends	12 yrs after piling ends	18 yrs after piling ends
SCANS III 77/day MU=1,069	Unimpacted mean	1,066	1,068	1,067	1,069	1,070
	Impacted mean	1,066	1,068	1,063	1,064	1,065
	Impacted as % of unimpacted	100%	100%	100%	100%	100%
SCANS IV 699/day MU=8,326	Unimpacted mean	8,326	8,322	8,342	8,370	8,375
	Impacted mean	8,326	8,322	8,290	8,320	8,325
	Impacted as % of unimpacted	100%	100%	99%	99%	99%
Irish Sea 8/day MU=496	Unimpacted mean	496	495	494	492	497
	Impacted mean	496	495	493	491	496
	Impacted as % of unimpacted	100%	100%	100%	100%	100%

Pinpiles (125 piling days over 3 years)						
Scenario		Start year 1 (before piling starts)	End year 3 (after piling ends)	6 yrs after piling ends	12 yrs after piling ends	18 yrs after piling ends
SCANS III 72/day MU=1,069	Unimpacted mean	1,066	1,067	1,069	1,071	1,070
	Impacted mean	1,066	1,067	1,060	1,062	1,062
	Impacted as % of unimpacted	100%	100%	99%	99%	99%
SCANS IV 651/day MU=8,326	Unimpacted mean	8,326	8,322	8,319	8,293	8,341
	Impacted mean	8,326	8,322	8,219	8,197	8,245
	Impacted as % of unimpacted	100%	100%	99%	99%	99%
Irish Sea 7/day MU=496	Unimpacted mean	496	496	498	497	497
	Impacted mean	496	496	498	497	497
	Impacted as % of unimpacted	100%	100%	100%	100%	100%

5.13.101 The harbour porpoise dose-response function has been used as a proxy for bottlenose dolphin response in the absence of similar empirical data. However, this makes the assumption that the same disturbance relationship is observed in bottlenose dolphins. It is anticipated that this approach will be overly precautionary as evidence suggests that bottlenose dolphins are less sensitive to disturbance compared to harbour porpoise. A literature review of (post Southall *et al.* (2007)) behavioural responses by harbour porpoises and bottlenose dolphins to noise was conducted by Moray Offshore Renewables Ltd (2012). Several studies have reported a moderate to high level of behavioural response at a wide range of received SPLs (100 and 180 dB re 1µPa) (Lucke *et al.*, 2009, Tougaard *et al.*, 2009, Brandt *et al.*, 2011). Conversely, a study by Niu *et al.* (2012) reported moderate level responses to non-pulsed noise by bottlenose dolphins at received SPLs of 140 dB re 1µPa. Another high frequency cetacean, Risso's dolphin, reported no behavioural response at received SPLs of 135 dB re 1µPa (Southall *et al.*, 2010). Whilst both species showed a high degree of variability in responses and a general positive trend with higher responses at higher received levels, moderate level responses were observed above 80 dB re 1µPa in harbour porpoise and above 140 dB re 1µPa in bottlenose dolphins (Moray Offshore Renewables Ltd, 2012), indicating that moderate level responses by bottlenose dolphins will be exhibited at a higher received SPL and, therefore, they are likely to show a lesser response to disturbance. Furthermore, the relatively dynamic social structure of bottlenose dolphins (Connor *et al.*, 2001) and the fact that they have no significant predation threats and do not appear to face excessive competition for food with other marine mammal species, have potentially resulted in a higher tolerance to perceived threats or disturbances in their environment, which may make them less sensitive to disturbance compared to harbour porpoise.

5.13.102 In light of this, the Level B harassment threshold has also been presented as an alternative disturbance threshold for bottlenose dolphins.

Magnitude: Level B harassment

5.13.103 The number of bottlenose dolphins predicted to be disturbed on a single piling day varies drastically depending on the density estimate used:

- **SCANS III density surface (Lacey *et al.*, 2022):** For a single piling location, the highest predicted disturbance impact was 11 dolphins (1.03% MU) for the installation of a monopile at the NE location. Figure 24 left presents the Level B harassment contour for the installation of a monopile at the NE location.

- **Irish Sea density surface (Evans and Waggitt, 2023):** The maximum number of bottlenose dolphins predicted to be disturbed on a single piling day using the Level B harassment threshold is zero dolphins for all scenarios. Figure 24 right presents the Level B harassment contour for the installation of a monopile at the NE location.

- **SCANS IV block density (Gilles *et al.*, 2023):** For a single piling location, the highest predicted disturbance impact was 85 dolphins (1.02% MU) for the installation of a monopile at the NE location.

5.13.104 Given that the number of animals disturbed using the Level B harassment threshold is lower than that predicted using the dose-response approach, the magnitude of impact will be the same or lower than that concluded above. Therefore, no additional iPCoD modelling has been presented here.

Array Area

Level B Threshold 160dB re 1 μPa (SPL_{RMS})

DRAWING STATUS

FINAL

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PROJECT TITLE

Dublin Array

DRAWING TITLE

Level B Threshold Contours With Density Surface for Bottlenose Dolphin

DRAWING NUMBER: 24

PAGE NUMBER: 1 of 1

VER	DATE	REMARKS	DRAW	CHEK	APRD
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N
GRID NORTH

SCALE	1:450,000	PLOT SIZE	A3
DATUM	WGS 1984	VERTICAL REF	LAT
PRJ	WGS 1984 UTM Zone 29N		

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Table 49 Determination of magnitude for bottlenose dolphins for disturbance from foundation piling activity

Definition	MDO	ADO
Extent	**Dose-response approach:** Medium - The effect is expected in a medium proportion of the population (max 8.95% of the MU is expected to experience disturbance). **Level B harassment:** Low - The effect is expected in a low proportion of the population (max 1.45% of the MU is expected to experience disturbance).	The MDO and ADO are aligned.
Duration	Duration of impact would be temporary to short-term. Active piling time per monopile foundation is a maximum of 3.9 hours. Active piling time for jacket foundations is a maximum of 12 hours for 4 piles per 24 hours. Duration of the effect is Low since it is assumed that animals return to the impacted area after piling ceases.	The MDO and ADO are aligned.
Frequency	Low - The impact will occur frequently throughout a relevant project phase **(**57 days over four months (piling schedule S2) or 125 days over 19 months (piling schedule S9) during the proposed construction activities).	The ADO will result in less impact as fewer WTGs will be installed resulting in fewer piling days.
Probability	Medium – there are some studies on pile driving activities causing disturbance in bottlenose dolphins.	The MDO and ADO are aligned.
Consequence	Low - Unlikely to cause any population effect (as shown by iPCoD modelling).	The MDO and ADO are aligned.
Overall magnitude	*The potential magnitude on bottlenose dolphins is rated as Medium.*	*The potential magnitude on bottlenose dolphins is rated as Medium.*

Sensitivity

5.13.105 Bottlenose dolphins have been shown to be displaced from an area as a result of the noise produced by offshore construction activities; for example, avoidance behaviour in bottlenose dolphins has been shown in relation to dredging activities (Pirotta et al., 2013). In a study on bottlenose dolphins in the Moray Firth (in relation to the construction of the Nigg Energy Park in the Cromarty Firth), small effects of pile driving on dolphin presence were observed; however, dolphins were not excluded from the vicinity of the piling activities (Graham *et al.*, 2017b). In this study, the median peak-to-peak source levels recorded during impact piling were estimated to be 240 dB re 1µPa (range ±8 dB) with a single pulse source sound exposure level of 198 dB re µPa^{2}s. The pile driving resulted in a slight reduction of the presence, detection positive hours and the encounter duration for dolphins within the Cromarty Firth; however, this response was only significant for the encounter durations. Encounter durations decreased within the Cromarty Firth (though only by a few minutes) and increased outside of the Cromarty Firth on days of piling activity. These data highlight a small spatial and temporal scale disturbance to bottlenose dolphins as a result of impact piling activities.

5.13.106 According to the opinions of the experts involved in the expert elicitation for iPCoD, which represents the current best available knowledge on the topic, disturbance would be most likely to affect bottlenose dolphin calf survival, where: "*Experts felt that disturbance could affect calf survival if it exceeded 30-50 days, because it could result in mothers becoming separated from their calves and this could affect the amount of milk transferred from the mother to her calf*" (Harwood *et al.*, 2014).

5.13.107 There is the potential for behavioural disturbance and displacement to result in disruption in foraging and resting activities and an increase in travel and energetic costs. However, it has been previously shown that bottlenose dolphins have the ability to compensate for behavioural responses as a result of increased commercial vessel activity (New *et al.*, 2013). Therefore, while there remains the potential for disturbance and displacement to affect individual behaviour and therefore vital rates and population level changes, bottlenose dolphins do have some capability to adapt their behaviour and tolerate certain levels of temporary disturbance. Therefore, since bottlenose dolphins are expected to be able to adapt their behaviour, with the impact most likely to result in potential changes in calf survival (but not expected to affect adult survival or future reproductive rates) bottlenose dolphins are considered to have a **Low** sensitivity to behavioural disturbance from piling.

Table 50 Determination of sensitivity for bottlenose dolphins to disturbance from pile driving

Bottlenose dolphin	Justification
Context	**Adaptability & Tolerance:** Medium - bottlenose dolphins do have some capability to adapt their behaviour and tolerate certain levels of temporary disturbance (New *et al.*, 2013). **Recoverability:** High - evidence that disturbance effects are short-term and that dolphins return to impacted areas.
Value	Bottlenose dolphins are categorised as European Protected Species. Therefore, they have a high value.
Overall sensitivity	*The potential sensitivity of bottlenose dolphin is rated as Low.*

Common dolphin

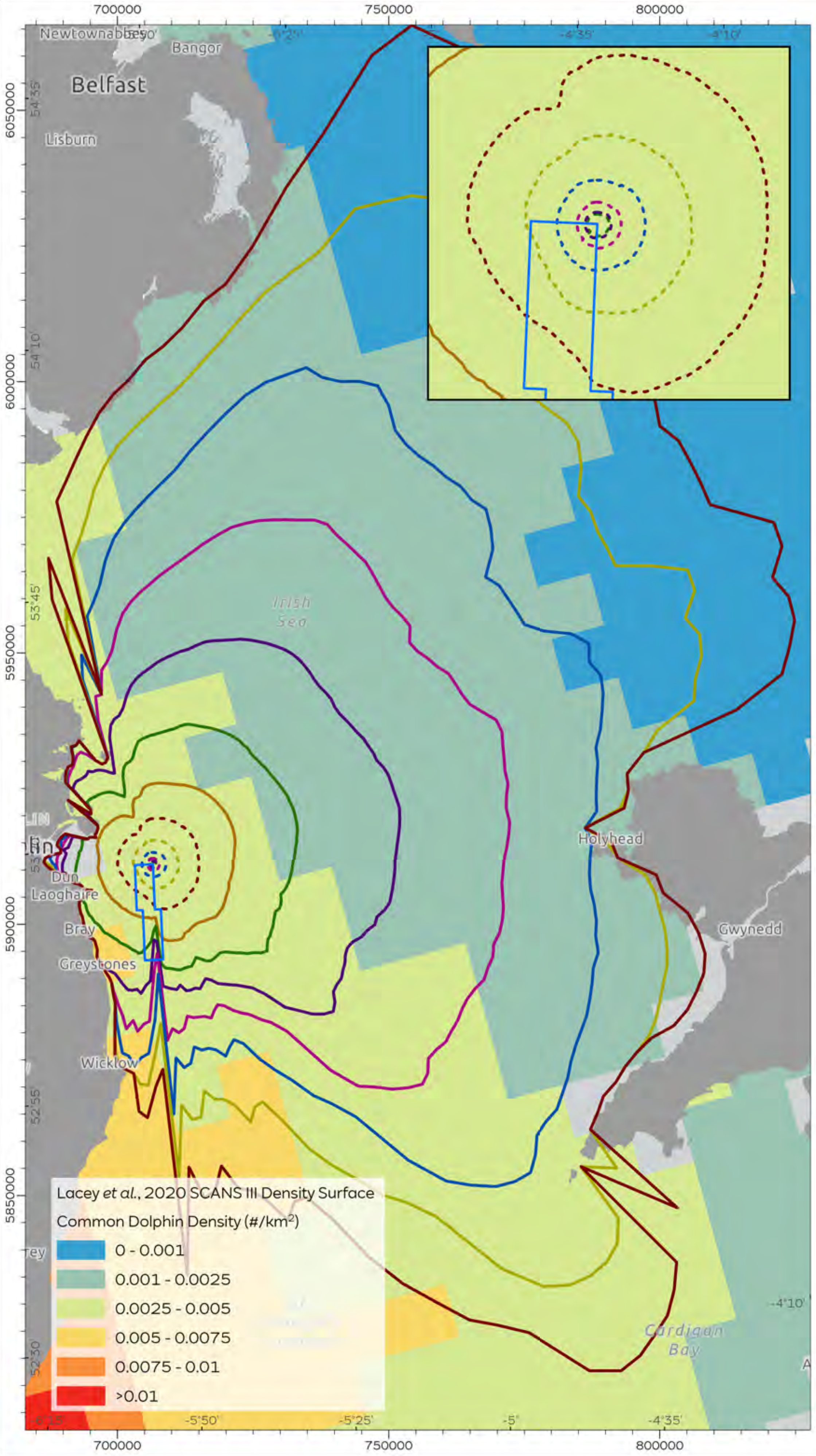
Magnitude: Dose-response

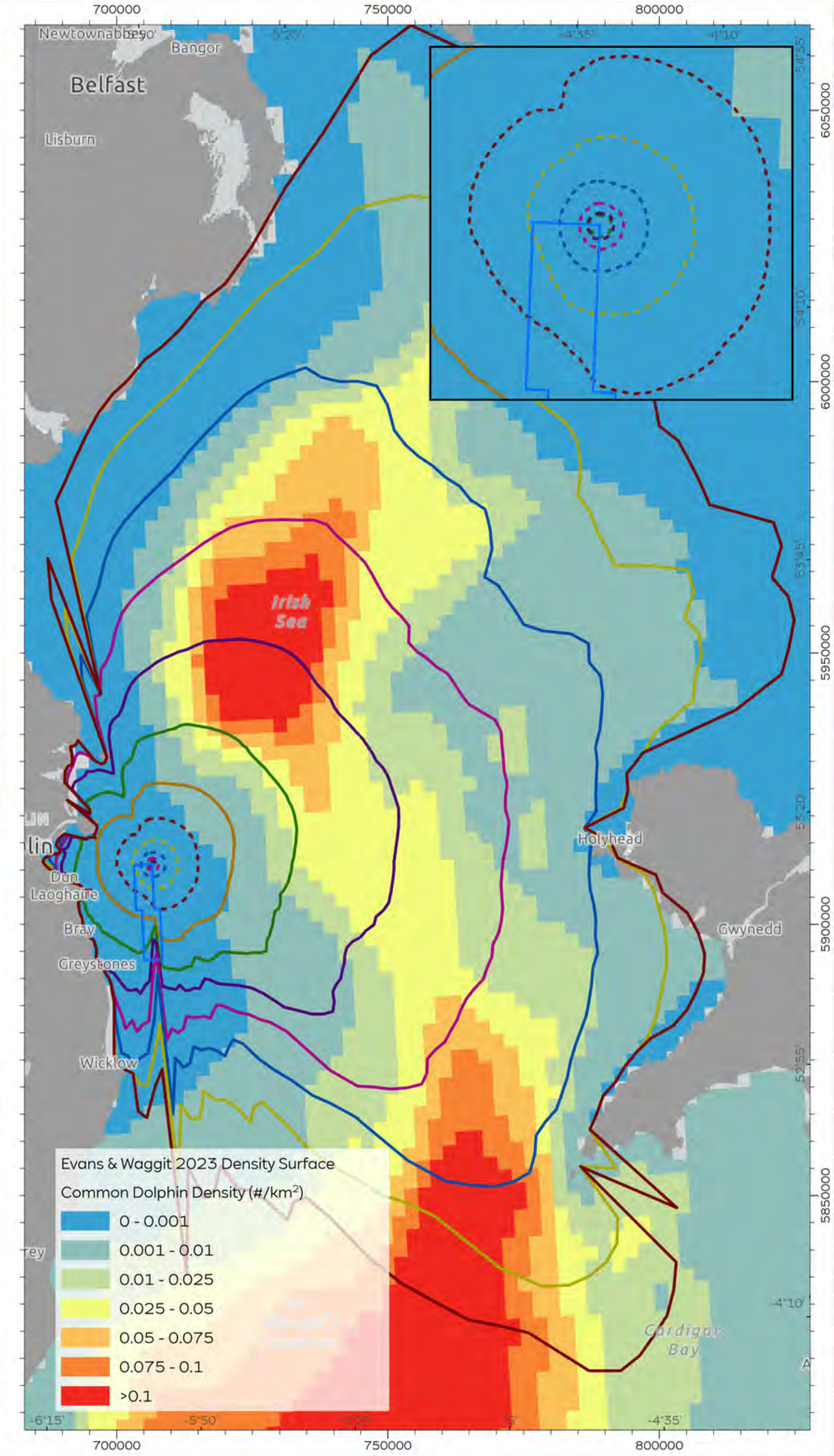
5.13.108 For common dolphins, it is predicted that a maximum of 81 dolphins (0.08% of the MU) will be disturbed for piling of a monopile at the NE location, based on a density estimate from SCANS IV (Gilles *et al.*, 2023).

5.13.109 No information is available regarding common dolphin behavioural response to disturbance from piling. As previously discussed for bottlenose dolphins, the number and proportion of common dolphin disturbed during piling were calculated based on the Graham *et al.* (2017b) dose-response curve for harbour porpoise, and is, therefore, likely to be an overestimate. Despite this conservative approach, given the number of common dolphins predicted to be impacted and the proportion of the population this represents, this impact is considered to be of Low Adverse magnitude (Table 51).

Magnitude: Level B harassment

5.13.110 For common dolphins, it is predicted that a maximum of 0.01% of the MU will be disturbed (13 individuals) for piling of a monopile at the NE location, based on a density surface from SCANS III. Given the number of common dolphins predicted to be impacted and the proportion of the population this represents, this impact is considered to be of Low Adverse magnitude (Table 51).





▭ Array Area

SELss dB re μPa2 (5dB) NE

- 120
- 125
- 130
- 135
- 140
- 145
- 150
- 155
- 160
- 165
- 170
- 175
- 180

DRAWING STATUS

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PROJECT TITLE

Dublin Array

DRAWING TITLE

Behavioural Disturbance Dose-Response Contours (5dB Increments) With Density Surface for Common Dolphin

DRAWING NUMBER: **25**

PAGE NUMBER: **1 of 1**

VER	DATE	REMARKS	DRAW	CHEK	APRD
01	2024-04-29	For Issue	GB	BB	SS

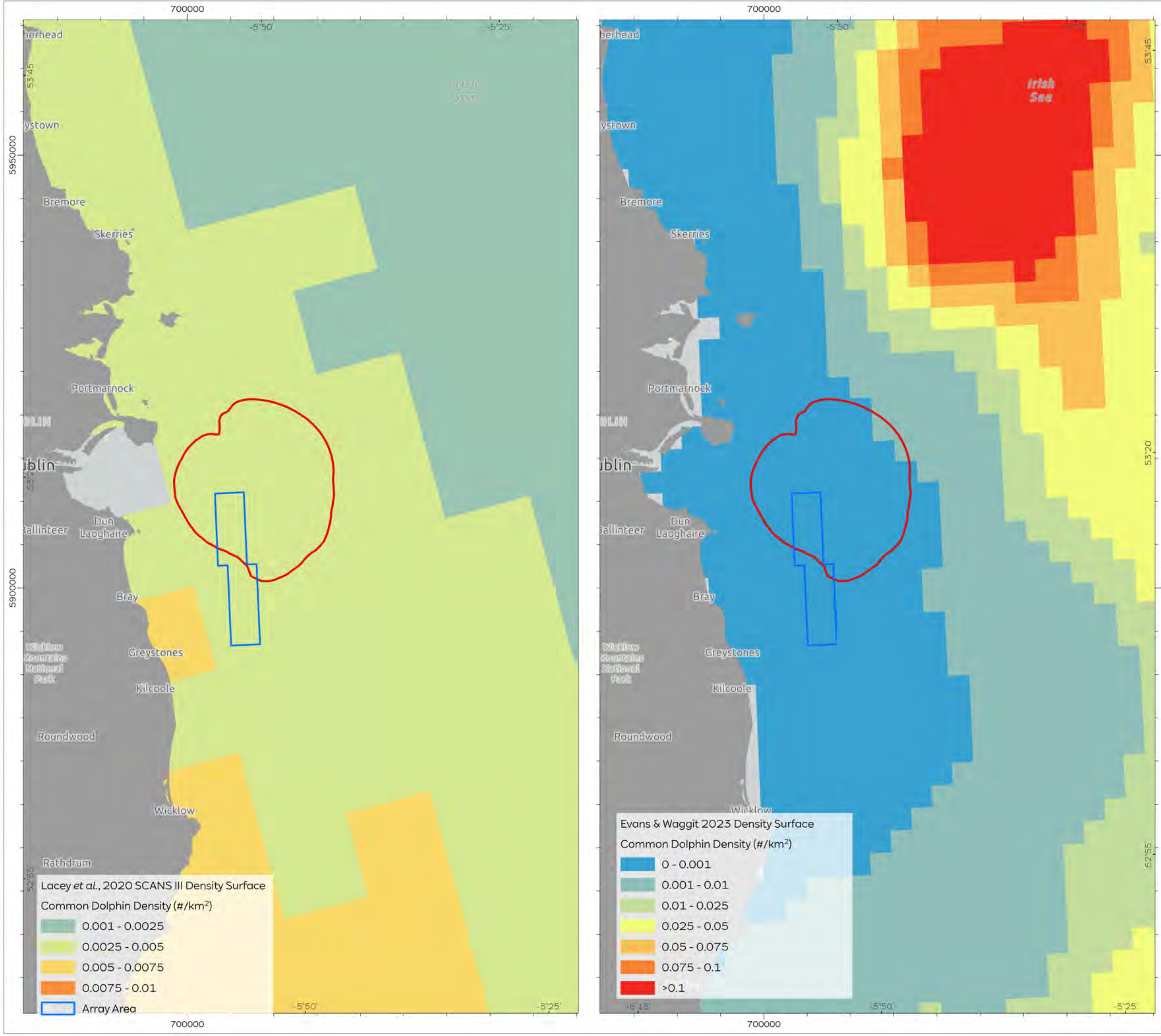
0 10 20 30 40 km
0 5 10 15 20 nm

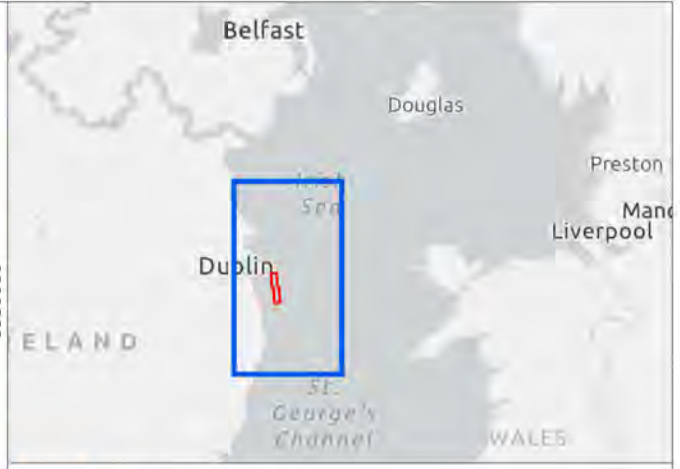
N
GRID NORTH

SCALE	1:1,015,625	PLOT SIZE	A3
DATUM	WGS 1984	VERTICAL REF	LAT
PRJ	WGS 1984 UTM Zone 29N		

GoBe
APEM Group

Dublin Array
Generation for generations
Kish Offshore Wind Limited - Bray Offshore Wind Limited





Array Area

Level B Threshold 160dB re 1 μPa (SPL_{RMS})

Lacey *et al.*, 2020 SCANS III Density Surface

Common Dolphin Density (#/km²)

- 🟩 0.001 - 0.0025
- 🟩 0.0025 - 0.005
- 🟨 0.005 - 0.0075
- 🟧 0.0075 - 0.01

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PROJECT TITLE

Dublin Array

DRAWING TITLE

Level B Threshold Contours With Density Surface for Common Dolphin

DRAWING NUMBER: **26**

PAGE NUMBER: **1 of 1**

VER	DATE	REMARKS	DRAW	CHEK	APRD
01	2024-04-29	For Issue	GB	BB	SS

0 4 8 12 16 km

0 2 4 6 8 nm

N

GRID NORTH

SCALE 1:450,000

PLOT SIZE A3

DATUM WGS 1984

VERTICAL REF LAT

PRJ WGS 1984 UTM Zone 29N

GoBe

APEM Group

DublinArray

Generation for generations

Kish Offshore Wind Limited - Bray Offshore Wind Limited

Table 51 Determination of magnitude for common dolphins for disturbance from foundation piling activity

Definition	MDO	ADO
Extent	Low - The effect is expected in a low proportion of the population (max 0.08% of the MU is expected to experience disturbance on a piling day).	The MDO and ADO are aligned.
Duration	Duration of impact would be temporary to short-term. Active piling time per monopile foundation is a maximum of 3.9 hours. Active piling time for jacket foundations is a maximum of 12 hours for 4 piles per 24 hours. Duration of the effect is Negligible-Low since evidence shows that animals return to the impacted area between one - three days after piling ceases.	The MDO and ADO are aligned.
Frequency	Low - The impact will occur frequently throughout a relevant project phase **(**57 days over four months (piling schedule S2) or 125 days over 19 months (piling schedule S9) during the proposed construction activities).	The ADO will result in less impact as fewer WTGs will be installed resulting in fewer piling days.
Probability	Medium – there are no studies which focus on the impact of disturbance from pile driving on common dolphins. It has been assumed that the probability of common dolphins to respond to pile driving is similar to that of bottlenose dolphins.	The MDO and ADO are aligned.
Consequence	Low - Unlikely to cause any long-term effect.	The MDO and ADO are aligned.
Overall magnitude	*The potential magnitude on common dolphins is rated as Low.*	*The potential magnitude on common dolphins is rated as Low.*

Sensitivity

5.13.111 The hearing range of common dolphins is currently estimated from their sound production, and has been labelled medium-high frequency, spanning between 150 Hz to 160 kHz (Finneran, 2016, Houser *et al.*, 2017). There are few studies investigating the effects of pile driving on common dolphins, which could relate to their occupation of deeper waters, contrasting the shallower habitat in which offshore construction frequently occurs. However, an analysis of pile driving activity in Broadhaven Bay, Ireland, found construction activity to be associated with a reduction in the presence of minke whales and harbour porpoise, but not with common dolphins (Culloch *et al.*, 2016). While there is little information on the impacts of pile driving on common dolphins, there are a few studies documenting the impacts of seismic activity. Although the noise produced by airguns differs in its duration and cumulative acoustic energy levels, it may be similar in its frequency range to the low-frequency noise produced by pile driving. In general, there is contrasting evidence for the response of common dolphins to seismic surveys. While some research indicates no change in the occurrence or sighting density of common dolphins when exposed to seismic activity (Stone *et al.*, 2017, Kavanagh *et al.*, 2019), Goold (1996) found a reduction in common dolphin presence within 1 km of ongoing seismic surveys near Pembrokeshire.

5.13.112 Relatively few studies document the impacts of marine construction or investigation on common dolphins, but there is some evidence of the impacts of vessel traffic and boat noise on common dolphins. While the direct impacts of vessel noise on common dolphins are rather under-researched, the presence of vessel activity has been found to alter their behavioural states and has been linked to disturbance. In New Zealand, Markov chain models were used to assess the impacts of tourism on the behaviour of common dolphins. Foraging and resting bouts were significantly disrupted by boat interactions, with less time spent in these states. In addition, post-disturbance activity indicated a shift from foraging states to milling and socialising and returns to foraging took significantly longer (Stockin *et al.*, 2008, Meissner *et al.*, 2015). While the aforementioned studies relate to short-term impacts, a long-term study of common dolphins in the waters around Ischia Island found declines that could have resulted from a combination of habitat degradation and disturbance from increasing traffic. The surrounding area has been listed as one of the noisiest in the Mediterranean due to a range of marine traffic, commercial and seismic surveys, and drilling activity (Mussi *et al.*, 2019). Conversely, some research suggests that common dolphins may be altering their communication to compensate for high levels of anthropogenic noise. It has been suggested that a difference in the frequency of whistles between two populations of common dolphins, one in the Celtic sea, and one in the English Channel, may reflect a shift in acoustic characteristics to counter masking caused by high levels of vessel traffic in the latter location (Ansmann *et al.*, 2007). Recently, for both Atlantic spotted dolphins and short-beaked common dolphins, the presence of high noise levels was associated with an increase in the maximum whistle frequency, indicating vocal compensation for potential masking in a noisy environment (Papale *et al.*, 2015).

5.13.113 The sparse information available for the impacts of construction, seismic activity and vessel noise on common dolphins make it difficult to assess the risk for this species. While there is some evidence of disturbance of animals by seismic activity, and reduced presence in increasingly noisy habitat, this species may adjust its whistle characteristics to account for masking, suggesting some flexibility or tolerance. However, given the high SPL and cumulative energy levels produced by pile driving, and our lack of understanding of the sensitivity of this species, it is considered to be precautionary to assign a **Low** sensitivity score (Table 52).

Table 52 Determination of sensitivity for common dolphins to disturbance from pile driving

Common dolphin	Justification
Context	**Adaptability:** Medium – potentially alter their communication to compensate for high levels of anthropogenic noise (Ansmann *et al.*, 2007). **Tolerance:** High – lack of displacement from construction activities (Culloch *et al.*, 2016). **Recoverability:** High – assumed to be similar to that of bottlenose dolphins.
Value	Common dolphins are categorised as European Protected Species. Therefore, they have a high value.
Overall sensitivity	*The potential sensitivity of common dolphin is rated as Low.*

Minke whale

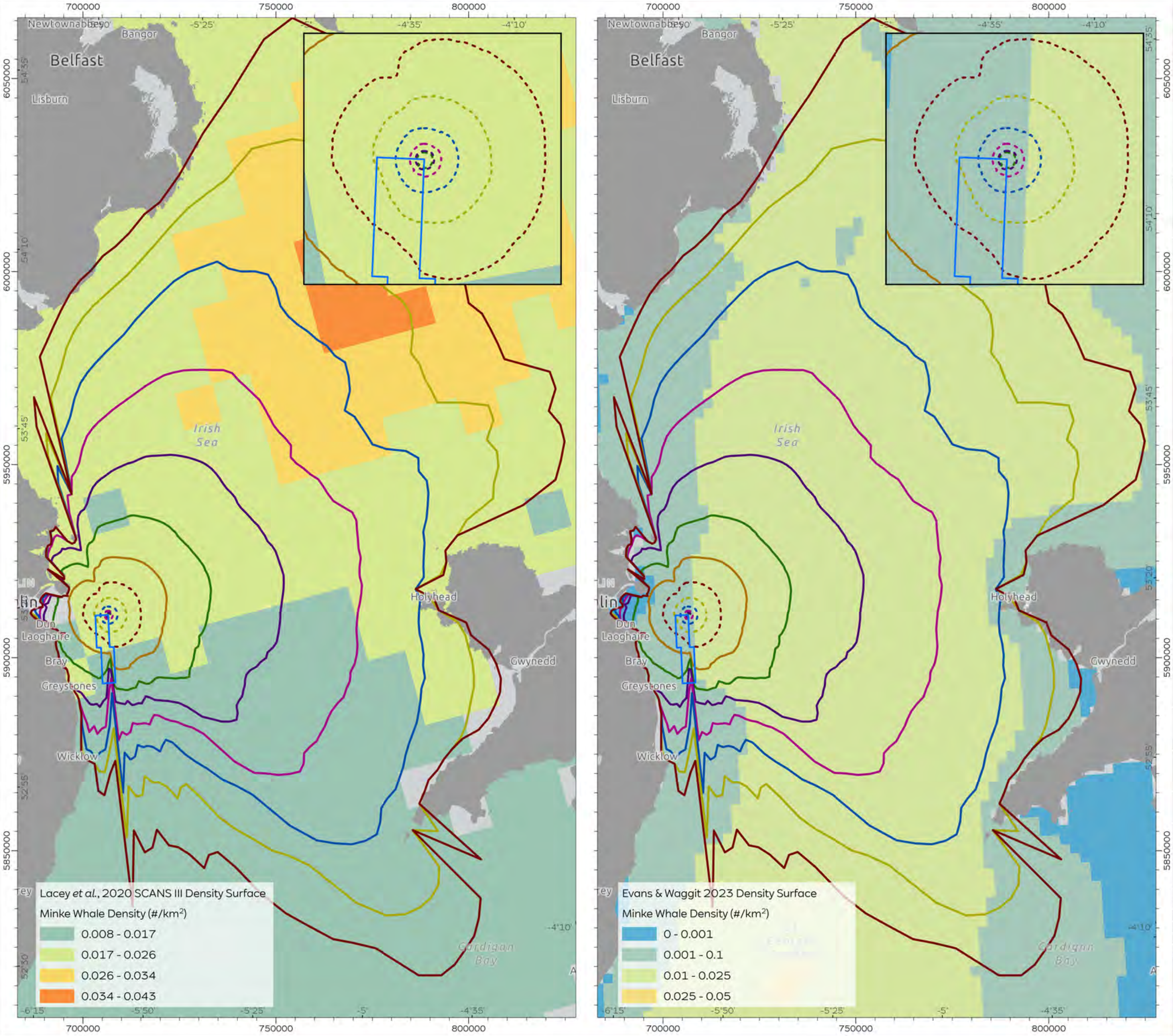
Magnitude: Dose-response

5.13.114 For a single piling event, the maximum number of minke whales predicted to be disturbed is 57 whales (0.28% MU) for piling of a monopile at the NE location.

5.13.115 It is important to note here that minke whales are expected to only be present in the spring/summer months, and therefore any pile driving activities that occur outside the summer months is expected to have no impact on minke whales as very few/none are expected to be present. Given the seasonal presence, the number of whales predicted to be impacted and the proportion of the population this represents, this impact is considered to be of Low Adverse magnitude.

Magnitude: Level B harassment

5.13.116 For a single piling event, the maximum number of minke whales predicted to be disturbed is 7 whales (0.03% MU) for piling of a monopile at the NE location. Given the seasonal presence, the number of whales predicted to be impacted and the proportion of the population this represents, this impact is considered to be of Low Adverse magnitude (Table 53).



Lacey *et al.*, 2020 SCANS III Density Surface

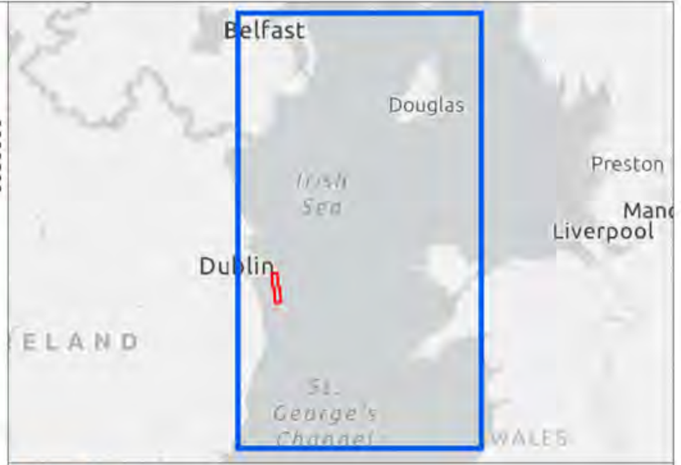
Minke Whale Density (#/km^2)

🟩	0.008 - 0.017
🟨	0.017 - 0.026
🟨	0.026 - 0.034
🟧	0.034 - 0.043

Evans & Waggit 2023 Density Surface

Minke Whale Density (#/km^2)

🟦	0 - 0.001
🟩	0.001 - 0.1
🟨	0.01 - 0.025
🟨	0.025 - 0.05



▭	Array Area

SELss dB re μPa2 (5dB) NE

—	120
—	125
—	130
—	135
—	140
—	145
—	150
- - -	155
- - -	160
- - -	165
- - -	170
- - -	175
- - -	180

DRAWING STATUS

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PROJECT TITLE

Dublin Array

DRAWING TITLE

Behavioural Disturbance Dose-Response Contours (5dB Increments) With Density Surface for Minke Whale

DRAWING NUMBER: 27

PAGE NUMBER: 1 of 1

VER	DATE	REMARKS	DRAW	CHEK	APRD
01	2024-04-29	For Issue	GB	BB	SS

0 10 20 30 40 km

0 5 10 15 20 nm

N

GRID NORTH

SCALE	1:1,015,625	PLOT SIZE	A3
DATUM	WGS 1984	VERTICAL REF	LAT
PRJ	WGS 1984 UTM Zone 29N		

GoBe

APEM Group

Dublin Array

Generation for generations

Kish Offshore Wind Limited - Bray Offshore Wind Limited

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PROJECT TITLE

Dublin Array

DRAWING TITLE

Level B Threshold Contours With Density Surface for Minke Whale

DRAWING NUMBER: 28

PAGE NUMBER: 1 of 1

VER	DATE	REMARKS	DRAW	CHEK	APRD
01	2024-04-29	For Issue	GB	BB	SS

0 4 8 12 16 km
0 2 4 6 8 nm

N

SCALE 1:450,000
PLOT SIZE A3
DATUM WGS 1984
VERTICAL REF LAT
PRJ WGS 1984 UTM Zone 29N

GoBe
APEM Group

Dublin Array
Generation for generations
Kish Offshore Wind Limited - Bray Offshore Wind Limited

Table 53 Determination of magnitude for minke whales for disturbance from foundation piling activity

Definition	MDO	ADO
Extent	Low - The effect is expected in a low proportion of the population (max 0.28% of the MU is expected to experience disturbance on a piling day).	The MDO and ADO are aligned.
Duration	Duration of impact would be temporary to short-term. Active piling time per monopile foundation is a maximum of 3.9 hours. Active piling time for jacket foundations is a maximum of 12 hours for 4 piles per 24 hours.	The MDO and ADO are aligned.
Frequency	Low - The impact will occur frequently throughout a relevant project phase **(**57 days over four months (piling schedule S2) or 125 days over 19 months (piling schedule S9) during the proposed construction activities).	The ADO will result in less impact as fewer WTGs will be installed resulting in fewer piling days.
Probability	Medium – there are no studies which focus on the impact of disturbance from pile driving on minke whales and as such, the probability of response is assumed as medium to remain precautionary.	The MDO and ADO are aligned.
Consequence	Low - Unlikely to cause any long-term effect given the low proportion of the MU predicted to be impacted and the lack of minke whales present outside of the summer months.	The MDO and ADO are aligned.
Overall magnitude	*The potential magnitude on minke whales is rated as Low.*	*The potential magnitude on minke whales is rated as Low.*

Sensitivity

5.13.117 There is little information available on the behavioural responses of minke whales to underwater noise. Minke whales have been shown to change their diving patterns and behavioural state in response to disturbance from whale watching vessels, and it was suggested that a reduction in foraging activity at feeding grounds could result in reduced reproductive success in this capital breeding species (Christiansen *et al.*, 2013b). There is only one study showing minke whale reactions to sonar signals (Sivle *et al.*, 2015) with severity scores[36] above 4 for a received SPL of 146 dB re 1 µPa (score 7) and a received SPL of 158 dB re 1 µPa (score 8). There is a study detailing minke whale responses to the Lofitech device which has a source level of 204 dB re 1 µPa @ 1 m, which showed minke whales within 500 m and 1,000 m of the source exhibiting a behavioural response. Estimated received level at 1,000 m was 136.1 dB re 1 µPa (McGarry *et al.*, 2017).

5.13.118 Since minke whales are known to forage in Irish (and UK) waters primarily in the spring/summer months, there is the potential for displacement to impact on reproductive rates. Therefore, minke whales have been assessed as having a medium sensitivity to disturbance and resulting displacement from foraging grounds. Due to their large size and capacity for energy storage, it is expected that minke whales will be able to tolerate temporary displacement from foraging areas much better than harbour porpoise. However, given the lack of empirical data on minke whale responses to pile driving, it is considered to be more precautionary to assign a **Low** sensitivity score to consequences of displacement (Table 54).

Table 54 Determination of sensitivity for minke whales to disturbance from pile driving

Minke whales	Justification
Context	**Adaptability & Tolerance:** Due to their large size and capacity for energy storage, it is expected that minke whales will be able to tolerate temporary displacement from foraging areas. **Recoverability:** unknown
Value	Minke whales are categorised as European Protected Species. Therefore, they have a high value.
Overall sensitivity	*The potential sensitivity of minke whales is rated as Low.*

---

[36] Severity scores refer to the level of response of an individual i.e., severity scores of 1 mean an individual may exhibit brief changes in orientation as a result of noise exposure, severity scores of 5 may result in individuals sustaining prolonged changes in directional movement, and severity scores of 8 may mean individuals become separated from their dependents (Sivle et al., 2015, Southall et al., 2021)

Harbour Seals

Magnitude

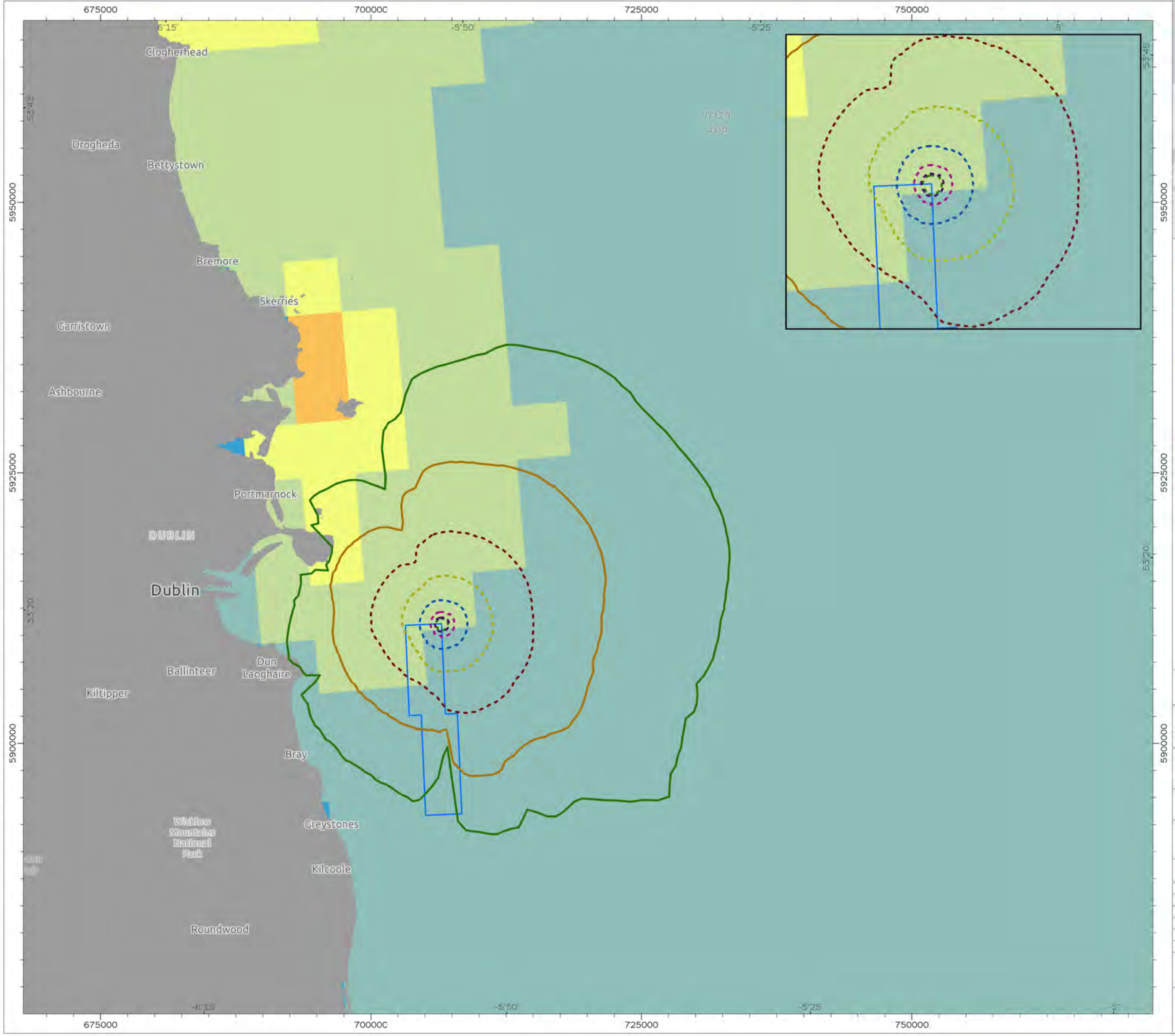
5.13.119 Harbour seals were assessed within the East RoI and Northern Ireland MU and had a low predicted number of disturbed individuals. For a single piling event, the maximum number of harbour seals predicted to be impacted is 13 seals (0.95% MU) for the piling of a monopile at the NE location, or 12 seals (0.88% MU) for piling of a pinpile at the NE location.

5.13.120 To determine the magnitude of this impact on a population level, iPCoD modelling was conducted. The iPCoD modelling assumed the following:

- Piling scenario S2: 57 piling days impacting 13 harbour seals per day (monopiles); and
- Piling scenario S9: 125 piling days impacting 12 harbour seals per day (pinpiles)

5.13.121 The iPCoD results show that the level of disturbance is not sufficient to result in any change at the population level, since the impacted population is predicted to remain the same size and on the same stable trajectory as the unimpacted population (monopile: Figure 30 and Table 55, pinpile: Figure 31 and Table 56).

5.13.122 Given the number of harbour seals predicted to be impacted and the proportion of the population this represents, coupled with the results of the population modelling, this impact is considered to be of Low Adverse magnitude (Table 57).



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PROJECT TITLE

Dublin Array

DRAWING TITLE

Behavioural Disturbance Dose-Response Contours (5dB Increments) With Density Surface for Harbour Seal

DRAWING NUMBER: 29

PAGE NUMBER: 1 of 1

VER	DATE	REMARKS	DRAW	CHEK	APRD
01	2024-04-24	For Issue	GB	BB	SS

0 3 6 9 12 km
0 1.5 3 4.5 6 nm

N

SCALE 1:360,000
PLOT SIZE A3
DATUM WGS 1984
VERTICAL REF LAT
PRJ WGS 1984 UTM Zone 29N

GoBe
APEM Group

Dublin Array
Generation for generations
Kish Offshore Wind Limited - Bray Offshore Wind Limited

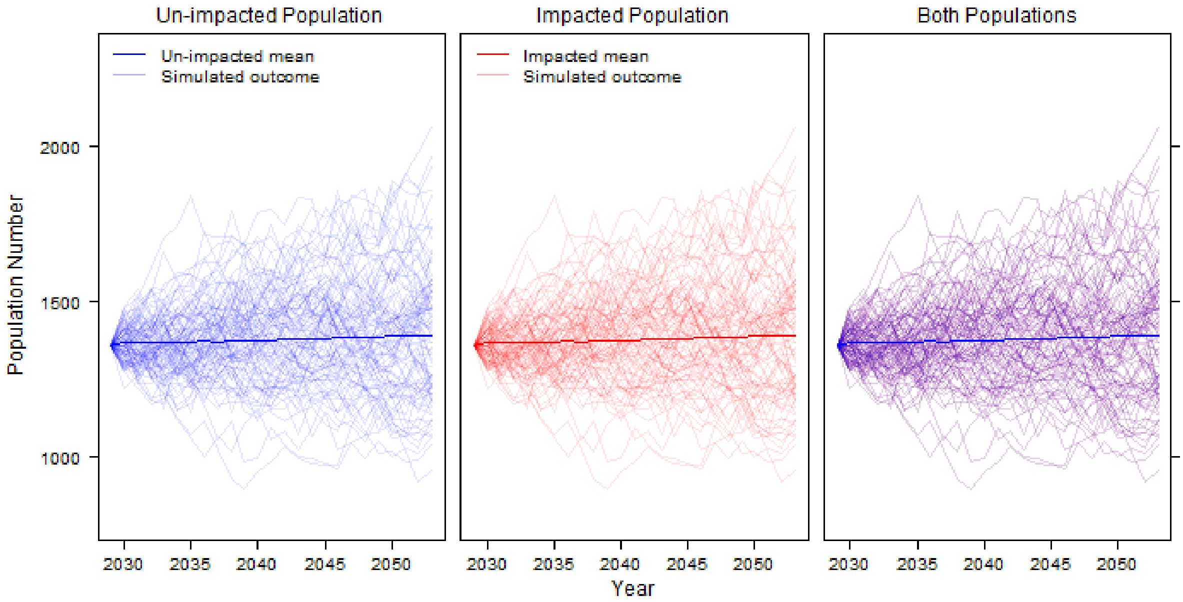


Figure 30 Predicted population trajectories for the unimpacted (baseline) and impacted harbour seal iPCoD simulations for monopiles (57 days piling in one year), impacting 13 harbour seals per day.

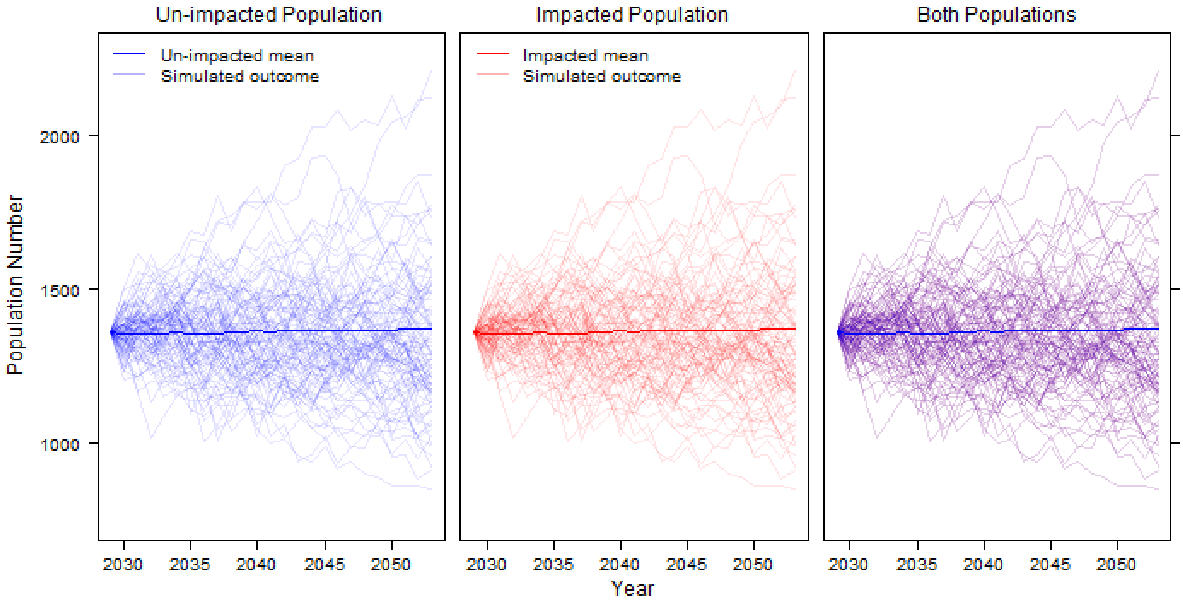


Figure 31 Predicted population trajectories for the unimpacted (baseline) and impacted harbour seal iPCoD simulations for pinpiles (125 days piling over 3 years), impacting 12 harbour seals per day.

Table 55 Predicted mean population size for the unimpacted (baseline) and impacted harbour seal iPCoD simulations for monopiles (57 days piling in one year), impacting 13 harbour seals per day.

	Unimpacted population mean size	Impacted population mean size	Impacted as a proportion of unimpacted
Start (before piling commences)	1,360	1,360	100%
End (after piling ends)	1,367	1,367	100%
6 years after piling ends	1,367	1,367	100%
12 years after piling ends	1,375	1,375	100%
18 years after piling ends	1,385	1,385	100%

Table 56 Predicted mean population size for the un-impacted (baseline) and impacted harbour seal iPCoD simulations for pinpiles (125 days piling over 3 years), impacting 12 harbour seals per day.

	Unimpacted population mean size	Impacted population mean size	Impacted as a proportion of unimpacted
Start year 1 (before piling commences)	1,360	1,360	100%
End year 3 (after piling ends)	1,358	1,358	100%
six years after piling ends	1,358	1,358	100%
12 years after piling ends	1,363	1,363	100%
18 years after piling ends	1,369	1,369	100%

Table 57 Determination of magnitude for harbour seals for disturbance from foundation piling activity

Definition	MDO	ADO
Extent	Low - The effect is expected in a low proportion of the population (max 0.95% of the MU is expected to experience disturbance on a piling day).	The MDO and ADO are aligned.
Duration	Duration of impact would be temporary to short-term. Active piling time per monopile foundation is a maximum of 3.9 hours. Active piling time for jacket foundations is a maximum of 12 hours for 4 piles per 24 hours. Duration of the effect is Negligible since evidence shows that harbour seals return to the impacted area within two hours of piling ceasing (Russell *et al.*, 2016a).	The MDO and ADO are aligned.
Frequency	Low - The impact will occur frequently throughout a relevant project phase **(**57 days over four months (piling schedule S2) or 125 days over 19 months (piling schedule S9) during the proposed construction activities).	The ADO will result in less impact as fewer WTGs will be installed resulting in fewer piling days.
Probability	High – studies show that harbour seals do respond to pile driving (Russell *et al.*, 2016a, Whyte *et al.*, 2020b).	The MDO and ADO are aligned.
Consequence	Low - Unlikely to cause any population effect (as shown by iPCoD modelling)	The MDO and ADO are aligned.
Overall magnitude	*The potential magnitude on harbour seals is rated as Low.*	*The potential magnitude on harbour seals is rated as Low.*

Sensitivity

5.13.123 A study of tagged harbour seals in the Wash (Norfolk, England) which took place at the same time as piling at the Lincs wind farm, has shown that they are displaced from the vicinity of piles during pile-driving activities. Russell *et al*. (2016) showed that seal abundance was significantly reduced within an area with a radius of 25 km from a pile, during piling activities, with a 19 to 83% decline in abundance during pile-driving compared to during breaks in piling. The duration of the displacement was only in the short-term as seals returned to non-piling distributions within two hours after the end of a pile-driving event. Unlike harbour porpoise, both harbour and grey seals store energy in a thick layer of blubber, which means that they are more tolerant of periods of fasting when hauled out and resting between foraging trips, and when hauled out during the breeding and moulting periods. Therefore, they are unlikely to be particularly sensitive to short-term displacement from foraging grounds during periods of active piling.

5.13.124 At an expert elicitation workshop in 2018 (Booth *et al.*, 2019), experts agreed the most likely potential consequences of a six-hour period of zero energy intake, assuming that disturbance (from exposure to low frequency broadband pulsed noise e.g. pile-driving) resulted in missed foraging opportunities. In general, it was agreed that harbour seals were considered to have a reasonable ability to compensate for lost foraging opportunities due to their generalist diet, mobility, life history and adequate fat stores. The survival of 'weaned of the year' animals[37] and fertility were determined to be the most sensitive life history parameters to disturbance (i.e. leading to reduced energy intake). Juvenile harbour seals are typically considered to be coastal foragers (Booth *et al.*, 2019) and so less likely to be exposed to disturbances and similarly pups were thought to be unlikely to be exposed to disturbance due to their proximity to land. Unlike for harbour porpoise, there was no DEB model available to simulate the effects of disturbance on seal energy intake and reserves, therefore the opinions of the experts were less certain. Experts considered that the location of the disturbance would influence the effect of the disturbance, with a greater effect if animals were disturbed at a foraging ground as opposed to when animals were transiting through an area. It was thought that for an animal in bad condition, moderate levels of repeated disturbance might be sufficient to reduce fertility (Figure 32 left), however there was a large amount of uncertainty in this estimate, with opinions ranging between <50 days and >300 days. The 'weaned of the year' were considered to be most vulnerable following the post-weaning fast, and that during this time, experts felt it might take ~60 days of repeated disturbance before there was expected to be any effect on the probability of survival (Figure 32 right), however again, there was a lot of uncertainty surrounding this estimate with estimates ranging between <50 days and >200 days. Similar to the above, it is considered unlikely that individual harbour seals would repeatedly return to a site where they'd been previously displaced from in order to experience this number of days of repeated disturbance.

5.13.125 Due to observed responsiveness to piling, harbour seals have been assessed as having **Low** sensitivity to disturbance and resulting displacement from foraging grounds during pile-driving events (Table 58).

---

[37] Young pups that have recently weaned off their mothers milk, that are presumed to be lacking independent foraging experience

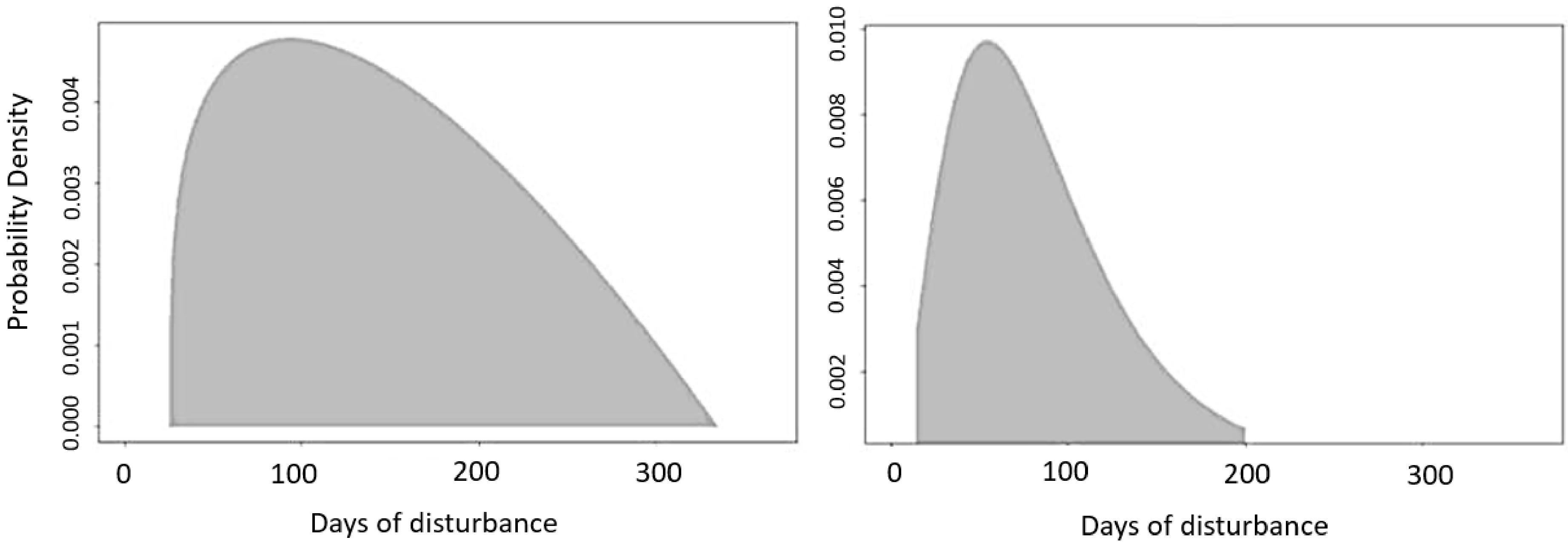


Figure 32 Probability distributions showing the consensus of the expert elicitation for harbour seal disturbance from piling (Booth *et al*., 2019). Left: the number of days of disturbance (i.e. days on which an animal does not feed for six hours) a pregnant female could 'tolerate' before it has any effect on fertility. Right: the number of days of disturbance (of six hours zero energy intake) a 'weaned of the year' harbour seal could 'tolerate' before it has any effect on survival.

Table 58 Determination of sensitivity for harbour seals to disturbance from pile driving

Minke whales	Justification
Context	**Adaptability:** Medium - reasonable ability to compensate for lost foraging opportunities due to their generalist diet, mobility, life history and adequate fat stores. **Tolerance:** High - Blubber stores provide tolerance of periods of fasting when hauled out and resting between foraging trips, and when hauled out during the breeding and moulting periods. **Recoverability:** High - displacement is short-term as seals return to non-piling distributions within two hours after the end of a pile-driving event.
Value	Seals are categorised as Annex II species of Community Interest. Therefore, they have a high value.
Overall sensitivity	*The potential sensitivity of harbour seals is rated as Low.*

Grey seals

Magnitude

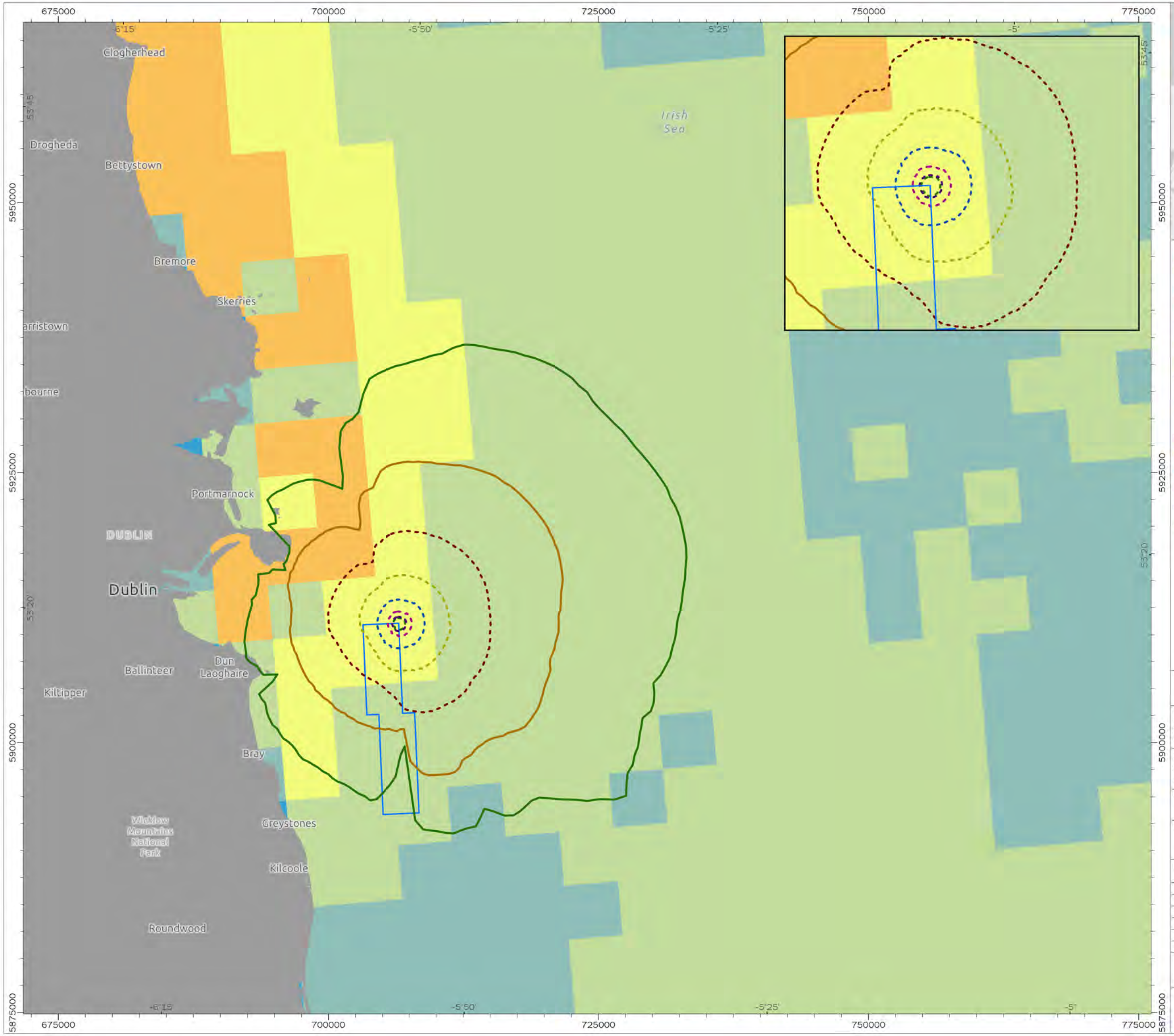
5.13.126 For a single piling event, the maximum number of grey seals predicted to be impacted is 177 seals equating to 2.92% MU, for the piling of a monopile at the NE location, or 163 seals (2.69% MU) for piling of a pinpile at the NE location.

5.13.127 To determine the magnitude of this impact on a population level, iPCoD modelling was conducted. The iPCoD modelling assumed the following:

- Piling scenario S2: 57 piling days impacting 177 grey seals per day (monopiles); and
- Piling scenario S9: 125 piling days impacting 163 grey seals per day (pinpiles)

5.13.128 The iPCoD results show that the level of disturbance is not sufficient to result in any change at the population level, since the impacted population is predicted to remain the same size and on the same increasing trajectory as the unimpacted population (monopile: Figure 34 and Table 59, pinpile: Figure 35 and Table 60).

5.13.129 Given the number of grey seals predicted to be impacted and the proportion of the population this represents, coupled with the results of the population modelling, this impact is considered to be of Low Adverse magnitude (Table 61).



☐	Array Area

% At-Sea Population per Cell

🟦	0
▨	0 - 0.001
🟩	0.001 - 0.005
🟨	0.005 - 0.01
🟧	0.01 - 0.025

SELss dB re µPa2 (5dB) NE Location

—	145
—	150
- - -	155
- - -	160
- - -	165
- - -	170
- - -	175
- - -	180

DRAWING STATUS

FINAL

DISCLAIMER

MAP NOTES / DATA SOURCES:

Esri UK, Esri, TomTom, Garmin, Foursquare, FAO, METI/NASA, USGS, Esri UK, Esri, TomTom, Garmin, FAO, NOAA, USGS, Esri UK, Esri, TomTom, Garmin, Foursquare, METI/NASA, USGS ©Ordnance Survey Ireland 2023 © Tailte Eireann. (CYSL50270365) Not to be used for Navigation.

PROJECT TITLE

Dublin Array

DRAWING TITLE

Behavioural Disturbance Dose-Response Contours (5dB Increments) With Density Surface for Grey Seal

DRAWING NUMBER: **33**

PAGE NUMBER: **1 of 1**

VER	DATE	REMARKS	DRAW	CHEK	APRD
01	2024-04-24	For Issue	GB	BB	SS

0 3 6 9 12 km
0 1.5 3 4.5 6 nm

N

SCALE	1:360,000	PLOT SIZE	A3
DATUM	WGS 1984	VERTICAL REF	LAT
PRJ	WGS 1984 UTM Zone 29N		

GoBe
APEM Group

Dublin Array
Generation for generations
Kish Offshore Wind Limited - Bray Offshore Wind Limited

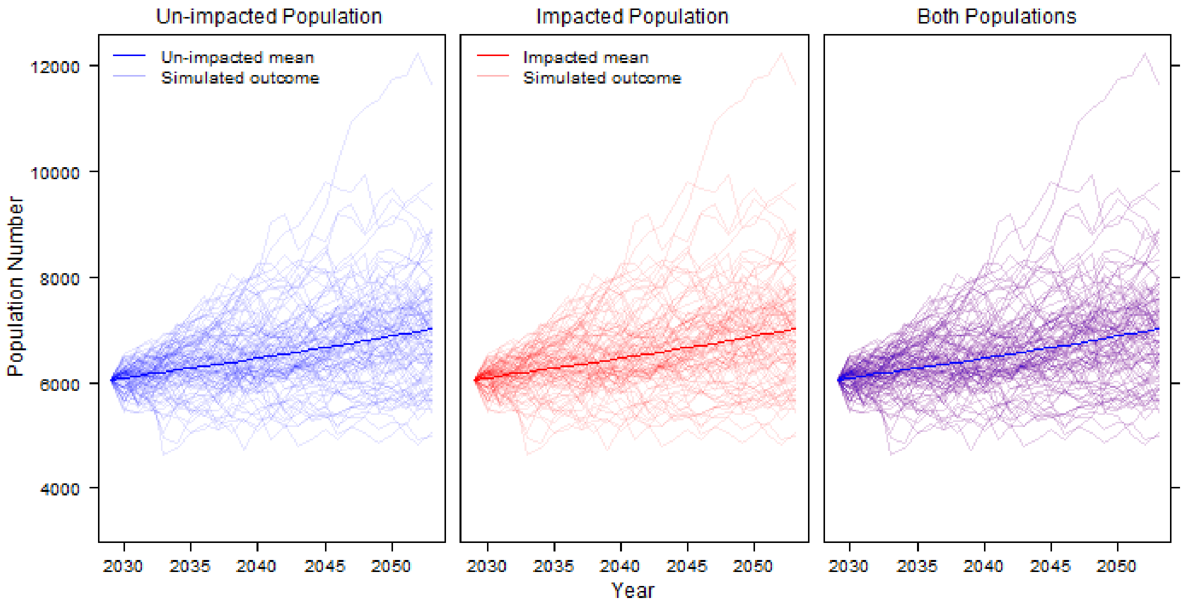


Figure 34 Predicted population trajectories for the unimpacted (baseline) and impacted grey seal iPCoD simulations for monopiles (57 days piling in one year), impacting 177 grey seals per day.

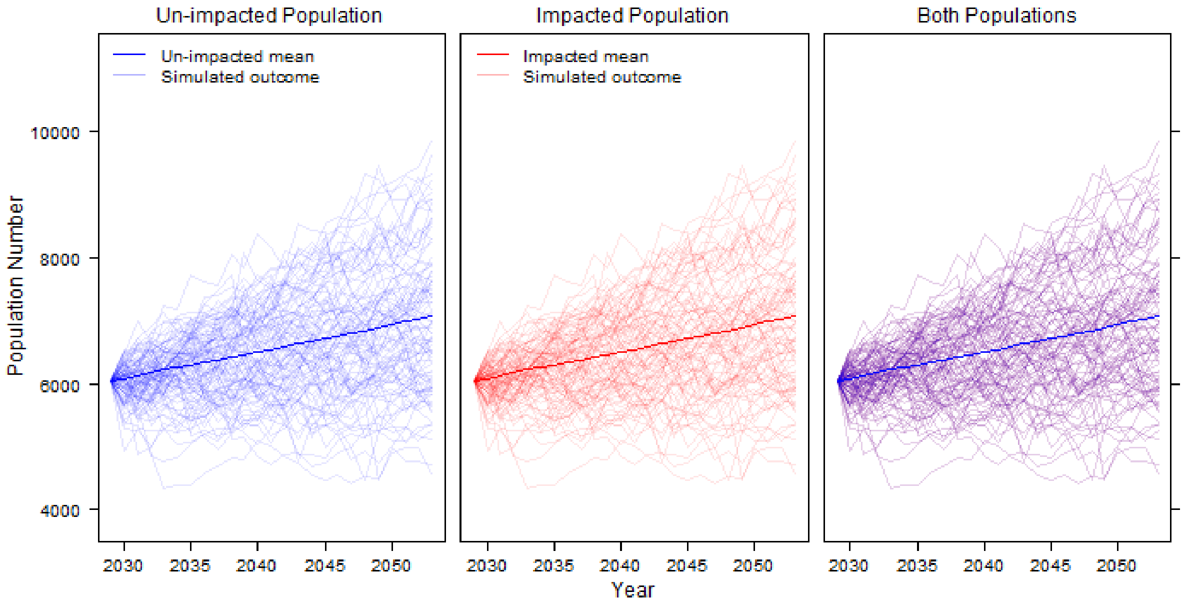


Figure 35 Predicted population trajectories for the unimpacted (baseline) and impacted grey seal iPCoD simulations for pinpiles (125 days piling over 3 years), impacting 163 grey seals per day.

Table 59 Predicted mean population size for the unimpacted (baseline) and impacted grey seal iPCoD simulations for monopiles (57 days piling in one year), impacting 177 grey seals per day.

	Unimpacted population mean size	Impacted population mean size	Impacted as a proportion of unimpacted
Start (before piling commences)	6,054	6,054	100%
End (after piling ends)	6,089	6,089	100%
6 years after piling ends	6,277	6,277	100%
12 years after piling ends	6,495	6,495	100%
18 years after piling ends	6,738	6,738	100%

Table 60 Predicted mean population size for the un-impacted (baseline) and impacted grey seal iPCoD simulations for pinpiles (125 days piling over 3 years), impacting 163 grey seals per day.

	Unimpacted population mean size	Impacted population mean size	Impacted as a proportion of unimpacted
Start year 1 (before piling commences)	6,054	6,054	100%
End year 3 (after piling ends)	6,076	6,076	100%
Six years after piling ends	6,297	6,297	100%
12 years after piling ends	6,530	6,530	100%
18 years after piling ends	6,791	6,791	100%

Table 61 Determination of magnitude for grey seals for disturbance from foundation piling activity

Definition	MDO	ADO
Extent	Low - The effect is expected in a low proportion of the population (max 2.92% of the MU is expected to experience disturbance on a piling day).	The MDO and ADO are aligned.
Duration	Duration of impact would be temporary to short-term. Active piling time per monopile foundation is a maximum of 3.9 hours. Active piling time for jacket foundations is a maximum of 12 hours for 4 piles per 24 hours. Duration of the effect is Negligible since evidence shows that seals (harbour as a proxy) return to the impacted area within two hours of piling ceasing (Russell *et al.*, 2016a).	The MDO and ADO are aligned.
Frequency	Low - The impact will occur frequently throughout a relevant project phase **(**57 days over four months (piling schedule S2) or 125 days over 19 months (piling schedule S9) during the proposed construction activities).	The ADO will result in less impact as fewer WTGs will be installed resulting in fewer piling days.
Probability	Medium – grey seals have shown high inter-individual variation in response to piling (Aarts *et al.*, 2018).	The MDO and ADO are aligned.
Consequence	Low - Unlikely to cause any population effect (as shown by iPCoD modelling).	The MDO and ADO are aligned.
Overall magnitude	*The potential magnitude on grey seals is rated as Low.*	*The potential magnitude on grey seals is rated as Low.*

Sensitivity

5.13.130 There are still limited data on grey seal behavioural responses to pile driving. The key dataset on this topic is presented in Aarts *et al.* (2018) where 20 grey seals were tagged in the Wadden Sea to record their responses to pile driving at two offshore wind farms: Luchterduinen in 2014 and Gemini in 2015. The grey seals showed varying responses to the pile driving, including no response, altered surfacing and diving behaviour, and changes in swimming direction. The most common reaction was a decline in descent speed and a reduction in bottom time, which suggests a change in behaviour from foraging to horizontal movement. The distances at which seals responded varied significantly; in one instance a grey seal showed responses at 45 km from the pile location, while other grey seals showed no response when within 12 km. Differences in responses could be attributed to differences in hearing sensitivity between individuals, differences in sound transmission with environmental conditions or the behaviour and motivation for the seal to be in the area. Telemetry data also showed that seals returned to the pile driving area ~ 2 hours after pile driving ceased (Russell *et al.*, 2016a).

5.13.131 The expert elicitation workshop in 2018 (Booth *et al.*, 2019) concluded that grey seals were considered to have a reasonable ability to compensate for lost foraging opportunities due to their generalist diet, mobility, life history and adequate fat stores and that the survival of 'weaned of the year' animals and fertility were determined to be most sensitive parameters to disturbance (i.e. reduced energy intake). However, in general, experts agreed that grey seals would be much more robust than harbour seals to the effects of disturbance due to their larger energy stores and more generalist and adaptable foraging strategies. It was agreed that grey seals would require moderate-high levels of repeated disturbance before there was any effect on fertility rates to reduce fertility (Figure 36 - left). The 'weaned of the year' were considered to be most vulnerable following the post-weaning fast, and that during this time it might take ~60 days of repeated disturbance before there was expected to be any effect on weaned-of-the-year survival (Figure 36 right), however there was a lot of uncertainty surrounding this estimate.

5.13.132 Grey seals are capital breeders[38] and store energy in a thick layer of blubber, which means that, in combination with their large body size, they are tolerant of periods of fasting as part of their normal life history. Grey seals are also highly adaptable to a changing environment and are capable of adjusting their metabolic rate and foraging tactics, to compensate for different periods of energy demand and supply (Beck *et al.*, 2003, Sparling *et al.*, 2006). Grey seals are also very wide ranging and are capable of moving large distances between different haul out and foraging regions (Russell *et al.*, 2013). Therefore, they are unlikely to be particularly sensitive to displacement from foraging grounds during periods of active piling.

5.13.133 Due to observed responsiveness to piling, and their life-history characteristics, grey seals have been assessed as having **Negligible** sensitivity to disturbance and resulting displacement from foraging grounds during pile-driving events (Table 62).

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[38] Capital breeders use stored reserves (capital) to resource reproduction.

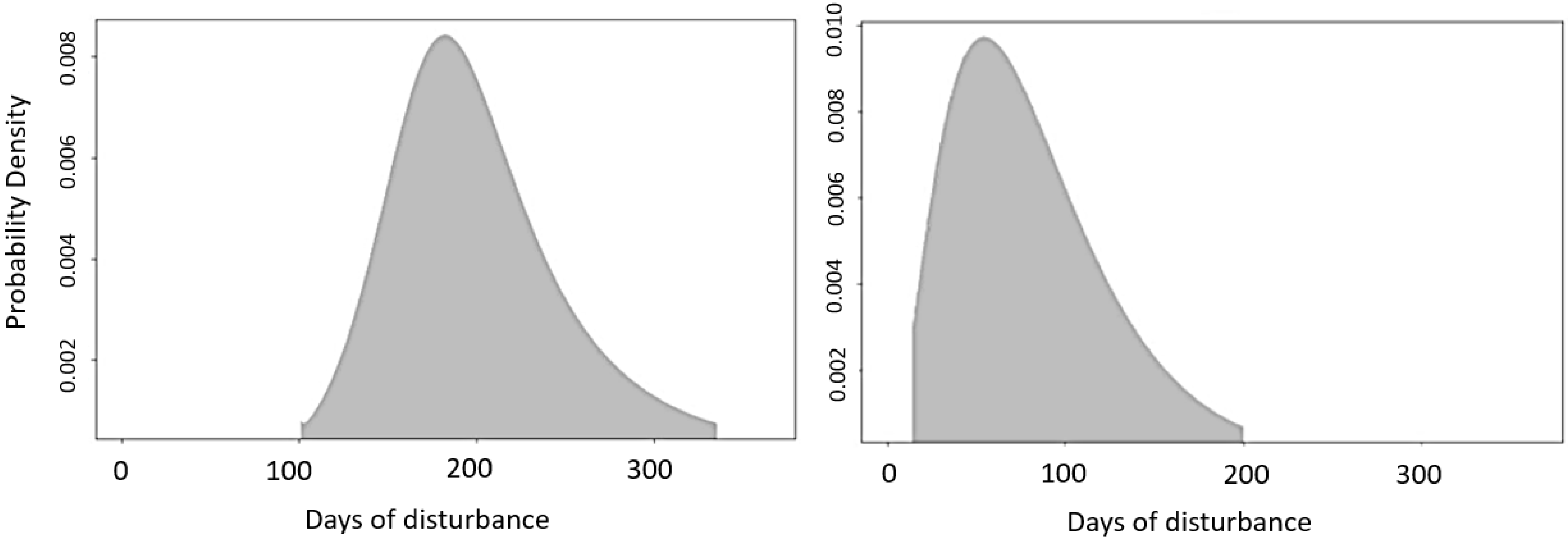

Figure 36 Probability distributions showing the consensus of the expert elicitation for grey seal disturbance from piling (Booth *et al*., 2019).[39]

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[39] Left: the number of days of disturbance (i.e. days on which an animal does not feed for six hours) a pregnant female could 'tolerate' before it has any effect on fertility. Right: the number of days of disturbance (of six hours zero energy intake) a 'weaned of the year' grey seal could 'tolerate' before it has any effect on survival.

Table 62 Determination of sensitivity for grey seals to disturbance from pile driving

Minke whales	Justification
Context	**Adaptability:** High - highly adaptable to a changing environment and are capable of adjusting their metabolic rate and foraging tactics, to compensate for different periods of energy demand and supply. **Tolerance:** High - tolerant of periods of fasting as part of their normal life history. **Recoverability:** High – assumed to be similar to harbour seals where displacement is short-term as seals return to non-piling distributions within two hours after the end of a pile-driving event.
Value	Seals are categorised as Annex II species of Community Interest. Therefore, they have a high value.
Overall sensitivity	*The potential sensitivity of grey seals is rated as Negligible.*

Summary

5.13.134 The maximum magnitude of the impact has been assessed as **Medium adverse**, with the maximum sensitivity of the receptors being **Low**. Therefore, the significance of effect from behavioural displacement and disturbance from pile driving is **Slight adverse** at most for all marine mammals except grey seal, which is not significant in EIA terms. For grey seals, the significance of effect from behavioural displacement and disturbance from pile driving is **Imperceptible** at most.

5.13.135 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Table 63 Summary of the marine mammal assessment for disturbance from pile driving. ǂ denotes where iPCoD modelling was used to inform the magnitude assessment.

Species	Magnitude (max % MU from single piling event)	Sensitivity	Impact Significance
Harbour porpoise	Low (1.59%)ǂ	Low	Slight adverse
Bottlenose dolphin	Medium (8.40%) ǂ	Low	Slight adverse
Common dolphin	Low (0.07%)	Low	Slight adverse
Minke whale	Low (0.28%)	Low	Slight adverse
Harbour seal	Low (0.95%) ǂ	Low	Slight adverse
Grey seal	Low (2.92%) ǂ	Negligible	Imperceptible

Residual effect assessment

The significance of effect from behavioural displacement and disturbance from pile driving is not significant in EIA terms for any marine mammal species. Therefore, no additional mitigation to that already identified in Table 13 are considered necessary. Therefore, ***no significant adverse residual effects*** *have been predicted in respect of marine mammals.*

Impact 7: Other construction activities

5.13.136 While impact piling will be the loudest noise source during the construction phase, there will also be several other construction activities that will produce underwater noise. These include dredging, drilling, cable laying, rock placement and trenching, as well as noise generated by the presence of construction vessels.

Cable laying, dredging, drilling, trenching, rock placement

Auditory injury – marine mammal sensitivity

5.13.137 Dredging is described as a continuous broadband sound source, with the main energy below 1 kHz; however, the frequency and sound pressure level can vary considerably depending on the equipment, activity, and environmental characteristics (Todd *et al.*, 2015). Dredging will likely be required for seabed preparation work for foundations as well as for export cable and inter array cable installation. The source level of dredging has been described to vary between SPL 172-190 dB re 1 µPa @ 1 m with a frequency range of 45 Hz to 7 kHz (Evans, 1990, Thompson *et al.*, 2009, Verboom, 2014). It is expected that the underwater noise generated by dredging will be below the PTS-onset threshold (Todd *et al.*, 2015) and thus the risk of injury is unlikely, though disturbance may occur. For harbour porpoise, dolphins and seals, the hearing sensitivity below 1 kHz is relatively poor and thus it is expected that a PTS at this frequency would result in little impact to vital rates. Therefore, the sensitivity of harbour porpoise, dolphins and seals to PTS from dredging is assessed as **Low**.

5.13.138 The low frequency noise produced during dredging may be more likely to overlap with the hearing range of low frequency cetacean species such as minke whales. Minke whale communication signals have been demonstrated to be below 2 kHz (Edds-Walton, 2000, Mellinger *et al.*, 2000, Gedamke *et al.*, 2001, Risch *et al.*, 2013, Risch *et al.*, 2014). Tubelli *et al.* (2012) estimated the most sensitive hearing range (the region with thresholds within 40 dB of best sensitivity) to extend from 30 to 100 Hz up to 7.5 to 25 kHz, depending on the specific model used. Therefore, the sensitivity of minke whales to PTS from dredging is precautionarily assessed as **Medium**.

5.13.139 The continuous sound produced by drilling has been likened to that produced by potential dredging activity; low frequency noise caused by rotating machinery (Greene, 1987). Recordings of drilling at the North Hoyle Offshore Wind Farm suggest that the sound produced has a fundamental frequency at 125 Hz (Nedwell *et al.*, 2003). For harbour porpoise, dolphins and seals, the hearing sensitivity below 1 kHz is relatively poor and thus it is expected that a PTS at these low frequency ranges would result in little impact to vital rates. Therefore, the sensitivity of harbour porpoise, dolphins and seals to PTS from drilling noise is assessed as **Low**. The low frequency noise produced during cable laying may be more likely to overlap with the hearing range of low frequency cetacean species such as minke whale. Therefore, the sensitivity of minke whales to PTS from drilling is precautionarily assessed as **Medium**.

5.13.140 Underwater noise generated during cable installation is generally considered to have a low potential for impacts to marine mammals due to the non-impulsive nature of the noise generated and the fact that any generated noise is likely to be dominated by the vessel from which installation is taking place (Genesis, 2011). OSPAR (2009) summarise general characteristics of commercial vessel noise. Vessel noise is continuous, and is dominated by sounds from propellers, thrusters and various rotating machinery (e.g., power generation, pumps). In general, support and supply vessels (50-100 m) are expected to have broadband source levels in the range 165-180 dB re 1µPa, with the majority of energy below 1 kHz (OSPAR, 2009). Large commercial vessels (>100 m) produce relatively loud and predominately low frequency sounds, with the strongest energy concentrated below several hundred Hz. For harbour porpoise, dolphins and seals, the hearing sensitivity below 1 kHz is relatively poor and thus it is expected that a PTS at these low frequency ranges would result in little impact to vital rates. Therefore, the sensitivity of harbour porpoise, dolphins and seals to PTS from cable laying is assessed as **Low**. The low frequency noise produced during cable laying may be more likely to overlap with the hearing range of low frequency cetacean species such as minke whales. Therefore, the sensitivity of minke whales to PTS from cable laying is assessed as **Medium**.

5.13.141 Underwater noise generation during cable trenching is highly variable and dependent on the physical properties of the seabed that is being cut. At the North Hoyle OWF, trenching activities had a peak energy between 100 Hz – 1 kHz and in general the sound levels were generally only 10-15 dB above background levels (Nedwell et al., 2003). For harbour porpoise, dolphins and seals, the hearing sensitivity below 1 kHz is relatively poor and thus it is expected that a PTS at these low frequency ranges would result in little impact to vital rates. Therefore, the sensitivity of harbour porpoise, dolphins and seals to PTS from trenching is assessed as **Low**. The low frequency noise produced during trenching may be more likely to overlap with the hearing range of low frequency cetacean species such as minke whales. Therefore, the sensitivity of minke whale to PTS from trenching is precautionarily assessed as **Medium**.

5.13.142 Underwater noise generation during rock placement activities is largely unknown. One study of rock placement activities in the Yell Sound in Shetland found that rock placement noise produced low frequency tonal noise from the machinery, but that measured noise levels were within background levels (Nedwell and Howell, 2004). Therefore, it is highly likely that any generated noise is likely to be dominated by the vessel from which activities taking place. Therefore, the sensitivity of harbour porpoise, dolphins and seals to PTS from rock placement is expected to be **Low**. The low frequency noise produced during rock placement may be more likely to overlap with the hearing range of low frequency cetacean species such as minke whales. Therefore, the sensitivity of minke whale to PTS from rock placement is precautionarily assessed as **Medium**.

Auditory injury – impact magnitude

5.13.143 Using the non-impulsive weighted SEL_{cum} PTS thresholds from Southall *et al.* (2019) resulted in estimated PTS impact ranges of <100 m for all marine mammal species for all non-piling construction noise (Table 64). These values mean that a marine mammal would have to be closer than 100 m from the continuous noise source at the start of the activity to acquire the necessary exposure to induce PTS as per Southall *et al.* (2019). This is an extremely unlikely scenario given the probability of an animal being in such a small area is extremely low given the average densities in the area. In addition, displacement of marine mammals is expected prior to such construction activities starting due to the presence of vessels on-site (Benhemma-Le Gall *et al.*, 2019, Benhemma-Le Gall *et al.*, 2020, Benhemma-Le Gall *et al.*, 2023).

Table 64 Summary of the source level (SEL_{cum} dB re 1 µPa@1m(RMS)) and impact ranges for the different non-piling construction noise sources using the non-impulsive criteria from Southall *et al.* (2019).

Source	Estimated unweighted source level	VHF	HF	LF	PCW
Cable laying	171	<100 m	<100 m	<100 m	<100 m
Suction dredging	186	<100 m	<100 m	<100 m	<100 m
Backhoe dredging	165	<100 m	<100 m	<100 m	<100 m
Drilling	169	<100 m	<100 m	<100 m	<100 m
Trenching	172	<100 m	<100 m	<100 m	<100 m
Rock placement	172	<100 m	<100 m	<100 m	<100 m

5.13.144 The impact of non-piling construction noise under the maximum design scenario is not considered to have a significant effect on any marine mammal species considered in this assessment. These noise sources will have a local spatial extent, short-term duration and are intermittent, meaning a marine mammal would have to be closer than 100 m from the continuous noise source at the start of the activity to acquire the necessary exposure for PTS-onset to occur. Therefore, the impact of these sources will have a **Negligible** magnitude.

Auditory injury – residual effect assessment

The sensitivity of harbour porpoise, dolphins and seals to auditory injury from other construction activities has been assessed as Low and minke whales have precautionarily been assessed as Medium sensitivity. The magnitude of impact of PTS to all marine mammals from other construction activities has been assessed as Negligible. Therefore, the significance of auditory injury from other non-piling construction activities is assessed as Slight adverse which is not significant in EIA terms.

Therefore, no additional mitigation to that already identified in Table 13 are considered necessary and ***no significant adverse residual effects*** *have been predicted in respect of marine mammals.*

Disturbance – cetacean sensitivity

5.13.145 Information regarding the sensitivity of marine mammals to other construction activities is currently limited. Available studies focus primarily on disturbance from dredging and confirmed behavioural responses have been observed in cetaceans. Pirotta *et al.* (2013) noted that bottlenose dolphin presence in foraging areas of Aberdeen harbour decreased as dredging intensity increased. Due to the consistently high presence of shipping activity all year round, the dolphins were considered to be habituated to high levels of vessel disturbance and, therefore, in this particular instance, Pirotta *et al.* (2013) concluded that the avoidance behaviour was a direct result of dredging activity. However, this distinction in the source of the disturbance reaction cannot always be determined. For example, Anderwald *et al.* (2013) observed minke whales off the coast of Ireland in an area of high vessel traffic during the installation of a gas pipeline where dredging activity occurred. The data suggested that the avoidance response observed was likely attributed to the vessel presence rather than the dredging and construction activities themselves. As the disturbance impact from other construction activities is closely associated with the disturbance from vessel presence required for the activity, it is difficult to determine the sensitivity specifically to disturbance from other construction activities in isolation (Todd *et al.*, 2015).

5.13.146 Harbour porpoise occurrence decreased at the Beatrice and Moray East offshore wind farms during non-piling construction periods (Benhemma-Le Gall *et al.*, 2021a). The probability of detecting harbour porpoise in the absence of piling decreased by 17% as the sound pressure levels from vessels during the construction period increased by 57 dB (note: vessel activity included not only wind farm construction related vessels, but also other third-party traffic such as fishermen, bulk carrier and cargo vessels). Despite this, harbour porpoise continued to regularly use both the Beatrice and Moray East sites throughout the three-year construction period. While a reduction in occurrence and buzzing was associated with increased vessel activity, this was of local scale and buzzing activity increased beyond a certain distance from the exposed areas, suggesting displaced animals resumed foraging once a certain distance from the noise source, or potential compensation behaviour for lost foraging or the increased energy expenditure of fleeing. While harbour porpoise may be sensitive to disturbance from other construction-related activities, it is expected that they are able to compensate for any short-term local displacement, and thus it is not expected that individual vital rates would be impacted. Therefore, the sensitivity of harbour porpoise to disturbance from other non-piling construction activities is considered to be **Low.**

5.13.147 For dolphin species, disturbance responses to non-piling construction activity appears to vary. Increased dredging activity at Aberdeen harbour was associated with a reduction in bottlenose dolphin presence and, during the initial dredge operations, bottlenose dolphins were absent for a total of five weeks over a sporadic, 5-month dredge period (dredging occurred for 1 month in both 2008 and 2009, and for 3 months in 2012) (Pirotta *et al.*, 2013). In an urbanised estuary in Western Australia, bottlenose dolphin responses to dredging varied between sites. At one site no bottlenose dolphins were sighted on days when backhoe dredging was present, while dolphins remained using the other site (Marley *et al.*, 2017). A study conducted in northwest Ireland concluded that construction related activity (including dredging) did not result in any evidence of a negative impact to common dolphins (Culloch *et al.*, 2016). Therefore, the sensitivity of dolphin species to disturbance from other non-piling construction activities is assessed as **Low**.

5.13.148 The same study conducted by Culloch *et al.* (2016) found evidence that the fine-scale temporal occurrence of minke whales in northwest Ireland was influenced by the presence of construction activity, with lower occurrence rates on these days (Culloch *et al.*, 2016). Due to their large size and capacity for energy storage, it is expected that minke whales will be able to tolerate temporary displacement from foraging areas much better than harbour porpoise and individuals are expected to be able to recover from any impact on vital rates. Therefore, the sensitivity of minke whales to disturbance from other non-piling construction activities is assessed as **Low**.

Disturbance – seal sensitivity

5.13.149 While seals are sensitive to disturbance from pile driving activities, there is evidence that the displacement is limited to the piling activity period only. At the Lincs wind farm, seal usage in the vicinity of construction activity was not significantly decreased during breaks in the piling activities and displacement was limited to within two hours of the piling activity (Russell *et al.*, 2016a). There was no evidence of displacement during the overall construction period, and the authors recommended that environmental assessments should focus on short-term displacement to seals during piling rather than displacement during construction as a whole. Even during periods of piling at the Lincs offshore wind farm, individual seals travelled in and out of the Wash which suggests that the motivation to forage offshore and come ashore to haul out could outweigh the deterrence effect of piling.

5.13.150 The array area is located in a relatively low-density area for both species of seal (compared to the coastal waters surrounding the Dublin coast), and thus it is not expected that any short term-local displacement caused by construction related activities would result in any changes to individual vital rates. Therefore, the sensitivity of both seal species to disturbance from other non-piling construction activities is considered to be **Negligible**.

Disturbance – impact magnitude

5.13.151 Dredging at a source level of 184 dB re 1 µPa @ 1 m resulted in avoidance of *harbour porpoise* up to 5 km from the dredging site (Verboom, 2014). Conversely, Diederichs *et al.* (2010) found much more localised impacts; using Passive Acoustic Monitoring there was short term avoidance (roughly three hours) at distances of up to 600 m from the dredging vessel, but no significant long-term effects. Modelling potential impacts of dredging using a case study of the Maasvlatke port expansion (assuming maximum source levels of 192 dB re 1 µPa) predicted a disturbance range of 400 m, while a more conservative approach predicted avoidance of harbour porpoise up to 5 km (McQueen *et al.*, 2020).

5.13.152 Localised, temporary avoidance of dredging activities is predicted. In addition, increased dredging activity at Aberdeen Harbour was associated with a reduction in *bottlenose dolphin* presence and, during the initial dredge operations, bottlenose dolphins were absent for five weeks (Pirotta et al, 2013). Based on the results of Pirotta et al, 2013, subsequent studies have assumed that dredging activities exclude dolphins from a 1 km radius of the dredging site (Pirotta *et al.*, 2015a). Dredging operations had no impact on sightings of Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) in South Australia (Bossley *et al.*, 2022).

5.13.153 For *common dolphins*, there is currently no information available on the impacts of dredging. Localised, temporary avoidance of dredging activities is assumed as with bottlenose dolphins.

5.13.154 In northwest Ireland, construction-related activity (including dredging) has been linked to reduced *minke whale* presence (Culloch *et al.*, 2016). Minke whale distance to construction site increased and relative abundance decreased during dredging and blasting activities in Newfoundland (Borggaard *et al.*, 1999).

5.13.155 Based on the generic threshold of behavioural avoidance of *pinnipeds* (140 dB re1µPa SPL) (Southall *et al.*, 2007), acoustic modelling of dredging demonstrated that disturbance could be caused to individuals between 400 m to 5 km from site (McQueen *et al.*, 2020).

5.13.156 Information on the disturbance effects of drilling (of WTG foundations) is limited and the majority of the research available was conducted more than 20 years ago and is focussed on baleen whales (Sinclair *et al.*, 2023). For example, drilling and dredging playback experiments observed that 50% of bowhead whales exposed to noise levels of 115 dB re 1 µPa exhibited some form of response, including changes to calling, foraging and dive patterns (Richardson and Wursig, 1990). More recent studies of bowhead whales also observed changes in behaviour from increased drilling noise levels, specifically an increase in call rate. However, the call rate plateaued and then declined as noise levels continued to increase, which could be interpreted as the whales aborting their attempt to overcome the masking effects of the drilling noise (Blackwell *et al.*, 2017). Playback experiments of drilling and industrial noise have also been undertaken with grey whales at a noise level of 122 dB re 1 µPa. This resulted in a 90% response from the individuals in the form of diverting their migration track (Malme *et al.*, 1984). Overall, the literature indicates that the impacts of drilling disturbance on marine mammals may occur at distances of between 10-20 km, and will vary depending on the species (Greene Jr, 1986, LGL and Greeneridge, 1986, Richardson and Wursig, 1990).

5.13.157 Whilst information is not available for the species of concern for the proposed development, it is still considered useful as it suggests that at least some species of cetacean may experience disturbance as a result of drilling. Furthermore, drilling is considered under the umbrella of industrial and construction noise, and has similar properties to dredging (Reine *et al.*, 2014), for which more information is available for species relevant to the Project. Therefore, it is considered that drilling could potentially cause disturbance over distances of up to 5 km from the noise source based on results for dredging, rather than up to 20 km based on results from the drilling literature given that this literature is considered slightly outdated.

5.13.158 There is a lack of information in the literature on disturbance ranges for other non-piling construction activities such as cable laying, trenching or rock placement. While construction-related activities (acoustic surveys, dredging, rock trenching, pipe laying and rock placement) for an underwater pipeline in northwest Ireland resulted in a decline in harbour porpoise detections, there was a considerable increase in detections after construction-activities ended which suggests that any impact is localised and temporary (Todd *et al.*, 2020).

5.13.159 It is expected that any disturbance impact will be primarily driven by the underwater noise generated by the vessel during non-piling construction-related activities, and, as such, it is expected that any impact of disturbance is highly localised (within 5 km). The magnitude of this impact is considered to be **Low** across all marine mammal species since the impact will be of short-term duration (<5 years), will occur intermittently at low intensity and is expected to be of limited spatial extent.

Disturbance – residual effect assessment

The sensitivity of marine mammals to disturbance from non-piling construction activities has been assessed as Negligible to Low. The magnitude of disturbance to all marine mammal species from non-piling construction activities has been assessed as Low. Therefore, disturbance from non-piling construction activities is assessed as Imperceptible to Slight adverse which is not significant in EIA terms.

Therefore, no additional mitigation to that already identified in Table 13 are considered necessary and ***no significant adverse residual effects*** *have been predicted in respect of marine mammals.*

Vessel noise

PTS

5.13.160 Increased vessel traffic during construction has the potential to result in disturbance of marine mammals. Disturbance from vessel noise is only likely to occur where increased noise from vessel movements associated with the construction of the offshore infrastructure is greater than the background ambient noise. The maximum design option (Table 12) lists the maximum number of vessels that will be involved in construction.

5.13.161 Using the non-impulsive weighted SEL_{cum} PTS-onset thresholds from Southall *et al.* (2019) resulted in estimated PTS impact ranges of <100 m for the majority of marine mammal species for all vessel noise (Table 65). These values mean that all marine mammal species likely to present at the site would have to be closer than 100 m from the continuous noise source at the start of the activity to acquire the necessary exposure to induce PTS as per Southall *et al.* (2019). This is an extremely unlikely scenario given the probability of an animal being in such a small area is extremely low given the average densities in the area.

Table 65 Summary of the source level (SEL_{cum} dB re 1 µPa@1m (RMS)) and impact ranges for the vessel noise sources using the non-impulsive criteria from Southall *et al.* (2019).

Source	Estimated unweighted source level	VHF	HF	LF	PCW
Vessel noise (large)	168	<100 m	<100 m	<100 m	<100 m
Vessel noise (medium)	161	<100 m	<100 m	<100 m	<100 m

5.13.162 During the period of piling operations, it is considered unlikely that vessel noise will impact marine mammal receptors at levels additional to the piling activity itself and therefore the magnitude of the impact is assessed as **Negligible**. It is difficult to separate out the effect of vessel presence and activity from the effect of pile driving in isolation, since the data collected to date on the response of animals to pile driving, will have included a degree of vessel activity in combination with the piling, therefore it could be considered that the typical vessel activity related to pile driving, may be already assessed to some extent under the pile driving assessment. Individuals have more potential to be impacted by increased vessel movements during periods when piling is not taking place.

Disturbance

5.13.163 Disturbance to marine mammals by vessels will be driven by a combination of underwater noise and the physical presence of the vessel itself (e.g. Pirotta *et al.* (2015b), Pirotta *et al.* (2015c)). It is not simple to disentangle these drivers and thus disturbance from vessels is assessed here in general terms, covering disturbance driven by both vessel presence and underwater noise.

5.13.164 Vessel noise levels from construction vessels will result in an increase in non-impulsive, continuous sound in the vicinity of the proposed development, typically in the range of 10 to 100Hz (although higher frequencies will also be produced) (Erbe *et al.*, 2019) with an estimated source level of 161 168 SEL_{cum} dB re 1 µPa@1m (RMS) for medium and large construction vessels, travelling at a speed of 10 knots (see the underwater noise modelling report). Underwater noise OSPAR (2009) summarise general characteristics of commercial vessel noise. Vessel noise is continuous, and is dominated by sounds from propellers, thrusters and various rotating machinery (e.g., power generation, pumps). In general, support and supply vessels (50-100m) are expected to have broadband source levels in the range 165-180dB re 1µPa, with the majority of energy below 1kHz (OSPAR 2009). Large commercial vessels (>100 m) produce relatively loud and predominately low frequency sounds, with the strongest energy concentrated below several hundred Hz.

5.13.165 There is little information available as to what level of vessel activity can result in disturbance to marine mammals. However, Heinänen and Skov (2015) suggested that harbour porpoise density was significantly lower in areas with vessel transit rates of greater than 20,000 ships/year (80/day) within an area of 5 km^2. The total maximum number of construction vessels expected to be offshore at any one time is 74 vessels; however, this assumes that all offshore activities overlap and are occurring at the same time. In reality, it is not expected that WTG installation would overlap with cable installation and therefore the peak number of vessels offshore at any one time will be lower than this, and not all vessels will be in transit at the same time. In addition, this is the number of vessels expected to be offshore across the entire project (array area and Offshore ECC) and therefore numbers within a single 5 km^2 area would be lower than the threshold of 80/day as identified by Heinänen and Skov (2015). Therefore, there is unlikely to be the potential for significant disturbance as a result of construction vessels.

Harbour porpoise

5.13.166 Given their high-frequency hearing range, it has been suggested that porpoise are more likely to be sensitive to vessels that produce medium to high frequency noise components (Hermannsen *et al.*, 2014). However, harbour porpoise are known to avoid vessels and behavioural responses have been shown in porpoise exposed to vessel noise that contains low levels of high-frequency components (Dyndo *et al.*, 2015). Thomsen *et al.* (2006) estimated that porpoise will respond to both small (~2 kHz) and large (~0.25 kHz) vessels at approximately 400 m. Wisniewska *et al.* (2018) presented data that suggested that porpoises may respond to very close range vessel passes with an interruption in foraging. However, observed responses were short-lived, porpoises were observed to resume foraging 10 minutes after a very close-range vessel encounter, and tagged porpoises remained in areas where shipping levels were high. Overall, despite animals remaining in heavily trafficked areas, the incidence of responses to vessels was low, indicating little fitness cost to exposure to vessel noise and any local scale responses taken to avoid vessels. It is likely that porpoise may become habituated where vessel movements are regular and predictable whereas they may be expected to show more of a local behavioural response to novel vessel activities related to construction activities.

5.13.167 Data collected during construction of the Beatrice Offshore Wind Farm (Moray Firth, Scotland) have demonstrated that porpoise detections around the pile driving site decline several hours prior to the start of pile driving, and it is assumed that this is due to the increase in other construction-related activities and vessel presence in advance of the actual pile driving (Brandt *et al.*, 2018, Benhemma-Le Gall *et al.*, 2021a). Therefore, because the dose-response relationships relating displacement to piling are based on data collected over periods including such vessel activity, these local responses to novel activity such as pile driving vessels have effectively already been included in the assessment of underwater noise related to pile driving above.

5.13.168 A study on the impacts from construction-related activities at the Beatrice and Moray East offshore wind farms in Scotland has shown that harbour porpoise are displaced by offshore wind farm construction vessels (Benhemma-Le Gall *et al.*, 2021a). Construction related vessels assessed in this study included key offshore service vessels used for pile-driving and jacket or turbine installation, as well as other construction-related vessel traffic including fishing vessels working as guard vessels, passenger vessels for crew-transfers and some port service craft or unassigned vessels; and across the Moray Firth during the study period, the median construction-related vessel density was 1.4 vessels/km^2. Passive acoustic monitoring at the site showed that porpoise occurrence (hourly occurrence of porpoise detections) declined within 2 km of construction vessels (from 0.37 when vessel intensity was zero, down to 0.02 for a vessel intensity of 9.8 min/km^2), but that responses declined with increasing distance to vessels, out to 4 km where no response was observed. Throughout the study period, buzzing activity (used as a proxy for foraging activity) decreased by up to 24.5% as vessel intensity increased, and by up to 45.9% as the hourly RMS sound pressure levels increased from 104 to 155 dB re 1µPa. Given the evidence available, harbour porpoise have been assessed as having a **Low** sensitivity to disturbance from vessels.

Dolphins

5.13.169 Although no studies on the interactions of bottlenose dolphins with vessels exist for Ireland specifically, other studies have demonstrated vessel disturbance has been shown to negatively affect foraging activity. Pirotta *et al.* (2015b) found that transit of vessels in the Moray Firth resulted in a reduction (by almost half) of the likelihood of recording bottlenose dolphin prey capture buzzes. They also suggest that vessel presence, not just vessel noise, resulted in disturbance. Based on the evidence, there is likely to be rapid recovery from disturbance from vessel presence and vessel noise, as they recorded little pre-emptive disturbance or recovery time following disturbance. There is evidence of bottlenose dolphin habituation to boat traffic, particularly in relation to larger vessel types (Sini *et al.*, 2005). Lusseau *et al.* (2011) undertook a modelling study which predicted that increased vessel movements associated with offshore wind development in the Moray Firth did not have a negative effect on the local population of bottlenose dolphin. They hypothesise that this was because most of the vessels were commercial ones, which have more predictable patterns of movement than the recreational vessels and are thus less likely to disrupt the feeding behaviour of dolphins than recreational or tourist activity. Therefore, bottlenose dolphins have been assessed as having a **Low** sensitivity to disturbance from vessels.

5.13.170 When considering common dolphins, there are currently limited studies available regarding the effects of vessel disturbance. Of the few studies available, disturbance effects on common dolphins have mainly focused on those from cetacean watching vessels. Meissner *et al.* (2015) reported that the presence of interacting vessels affected the behavioural budget of common dolphins, and common dolphin groups spent significantly less time foraging. Once disrupted, dolphins took at least twice as long to return to foraging when compared to control conditions (vessels > 300 m away from dolphin group). In addition, Meissner *et al.* (2015) reported that the probability of starting to forage while engaged in travelling in the presence of a cetacean-watching vessel decreased by two thirds. Given foraging tactics used by common dolphins include cooperative herding of prey (Neumann and Orams, 2003), it is possible that the behavioural changes of some individuals, as a result of approaching vessels, could compromise the success of the overall foraging event (Meissner *et al.,* 2015). When considering the impacts of cetacean-watching vessels reported by Meissner *et al.* (2015) to those likely to occur from construction vessel activities, they cannot be directly transposed, as the likely interactions between common dolphins and vessels during the construction of the project are unlikely to be deliberate and targeted to dolphin groups. As such, it is not anticipated that vessels will regularly persist within 300 m of a dolphin group (the distance in which behavioural responses occurred) for extended periods of time. Therefore, it is assumed that the sensitivity of short-beaked common dolphin to disturbance from vessel activity can be classified as **Low**.

Minke whale

5.13.171 There is limited information available on the responses of minke whales to vessels. Whale watching vessels that specifically target minke whales have been shown to cause behavioural responses in minke whales and repeated exposure can result in a decrease in foraging activity (Christiansen *et al.*, 2013a). However, these are vessels which specifically target and follow minke whales, so it is unknown whether minke whales respond to more general ship traffic. When considering the impacts of whale watching vessels reported by Christiansen *et al.* (2013a) to those likely to occur from construction vessel activities, they cannot be directly transposed, as disturbance effects from whale watching are direct impacts, whilst those from construction activities are indirect. However, it is assumed that vessel disturbance could result in temporary displacement of minke whales from the immediate area. The sensitivity of minke whales to vessel disturbance is therefore assessed as **Low**.

Seals

5.13.172 Jones *et al.* (2017) presents an analysis of the predicted co-occurrence of ships and seals at sea which demonstrates that UK wide there is a large degree of predicted co-occurrence, particularly within 50 km of the coast close to seal haul-outs. There is no evidence relating decreasing seal populations with high levels of co-occurrence between ships and animals. In fact, in areas where seal populations are showing high levels of growth (e.g. southeast England) ship co-occurrences are highest (Jones *et al.*, 2017). By contrast, on the northwest coast of Ireland, a study of vessel traffic and marine mammal presence found grey seals sightings to decrease with increased vessel activity as a result of construction (Anderwald *et al.*, 2013). Thomsen *et al.* (2006) estimated that both harbour and grey seals will respond to both small (~2 kHz) and large (~0.25 kHz) vessels at approximately 400 m.

5.13.173 In terms of physiology, harbour seal disturbance was also assessed by examining heart rate changes in response to incidental and experimental vessel disturbance (Karpovich *et al.*, 2015). Hauled out seals exhibited a vigilance behaviour (head-lift) and experienced a 4 bpm vessel^{-1} increase as a result of incidental traffic and a 5 bpm vessel^{-1} increase from experimental disturbance. This increase in heart rate could be a result of the seal switching from a sleeping to awake status as the vessel approached or could indicate that the seal is experiencing stress. If seals remained hauled out, their heart rate continued to increase with each additional vessel that approached; if seals entered the water following the disturbance, the heart rate decreased, suggesting they are shifting to an energetically conservative state in response to the disturbance event. The effect of the heart rate increase was still noticeable in the following haul out, indicating that the disturbance has a prolonged energetic cost for harbour seals (Karpovich *et al.,* 2015). However, this study relates to the direct, intended disturbance of harbour seals at haul-out sites.

5.13.174 While construction vessels will be active in the Dublin Bay area, they are unlikely to transit very close to haul-out sites. A recent study of seals hauled-out in the Dublin Bay and wider area has shown that despite increased vessel activity in the area due to major infrastructure development at Dublin Port, there has been no change in harbour seal haul-out use in the area (Berrow et al., 2024). As such, the sensitivity of harbour seals to disturbance from vessel activity is based on the responses reported by Thomsen *et al.* (2006), and is therefore classified as **Low**.

5.13.175 Although there are few studies on the physiological and behavioural response of grey seals from vessel presence when compared with harbour seals, Bishop *et al.* (2015) reported that breeding male grey seals exhibit similar activity (behavioural) budgets across varying exposures to human activity. In the presence or absence of human activities and/or disturbance, male grey seals exhibited similar time budgets for non-active behaviours (i.e., resting or alert) versus active behaviours (i.e., aggressions or attempted copulation) suggesting strong selection pressures for overarching conservation of energy. Bishop *et al.* (2015) reported that selection for this lack of a behavioural response is likely driven by the increased mating success of males who maintain their position amongst groups of females for the longest time because of reduced energy expenditure, irrespective of human activity.

5.13.176 Although Bishop *et al.* (2015) classified alert behaviours under the non-active category, as Karpovich *et al.* (2015) indicated, increased alertness/vigilance and in turn, increased stress levels, can increase the heart rate of seals (irrespective of sex) and thus, energy expenditure. Should vessel disturbance to grey seals, male or female, be repetitive, this could lead to increased heart rates over time and a prolonged energetic cost. While construction vessels will be active in the Dublin Bay area, they are unlikely to transit very close to haul-out sites. A recent study of seals hauled-out in the Dublin Bay and wider area has shown that despite increased vessel activity in the area due to major infrastructure development at Dublin Port, there has been no change in grey seal haul-out use in the area; even at the haul-out site closest to the construction activity (Bull Island) the grey seal counts show a continued increase (Berrow et al., 2024). As construction vessels shall not be transiting past, or close to haul-out sites, it is unlikely that grey seals shall experience same levels of disturbance while at-sea. As such, the sensitivity of grey seals to disturbance from vessel activity is based on the responses reported by Thomsen *et al.* (2006), and is therefore classified as **Low**.

Summary

5.13.177 It is expected that any changes resulting from other construction activities will be temporary due to the short-term duration of the activities. Given the potential for other construction activities such as dredging to impact animals out to 5 km from the source, the impact is likely to be of a **Low adverse** magnitude. It has been assumed that marine mammal sensitivity to other construction activities will be similar to that of disturbance from pile driving or vessel activity.

Table 66 Determination of magnitude for disturbance from other construction activities

Definition	MDO	ADO
Extent	Low - The effect is expected in a low proportion of the population (expected disturbance ranges out to 4 km from construction vessels, 5 km from dredging activities and ~15 km from vibro-sheet piling).	The MDO and ADO are aligned.
Duration	Medium - The impact is medium-term (consistent with the longest construction programme of 30 months on site for construction of 50 WTG monopile foundations)	Medium - The impact is medium-term (consistent with the shortest construction period of 18 months with a mean of 24 months for construction of 46 or 40 pre commissioned structures)
Frequency	Low - The impact will occur frequently throughout a relevant project phase**.**	The MDO and ADO are aligned.
Probability	Medium – The effect is reasonably expected to occur. There is evidence in the literature that these activities can cause disturbance in marine mammals, however information on the level of disturbance and impact range for most species is limited.	The MDO and ADO are aligned.

Definition	MDO	ADO
Consequence	Low - Local scale, intermittent disturbance is unlikely to result in impacts on individual survival or reproductive rates.	The MDO and ADO are aligned.
Overall magnitude	*The potential magnitude on marine mammals is rated as Low.*	*The potential magnitude on marine mammals is rated as Low.*

5.13.178 The maximum magnitude of the impact has been assessed as **Low adverse**, with the maximum sensitivity of the receptors being **Low**. Therefore, the significance of effect from disturbance caused by non-piling construction activities is **Slight adverse**, which is not significant in EIA terms.

5.13.179 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Residual effect assessment

The significance of effect from other construction noise is not significant in EIA terms. Therefore, no additional mitigation to that already identified in Table 13 are considered necessary. Therefore, ***no significant adverse residual effects*** *have been predicted in respect of marine mammals.*

Impact 8: Vessel collision risk (construction)

5.13.180 The area surrounding the study area already experiences a high amount of vessel traffic (see Volume 3, Chapter 10: Shipping and Navigation for full details). The Shipping and Navigation Baseline study recorded an average of 96 unique vessels per day within the study area[40] during the summer survey period (July 2019). During the winter survey period (November 2019), an average of 52 unique vessel per day were recorded within the Study area. Vessels comprised primarily of cargo and fishing vessels during the study period, as well as a large proportion of recreational vessels during the summer.

5.13.181 Updated summer and winter baseline surveys were undertaken for Shipping and Navigation in 2023 and 2022 respectively. On the busiest day of the updated summer survey period (August 2023), an average of 81 unique vessels were recorded. Vessels comprised primarily of recreational, cargo and passenger vessels during the study period.

5.13.182 During the updated winter survey period (March 2022), an average of 60 unique vessels per day were recorded within the Study area. Vessels comprised primarily of cargo, recreational, fishing and passenger vessels during the study period.

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[40] Shipping and Navigation Baseline defines the Study area as a 10 nm buffer around the Dublin Array offshore site boundary. This radius is standard for shipping and navigation assessments and is considered as being large enough to capture relevant passing traffic while still remaining site specific.

5.13.183 During construction of the wind farm, a potential source of impact from increased vessel activity is physical trauma from collision with a boat or ship. These injuries include blunt trauma to the body or injuries consistent with propeller strikes. The risk of collision of marine mammals with vessels would be directly influenced by the type of vessel and the speed with which it is travelling (Laist *et al.*, 2001) and indirectly by ambient noise levels underwater and the behaviour the marine mammal is engaged in.

5.13.184 There is currently a lack of information on the frequency of occurrence of vessel collisions as a source of marine mammal mortality, and there is little evidence from marine mammals stranded in the UK and Ireland that injury from vessel collisions is an important source of mortality. The UK Cetacean Strandings Investigation Programme (CSIP) documents the annual number of reported strandings and the cause of death for those individuals examined at post-mortem. The CSIP data shows that very few strandings have been attributed to vessel collisions[41], therefore, while there is evidence that mortality from vessel collisions can and does occur, it is not considered to be a key source of mortality highlighted from post-mortem examinations.

5.13.185 Harbour porpoises, dolphins and seals are relatively small and highly mobile, and given observed responses to noise, are expected to detect vessels in close proximity and largely avoid collision. Predictability of vessel movement by marine mammals is known to be a key aspect in minimising the potential risks imposed by vessel traffic (Nowacek *et al.*, 2001, Lusseau, 2003, 2006). The avoidance and preventative measures to be incorporated in a VMP (see Table 13) will ensure that vessel traffic moves along predictable routes and will define how vessels should behave in the presence of marine mammals.

5.13.186 It is estimated that a maximum of 74 construction vessels will be utilised at peak periods, resulting in a maximum potential of 2,510 round trips over the three-year construction period (Table 12). The majority of vessels used during construction will be large vessels that are stationary or slow moving throughout construction activities for significant periods of time. Therefore, the actual increase in vessel traffic moving around the site and to/from port to the site will occur over short periods of the offshore construction activity. Furthermore, due to the already high volume of vessel traffic already in the Study area, the introduction of additional vessels during construction of the proposed development is not a novel impact for marine mammals present in the area.

5.13.187 It is not expected that the level of vessel activity during construction would cause an increase in the risk of mortality from collisions. The adoption and implementation of a VMP during construction will minimise the potential for any impact. Therefore, the magnitude of the risk of vessel collisions occurring is **Negligible** (Table 67).

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[41] (CSIP, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018)

5.13.188 All marine mammal receptors are deemed to be of low vulnerability given that vessel collision is not considered to be a key source of mortality highlighted from post-mortem examinations of stranded animals. However, should a collision event occur, this has the potential to kill the animal, from which they have no ability to recover from. As a result of the low vulnerability to a strike but the serious consequences of a strike, marine mammal receptors are considered to have a **High** sensitivity to vessel collisions (Table 68).

Table 67 Determination of magnitude for collision risk from construction vessels

Definition	MDO	ADO
Extent	Negligible - Given the implementation measures listed in Table 13, particularly vessel code of contact to be applied when encountering marine species.	The MDO and ADO are aligned.
Duration	Low - The impact is anticipated to be short-term (construction period lasting a maximum of 30 months).	Low - The impact is anticipated to be short-term (construction period lasting a maximum of 18 months).
Frequency	Medium - The impact will occur almost constantly throughout a relevant project phase (up to 813 round trips to port from construction vessels and an additional 1,825 round trips from small vessels such as CTVs during construction period).	Medium - The impact will occur almost constantly throughout a relevant project phase (up to 774 round trips to port from construction vessels and an additional 538 round trips from small vessels such as CTVs during construction period).
Probability	Negligible - Given the implementation measures listed in Table 13, particularly vessel code of contact to be applied when encountering marine species, the likelihood of any marine mammal collision with construction vessels is highly unlikely.	The MDO and ADO are aligned.
Consequence	Negligible - Given the implementation measures listed in Table 13, particularly vessel code of contact to be applied when encountering marine species, there is expected to be no effect or consequence for marine mammals.	The MDO and ADO are aligned.
Overall magnitude	*The potential magnitude on marine mammals is rated as Negligible.*	*The potential magnitude on marine mammals is rated as Negligible.*

Table 68 Determination of sensitivity for marine mammals to collision risk from construction vessels

Marine Mammals	Justification
Context	**Adaptability & Tolerance:** Most species are relatively small and mobile and, given observed responses to noise will be able to detect vessels in close proximity and implement an avoidance response.

Marine Mammals	Justification
	Recoverability: Variable – severity of collision will affect severity of resulting injury and therefore an individual's ability to recover. Collision has the potential to kill marine mammals from which there is no recovery.
Value	All cetaceans are categorised as European Protected Species. Therefore they have a high value. Seals are categorised as Annex II species of Community Interest. Therefore they have a high value.
Overall sensitivity	*The potential sensitivity of marine mammals is rated as High.*

5.13.189 The magnitude of the impact has been assessed as **Negligible adverse**, with the sensitivity of all marine mammal receptors being **High**. Therefore, the significance of effect from collision risk from construction vessels is assessed as **Not significant**.

5.13.190 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Residual effect assessment

*The significance of effect from vessel collision during construction is not significant in EIA terms. Therefore, no additional mitigation to that already identified in Table 13 are considered necessary. Therefore, **no significant adverse residual effects** have been predicted in respect of marine mammals.*

Impact 9: Increases in suspended sediment concentrations (construction)

5.13.191 Disturbance to water quality as a result of construction activities can have both direct and indirect impacts on marine mammals. Indirect impacts would include effects on prey species which is covered in the subsequent section (Impact 10: Changes in prey availability and distribution). Direct impacts include the impairment of visibility and therefore foraging ability which might be expected to reduce foraging success.

5.13.192 During construction of the project, sediment will be disturbed and released into the water column. This will give rise to suspended sediment plumes and localised changes in bed levels as material settles out of suspension. The main activities resulting in disturbance of seabed sediments, detailed in Volume 3, Chapter 1: Marine Geology, Oceanography and Physical Processes and Volume 3, Chapter 2: Marine Water and Sediment Quality are:

- Seabed preparation for foundations;
- Drill arisings release;
- Release of drilling mud during trenchless installation;
- Drilling spoil disposal;
- Sandwave clearance; and

- Cable installation (including trenching).

5.13.193 Seabed preparation may result in the release of sediment from overspill during dredging of sediment from the seabed and the disposal of dredged sediment on the seabed at a nearby location. Drill arising may be released during foundation installation when seabed material is drilled from within the pile to assist with the piling process. This may then result in the release of drilling spoil at or above the water surface which will put sediment into suspension and will then be subsequently re-deposited to the seabed. The nature of this potential change will be determined by the rate and total volume of material to be drilled, the nature of the seabed/ underlying geology and the drilling method. Cable installation results in sediment disturbance due to cable burial, and the effects will vary depending on the seabed conditions, burial depth and burial method required. Sandwave clearance may be required to ensure effective burial to remove sections of sandwaves before trenching the underlying sediment.

5.13.194 Temporary increases in suspended sediment concentration (SSC) is anticipated to vary dependent on sediment fraction size and activity. The distribution of coarse sediment is expected to be high (in the order of tens to thousands mg/l) but very localised for all construction activities. Fine sediment is anticipated to have a more varied effect, ranging from very localised for sandwave clearance to plumes extending up to 10 km as a result of drill arisings from foundation installation, albeit at very low concentrations close to the ambient conditions.

5.13.195 Any disturbance to the seabed will be both localised and temporary so will, therefore, be of **Low adverse** magnitude.

Table 69 Determination of magnitude for increased suspended sediment

Definition	MDO	ADO
Extent	Low - The effect is expected in a low proportion of the population (the temporary impact of increased SSC and deposition from construction activities is expected to be restricted to the near field and the adjacent areas of the far-field (within one tidal cycle)).	The MDO and ADO are aligned.
Duration	Low - The impact will occur frequently throughout a relevant project phase. The impact will be restricted to the offshore construction phase of the project and will therefore be short-term (one to three years), although works in any given discrete location and activity within the project boundary will often be temporary (considerably less than one year).	The MDO and ADO are aligned.
Frequency	Low - The impact will occur frequently in discrete areas throughout the construction phase of the development.	The MDO and ADO are aligned.
Probability	Medium - The impact can reasonably be expected to occur during construction due to the disturbance of sediment.	The MDO and ADO are aligned.
Consequence	Negligible – Very short term, recoverable effect on the behaviour and/or distribution in a very small proportion of the population. No potential for changes to the population size or trajectory. Sediment plumes are expected to quickly dissipate after cessation of the activities, due to settling and wider dispersion with the concentrations reducing quickly over time to background levels. Therefore, the consequence will be noticeable but brief changes in SCC concentrations occurring during the construction phase within the near-field and the adjacent areas of the far-field.	The MDO and ADO are aligned.
Overall magnitude	*The potential magnitude on marine mammals is rated as Low (adverse).*	*The potential magnitude on marine mammals is rated as Low (adverse).*

5.13.196 Marine mammals are well known to forage in tidal areas where water conditions are turbid and visibility conditions poor. For example, harbour porpoise and harbour seals in the UK have been documented foraging in areas with high tidal flows (e.g. Pierpoint, 2008, Marubini *et al.*, 2009, Hastie *et al.*, 2016). Therefore, low light levels, turbid waters and suspended sediments are unlikely to negatively impact marine mammal foraging success. It is important to note that it is hearing, not vision that is the primary sensory modality for most marine mammals. When the visual sensory systems of marine mammals are compromised, they are able to sense the environment in other ways, for example, seals can detect water movements and hydrodynamic trails with their mystacial vibrissae; while odontocetes primarily use echolocation to navigate and find food in darkness. Short term increases in turbidity as a result of an increase in suspended sediment during the construction phase is, therefore, not anticipated to effect marine mammals which rely primarily on hearing, resulting in **Negligible** sensitivity.

Table 70 Determination of sensitivity for marine mammals to increased suspended sediment

Marine Mammals	Justification
Context	**Adaptability & Tolerance:** Marine mammals rely primarily on hearing and therefore, are not likely to be impacted by an increase in SSC. Furthermore, most species are relatively small and mobile and will be able to move away from any areas where SSCs are increased. **Recoverability:** Any impacts of increased SSC would be short term and, therefore, receptors would recover quickly.
Value	All cetaceans are categorised as European Protected Species. Therefore they have a high value. Seals are categorised as Annex II species of Community Interest. Therefore they have a high value.
Overall sensitivity	*The potential sensitivity on marine mammals is rated as Negligible.*

5.13.197 The magnitude of the impact has been assessed as **Low adverse**, with the maximum sensitivity of the receptors being **Negligible**. Therefore, the significance of effect from an increase in suspended sediment concentration occurring as a result of construction activities is a **Not Significant**.

5.13.198 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Residual effect assessment

The significance of effect from an increase in suspended sediment concentration is not significant in EIA terms. Therefore, no additional mitigation to that already identified in Table 13 are considered necessary. Therefore, ***no significant adverse residual effects*** *have been predicted in respect of marine mammals.*

Impact 10: Changes in prey availability and distribution (construction)

5.13.199 Given that marine mammals are dependent on fish prey, there is the potential for indirect effects on marine mammals as a result of impacts upon fish species or the habitats that support them. The key prey species for each marine mammal receptor are listed in Table 71.

Table 71 Key prey species of the marine mammal receptors (**bold** = species present in study area)

Receptor	Site	Key Prey Species	Reference
Harbour porpoise	Ireland	**Small (poor) cod (*Trisopterus* spp),** various Clupeoids, **whiting**, herring, and cephalopods	Berrow and Rogan (1995), Hernandez-Milian *et al.* (2011)
Bottlenose dolphin	Ireland	**Catsharks**, conger eel, **Atlantic salmon,** blue whiting, **whiting**, **haddock**, pollock, Norway pout, pout, **poor cod, silvery cod**, **ling, hake, Atlantic horse mackerel, Atlantic mackerel,** gobies, **sand smelt,** lanternfish, flounder, **plaice**, dab, brill, **sole**, various squid, and octopus sp.	Hernandez-Milian *et al.* (2015)
Common dolphin	British Isles	Seabass, goby, **cod,** cephalopods, **mackerel**, lanternfish, blue whiting	Brophy *et al.* (2009)
Minke whale	Scotland	**Sandeel, herring, sprat, mackerel**, goby, **Norway pout/poor cod**	Pierce *et al.* (2004)
Grey seal	British Isles	**Lamprey,** eels, **herring, salmonids, haddock**, pollock, saithe, **whiting**, blue whiting, Norway pout, **poor cod,** bib, rock**ling**, **ling, hake,** perch, scad, wrasse, **sandeel**, goby, **mackerel**, flounder, dab, **sole,** witch, halibut, and squid species	Gosch *et al.* (2014), SCOS (2021)
Harbour seal	British Isles	**Atlantic herring, sprat, salmonids,** pollock, **haddock**, saithe, **whiting**, **poor cod,** rockling, **ling,** wrasse, **Atlantic horse mackerel, sandeel,** dragonet, red bandfish, **plaice**, flounder, **sole,** squid and octopus species	Kavanagh *et al.* (2010), SCOS (2021)

5.13.200 During construction activities, there is the potential for impacts upon fish species, including:

- direct damage (e.g. crushing) and disturbance;
- temporary increase in SSC and sediment deposition;
- Seabed disturbances leading to the release of sediment contaminants and /or accidental contamination; and
- additional underwater noise and vibration leading to mortality, injury, behavioural changes or auditory masking.

5.13.201 Volume 3, Chapter 5: Fish and Shellfish Ecology concludes no significant adverse residual effects in respect of fish and shellfish ecological receptors from construction activities.

5.13.202 Since there is expected to be no significant impacts on fish species, the potential magnitude of impact on marine mammals is rated as **Negligible** (Table 72).

5.13.203 While there may be certain species that comprise the main part of their diet, all marine mammals in this assessment are considered to be generalist feeders and are thus not reliant on a single prey species. Therefore, they are assessed as having a **Low** sensitivity to changes in prey abundance and distribution.

Table 72 Determination of magnitude for changes in prey availability

Definition	MDO	ADO
Extent	**Direct damage:** highly localised impacts on fish species **SSC:** highly localised impacts on fish species **Seabed disturbance:** highly localised impacts on fish species **Noise:** Impacts to fish from piling and UXO will extend into the far-field. Impacts from other construction noise are expected to be within the near-field only.	The MDO and ADO are aligned.
Duration	**Direct damage:** impacts on fish species restricted to construction phase **SSC:** impacts on fish species restricted to construction phase **Seabed disturbance:** impacts on fish species restricted to construction phase **Noise:** impacts on fish species will occur intermittently throughout the construction phase and will therefore be short term.	The MDO and ADO are aligned.
Frequency	**Direct damage:** impacts on fish species could occur frequently in discrete locations **SSC:** impacts on fish species could occur frequently in discrete locations **Seabed disturbance:** impacts on fish species could occur frequently in discrete locations **Noise:** impact from piling will occur almost constantly throughout certain stages of construction, with impacts from other activities being frequent throughout construction.	The MDO and ADO are aligned.

Definition	MDO	ADO
Consequence	**Direct damage:** Effects upon fish populations are unlikely to be discernible. **SSC:** Effects upon fish populations are unlikely to be discernible. **Seabed disturbance:** Effects upon fish populations are unlikely to be discernible. **Noise:** Impacts from piling and UXO may cause mortality or potential mortal injury in the near-field and other temporary physiological and behavioural changes in the far-field. Impacts from other activities will be restricted to small scale behavioural changes in the near and immediately adjacent far-field. **Marine mammals:** Since there is expected to be no significant impacts to fish species, there is expected to be no subsequent impact to marine mammals (Negligible consequence).	The MDO and ADO are aligned.
Overall magnitude	*The potential magnitude of impact on marine mammals is rated as Negligible.*	*The potential magnitude of impact on marine mammals is rated as Negligible.*

Table 73 Determination of sensitivity for marine mammals to changes in prey availability

Marine mammals	Justification
Context	The marine mammals considered in this assessment are considered to be generalist feeders and are thus not reliant on a single prey species. Therefore it is expected that any small scale or short-term duration change in prey density and distribution would not cause any significant level effect.
Value	All cetaceans are categorised as European Protected Species. Therefore they have a high value. Seals are categorised as Annex II species of Community Interest. Therefore they have a high value.
Overall sensitivity	The potential sensitivity on marine mammals is rated as Low.

5.13.204 The magnitude of the impact has been assessed as **Negligible**, with the maximum sensitivity of the receptors being **Low**. Therefore, the significance of effect from changes in prey abundance occurring as a result of construction activities is **Not Significant**.

5.13.205 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Residual effect assessment

The significance of effect from changes in prey availability and distribution is not significant in EIA terms. Therefore, no additional mitigation to that already identified in Table 13 are considered necessary. Therefore, ***no significant adverse residual effects*** *have been predicted in respect of marine mammals.*

5.14 Environmental assessment: operational phase

5.14.1 The potential environmental impacts arising from the operation and maintenance of the offshore infrastructure are listed in Table 12 along with the MDO against which each operation and maintenance phase impact has been assessed. Further details on the activities, scheduled and unplanned, are found within the Project Description Chapter. A description of the potential impact on marine mammal receptors caused by each impact under consideration is given below.

Impact 11: Disturbance from vessel noise (O&M)

5.14.2 As stated in the text for Impact 8: Vessel collision risk (construction), the area surrounding the proposed development already experiences a high amount of vessel traffic (see Volume 3, Chapter 10: Shipping and Navigation for full details). It is estimated that a maximum of six O&M vessels will be utilised (on average, two vessels shall be utilised per day), resulting in 1,095 round trips (to port) per year of O&M (generally single-trips per day, operating 7 days/week = 365 trips/vessel. Two vessels = 730, plus margin for exceptional years) (Table 12). A proportion of these vessels will be stationary or slow moving throughout O&M activities for significant periods of time. The actual increase in vessel traffic moving around the site and to/from port to the site will occur over short periods of the offshore O&M activity. Fewer unique vessels will be introduced to the area than during the construction phase and, due to the already high volume of vessel traffic already in the study area, the introduction of these vessels is not a novel impact for marine mammals present in the area.

5.14.3 Given this level of activity, there is unlikely to be the potential for significant disturbance as a result of O&M vessels. The magnitude of disturbance from O&M vessels is described in Table 74 and the sensitivity of marine mammals to vessel activity is Low (described previously in section 5.13.166).

Table 74 Determination of magnitude for vessel disturbance

Definition	MDO	ADO
Extent	Low - The spatial extent will be limited to the Array area and the ECC to/from port.	The MDO and ADO are aligned.
Duration	Medium - The impact is anticipated to be long-term (15 – 60 years over the life time of the O&M phase).	The MDO and ADO are aligned.
Frequency	Low - The impact will occur frequently throughout a relevant project phase**.** Three daily CTV trips with the addition of up to 100 vessels trips to support scheduled routine and non-routine maintenance per year.	Low - The impact will occur frequently throughout a relevant project phase**.** 2 daily CTV trips with the addition of up to 75 vessels trips to support scheduled routine and non-routine maintenance per year.
Probability	Medium – there is evidence in the literature that these activities can cause disturbance in marine mammals, however information on the level of disturbance and impact range for most species is limited.	The MDO and ADO are aligned.
Consequence	Low - Local scale, intermittent disturbance to a very small proportion of the population is unlikely to result in impacts on individual survival or reproductive rates and population size or trajectory is expected to be unchanged.	The MDO and ADO are aligned.
Overall magnitude	*The potential magnitude on marine mammals is rated as Low.*	*The potential magnitude on marine mammals is rated as Low.*

5.14.4 The magnitude of the impact has been assessed as **Low adverse**, with the maximum sensitivity of the receptors being **Low**. Therefore, the significance of effect from disturbance from vessel noise is **Slight adverse**, which is not significant in EIA terms.

5.14.5 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Residual effect assessment

The significance of effect from disturbance from vessel noise is not significant in EIA terms. Therefore, no additional mitigation to that already identified in Table 13 are considered necessary. Therefore, ***no significant adverse residual effects*** *have been predicted in respect of marine mammals.*

Impact 12: Vessel collision risk (O&M)

5.14.6 The area surrounding the proposed development already experiences a high amount of vessel traffic (see Volume 3, Chapter 10: Shipping and Navigation for full details). Therefore, the introduction of additional vessels during O&M is not a novel impact for marine mammals present in the area.

5.14.7 Harbour porpoises, dolphins and seals are relatively small and highly mobile, and given observed responses to noise, are expected to detect vessels in close proximity and largely avoid collision. Predictability of vessel movement by marine mammals is known to be a key aspect in minimising the potential risks imposed by vessel traffic (Nowacek *et al.*, 2001, Lusseau, 2003, 2006). The implementation of a code of conduct by all vessel operators when encountering marine species detailed within an environmental VMP (see Table 13) will ensure that vessel traffic moves along predictable routes and will define how vessels should behave in the presence of marine mammals.

5.14.8 It is estimated that a maximum of four vessel construction vessels will be utilised, resulting in 1,080 round trips per year of O&M (Table 12). A proportion of these vessels will be stationary or slow moving throughout O&M activities for significant periods of time. The actual increase in vessel traffic moving around the site and to/from port to the site will occur over short periods of the offshore O&M activity. Fewer unique vessels will be introduced to the area than during the construction phase and, due to the already high volume of vessel traffic already in the Study area, the introduction of these vessels is not a novel impact for marine mammals present in the area.

5.14.9 It is not expected that the level of vessel activity during operations would cause an increase in the risk of mortality from collisions. The adoption of a vessel management plan during operations will minimise the potential for any impact. Therefore, the risk of vessel collisions occurring is of **Negligible** magnitude (Table 75). All marine mammal receptors are considered to have a **High** sensitivity to vessel collisions (see Table 68).

Table 75 Determination of magnitude for marine mammals

Definition	MDO	ADO
Extent	Negligible - Given the implementation measures listed in Table 13, particularly vessel code of contact to be applied when encountering marine species.	The MDO and ADO are aligned.
Duration	Medium - The impact is anticipated to be long-term (15 – 60 years over the life time of the O&M phase).	The MDO and ADO are aligned.
Frequency	Low - The impact will occur frequently throughout a relevant project phase**.** Three daily CTV trips with the addition of up to 100 vessels trips to support scheduled routine and non-routine maintenance per year.	Low - The impact will occur frequently throughout a relevant project phase**.** 2 daily CTV trips with the addition of up to 75 vessels trips to support scheduled routine and non-routine maintenance per year.
Probability	Negligible - Given the implementation measures listed in Table 13, particularly vessel code of contact to be applied when encountering marine species, the likelihood of any marine mammal collision with O&M vessels is highly unlikely.	The MDO and ADO are aligned.
Consequence	Negligible - Given the implementation measures listed in Table 13, particularly vessel code of contact to be applied when encountering marine species, there is expected to be no effect or consequence for marine mammals.	The MDO and ADO are aligned.
Overall magnitude	*The potential magnitude on marine mammals is rated as Negligible.*	*The potential magnitude on marine mammals is rated as Negligible.*

5.14.10 The magnitude of the impact has been assessed as **Negligible**, with the maximum sensitivity of the receptors being **High**. Therefore, the significance of effect from collision risk from O&M vessels is **Not Significant**.

5.14.11 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Residual effect assessment

The significance of effect from vessel collision during O&M is not significant in EIA terms. Therefore, no additional mitigation to that already identified in Table 13 are considered necessary. Therefore, ***no significant adverse residual effects*** *have been predicted in respect of marine mammals.*

Impact 13: Increases in suspended sediment concentrations (O&M)

5.14.12 During O&M, SSC could potentially be increased and an associated deposition of material within the array area and Offshore ECC may occur from the following activity:

- Reburial or replacement of cables.

5.14.13 If a section of the cable became exposed or damaged during O&M it would require reburial and/ or replacement. Reburial or replacement would be undertaken similarly to during construction and result in the resuspension of sediment, although the potential impact is expected to be more localised and of shorter duration.

5.14.14 Any disturbance to the seabed will be localised and any resultant increase in SSC will be temporary. The changes in SSC and resultant water quality during O&M are anticipated to be lesser than those associated with construction, which were considered to be of Low adverse magnitude to marine mammals and, therefore the magnitude during O&M is also rated as **Low adverse** (Table 69). As previously discussed in Impact 9: Increases in suspended sediment concentrations, marine mammals have **Negligible** sensitivity to this potential impact (Table 70).

5.14.15 The magnitude of the impact has been assessed as **Low adverse**, with the maximum sensitivity of the receptors being **Negligible**. Therefore, the significance of effect from an increase in suspended sediment concentration occurring as a result of O&M of the offshore infrastructure is **Negligible**, which is not significant in EIA terms.

Residual effect assessment

The significance of effect from increased suspended sediment concentration during O&M is not significant in EIA terms. Therefore, no additional mitigation to that already identified in Table 13 are considered necessary. Therefore, ***no significant adverse residual effects*** *have been predicted in respect of marine mammals.*

Impact 14: Changes in prey availability and distribution (O&M)

5.14.16 As previously discussed in Section 5.13 Impact 10: Changes in prey availability and distribution (construction) marine mammals are dependent on fish prey. Therefore, there is the potential for indirect effects on marine mammals as a result of impacts upon fish species or the habitats that support them. The key prey species for each marine mammal receptor are listed in Table 71.

5.14.17 During O&M activities, there is the potential for impacts upon fish species, including:

- Long-term loss of habitat;
- Temporary increase in SSC and sediment deposition;
- Increased hard substrate and structural complexity;
- Electromagnetic field (EMF);

- Direct physical damage and disturbance;
- Seabed disturbances leading to the release of sediment contaminants and /or accidental contamination; and
- Changes to supporting seabed habitats arising from effects on physical processes.

5.14.18 Volume 3, Chapter 5: Fish and Shellfish Ecology concludes no significant adverse residual effects in respect of fish and shellfish ecological receptors from construction activities.

5.14.19 Since there is expected to be no significant impacts on fish species, the potential magnitude of impact on marine mammals is rated as **Negligible** (Table 76, Table 72).

5.14.20 It is known that the presence of anthropogenic structures in the marine environment can act as fish aggregating devices and artificial reef systems (Guerin *et al.*, 2007, Zawawi *et al.*, 2012). Further, ongoing studies have shown increases in fish abundance near WTG sites. Initial findings as part of the ongoing multi-year PrePARED (Predators + Prey Around Renewable Energy Developments) Project have shown there to be an increase in flatfish and gadoid abundance at the Beatrice and Moray East offshore wind farms, when compared with outside offshore wind farm reference sites (i.e., sites where data on flatfish and gadoid abundance were recorded, but located outwith of any offshore wind farm area) (PrePARED, 2024).

5.14.21 These findings support a number of studies which have reported the increased presence of foraging marine mammals within operational offshore wind farms and other marine structure sites. For example, Russell *et al*. (2014) found that some tagged harbour and grey seals demonstrated grid-like movement patterns as these animals moved between individual WTGs, strongly suggestive of these structures being used for foraging. Further, studies at Dutch and Danish OWFs (Scheidat *et al.*, 2011) and in the Moray Firth in Scotland (Fernandez-Betelu *et al.*, 2022) suggest that harbour porpoise may be attracted to anthropogenic structures due to the potential for increased foraging opportunities within operating offshore windfarms. The study conducted by Fernandez-Betelu et al. (2022) found the increased foraging activity and the occurrence of harbour porpoise happened at night, with the change in diel pattern being specifically linked to the presence of an offshore structure. There was also a significant increase in porpoise presence and foraging activity near isolated offshore structures (Fernandez-Betelu *et al.*, 2022) which again, could be linked to increased foraging opportunities.

5.14.22 Despite there being reported links between increased foraging opportunities and the presence of anthropogenic structures, one new study suggests that the introduction of WTGs may moderate the types of prey present within offshore wind farm sites. Using modelled sandeel distribution maps to characterise spatio-temporal variation in the occurrence and foraging behaviour of harbour porpoises around offshore windfarms, Fernandez-Betelu *et al.* (2024) found that the positive relationship between harbour porpoise presence and sandeel densities were weaker at one offshore wind farm site post-construction, and absent from another, when compared with pre-construction data. However, as aforementioned, early results from the PrePARED project suggest that the abundance of gadoids and flatfish is higher within constructed windfarms compared to outside offshore wind farm reference areas (PrePARED, 2024), and therefore, such changes in prey populations may modify the positive relationship between porpoise occurrence and sandeel density observed in the pre-construction data (Fernandez-Betelu *et al.*, 2024). The authors did highlight however that definitive conclusions are constrained, as there was only a single year of post-construction data (Fernandez-Betelu *et al.*, 2024).

5.14.23 Overall, it is anticipated that there will be no significant indirect negative impacts to marine mammals through changes in prey abundance and distribution. Any potential habitat change as a result of fish aggregation or artificial reefs is expected to positively affect marine mammals by providing novel foraging opportunities and is therefore assessed as being of minor beneficial significance to marine mammals. Further, given the expected adaptability of most marine mammal species to find alternative prey species or locations, it is highly likely that impacts to prey species would result in only very slight or imperceptible changes to marine mammal receptors, and it is expected that this will not result in any population level change. Therefore, indirect impacts on prey species during operations and maintenance are most likely to be of Negligible magnitude.

Table 76 Determination of magnitude for changes in prey availability

Definition	MDO	ADO
Extent	**Habitat loss:** impacts on fish species restricted to the immediate footprint of the infrastructure. **SSC:** impacts on fish species even more localized than construction. **Hard substrate:** impacts on fish species restricted to the placement of infrastructure. **EMF:** impacts on fish species restricted to the proposed development area (near-field), within the order of 10 m each side of the cable. **Damage & disturbance:** impacts on fish species restricted to the immediate footprint of operational and maintenance activities.	The MDO and ADO are aligned.
Duration	**Habitat loss:** long-term. **SSC:** impacts on fish species will be less than construction.	The MDO and ADO are aligned.

Definition	MDO	ADO
	Hard substrate: long-term. **EMF:** long-term **Damage & disturbance:** temporary and of short-term duration.	
Frequency	**Habitat loss:** constantly throughout the operational phase. **SSC:** impacts on fish species will occur less frequently less than construction. **Hard substrate:** constantly throughout the operational phase. **EMF:** constantly throughout the operational phase. **Damage & disturbance:** intermittently throughout the operational phase.	The MDO and ADO are aligned.
Consequence	**Habitat loss:** no discernible loss of resource, imperceptible consequence to fish species. **SSC:** no discernible loss of resource, imperceptible consequence to fish species. **Hard substrate:** no discernible effect on fish species **EMF:** may be detectable within the immediate nearfield of the cables (within 10 m). **Damage & disturbance:** no discernible change to fish species. **Marine mammals:** Since there is expected to be no significant impacts to fish species, there is expected to be no subsequent impact to marine mammals (Negligible consequence).	The MDO and ADO are aligned.
Overall magnitude	The potential magnitude of impact on marine mammals is rated as Negligible.	*The potential magnitude of impact on marine mammals is rated as Negligible.*

5.14.24 The sensitivity of all marine mammals was assessed as Low (Table 73).

5.14.25 The magnitude of the impact has been assessed as **Negligible**, with the maximum sensitivity of the receptors being **Low**. Therefore, the significance of effect from changes in prey abundance occurring as a result of O&M activity on offshore infrastructure is **Not Significant**.

5.14.26 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Residual effect assessment

The significance of effect from changes in prey availability and abundance during O&M is not significant in EIA terms. Therefore, no additional mitigation to that already identified in Table 13 are considered necessary. Therefore, ***no significant adverse residual effects*** *have been predicted in respect of marine mammals.*

5.15 Environmental assessment: decommissioning phase

5.15.1 As referenced in the Project Description, the Decommissioning and Restoration Plan (Volume 7, Appendix 2), including the three rehabilitation schedules attached thereto, describes how the Applicant proposes to rehabilitate that part of the maritime area, and any other part of the maritime area, adversely affected by the permitted maritime usages that are the subject of the MACs (Reference Nos. 2022-MAC-003 and 004 / 20230012 and 240020).

5.15.2 It is based on the best scientific and technical knowledge available at the time of submission of this Planning Application. However, the lengthy passage of time between submission of the Planning Application and the carrying out of decommissioning works (expected to be in the region of 35 years as defined in the MDO) gives rise to knowledge limitations and technical difficulties. Accordingly, the Decommissioning and Restoration Plan will be kept under review by the Applicant as the project progresses, and an alteration application will be submitted if necessary. In particular, it will be reviewed having regard to the following:

- The baseline environment at the time rehabilitation works are proposed to be carried out,
- What, if any, adverse effects have occurred that require rehabilitation,
- Technological developments relating to the rehabilitation of marine environments,
- Changes in what is accepted as best practice relating to the rehabilitation of marine environments,
- Submissions or recommendations made to the Applicant by interested parties, organisations and other bodies concerned with the rehabilitation of marine environments, and/or
- Any new relevant regulatory requirements.

5.15.3 The Decommissioning and Restoration Plan outlines the process for decommissioning of the WTG, foundations, scour protection, OSP, inter array cables and Offshore ECC. The plan outlines the assumption that the most practicable environmental option is to leave certain structures in situ (e.g. inter array cables, scour protection), however the general principle for decommissioning is for all surface structures to be removed and it is assumed that the wind turbine generators (WTG's) will be dismantled and completely removed to shore. Piled foundations will be cut at a level below the seabed, buried cables and scour and cable protection left in situ.

Impact 15: Disturbance (decommissioning)

5.15.4 The Decommissioning and Restoration Plan details the process for dismantling and removal of the WTGs and the provision for piled foundations to be cut below seabed level, and the remaining sections below the cut left in situ. Typical current methods for cutting piles are abrasive water jet cutters or diamond wire cutting. The final method chosen shall be dependent on the technologies available at the time of decommissioning.

5.15.5 As the exact methods to be used for decommissioning are to be decided subject to the technology available at the time of decommissioning, the impact from disturbance levels of decommissioning activities can only be estimated at this time. When considering the implementation of the avoidance and preventative measures incorporated in an environmental VMP and a MMMP specific to decommissioning activities (Table 13) , the impacts of decommissioning activities will likely be similar, or of a lesser extent, than during piling in the construction phase and therefore will be of **Slight adverse** significance, therefore, not significant in EIA terms.

5.15.6 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Residual effect assessment

The significance of effect from disturbance from decommissioning activities is not significant in EIA terms. Therefore, no additional mitigation to that already identified in Table 13 are considered necessary. Therefore, ***no significant adverse residual effects*** *have been predicted in respect of marine mammals.*

Impact 16: Vessel collision risk (decommissioning)

5.15.7 As stated in section 1.12, the area surrounding the proposed development already experiences a high amount of vessel traffic. Therefore, the introduction of additional vessels during the decommissioning is not a novel impact for marine mammals present in the area.

5.15.8 Harbour porpoises, dolphins and seals are relatively small and highly mobile, and given observed responses to noise, are expected to detect vessels in close proximity and largely avoid collision. Predictability of vessel movement by marine mammals is known to be a key aspect in minimising the potential risks imposed by vessel traffic (Nowacek *et al.*, 2001, Lusseau, 2003, 2006). The implementation of avoidance and preventative measures incorporated in a VMP (see Table 13) will ensure that vessel traffic moves along predictable routes and will define how vessels should behave in the presence of marine mammals.

5.15.9 It is anticipated that collision risk during decommissioning will the same as during the construction phase, with a similar number of vessels (107) and round trips anticipated over three years (2,660). The majority of vessel used during decommissioning will be large vessels that are stationary or slow moving throughout decommissioning activities for significant periods of time. Therefore, the actual increase in vessel traffic moving around the site and to/from port to the site will occur over short periods of the offshore decommissioning activity.

5.15.10 It is not expected that the level of vessel activity during decommissioning would cause an increase in the risk of mortality from collisions. Considering the implementation of appropriate measures within an environmental VMP during decommissioning, the risk of vessel collisions occurring is of **Negligible** magnitude.

5.15.11 All marine mammal receptors are deemed to be of low vulnerability given that vessel collision is not considered to be a key source of mortality highlighted from post-mortem examinations of stranded animals. However, should a collision event occur, this has the potential to kill the animal. As a result of the low vulnerability to a strike but the serious consequences of a strike, marine mammal receptors are considered to have a **High** sensitivity to vessel collisions.

5.15.12 The magnitude of the impact has been assessed as **Negligible**, with the maximum sensitivity of the receptors being **High**. Therefore, the significance of effect from collision risk from decommissioning vessels is **Negligible**, which is not significant in EIA terms.

5.15.13 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Residual effect assessment

*The significance of effect from vessel collision is not significant in EIA terms. Therefore, no additional mitigation to that already identified in Table 13 are considered necessary. Therefore, **no significant adverse residual effects** have been predicted in respect of marine mammals.*

Impact 17: Increases in suspended sediment concentrations (decommissioning)

5.15.14 During decommissioning activity, SSC could potentially be increased and an associated deposition of material within the array area and ECC may occur from activities conducted in reverse of the construction process to remove monopile and jacket foundation legs and cut below the seabed.

5.15.15 Any disturbance to the seabed will be localised and any resultant increase in SSC will be temporary. The changes in SSC and resultant water quality during decommissioning are anticipated to be similar or lesser than those associated with construction, which were considered to be of low adverse magnitude to marine mammals and, therefore the magnitude during decommissioning is also rated as **Low adverse**.

5.15.16 As previously discussed in section 5.13 – Impact 9: Increases in suspended sediment concentrations, marine mammals are well-adapted to foraging in turbid and poor visibility conditions which may result from an increase in suspended sediment (e.g. Pierpoint, 2008, Marubini *et al.*, 2009, Hastie *et al.*, 2016). Therefore, marine mammals have **Negligible** sensitivity to this potential impact (Table 70).

5.15.17 The magnitude of the impact has been assessed as **Low adverse**, with the maximum sensitivity of the receptors being **Negligible**. Therefore, the significance of effect from changes in SSC and associated sediment deposition occurring as a result of foundation and cable removal activities in the intertidal area is **Negligible**, which is not significant in EIA terms.

5.15.18 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Residual effect assessment

The significance of effect from increased suspended sediment concentrations is not significant in EIA terms. Therefore, no additional mitigation to that already identified in Table 13 are considered necessary. Therefore, ***no significant adverse residual effects*** *have been predicted in respect of marine mammals.*

Impact 18: Changes in prey availability and distribution (decommissioning)

5.15.19 As previously discussed in Impact 10: Changes in prey availability and distribution (construction) marine mammals are dependent on fish prey. Therefore, there is the potential for indirect effects on marine mammals as a result of impacts upon fish species or the habitats that support them. The key prey species for each marine mammal receptor are listed in Table 71.

5.15.20 During decommissioning activities, there is the potential for impacts upon fish species, including:

- Temporary physical loss and disturbance;
- Temporary increases in SSC and sediment deposition;
- Seabed disturbances leading to the release of sediment contaminants and /or accidental contamination; and
- Additional underwater noise and vibration.

5.15.21 Volume 3, Chapter 5: Fish and Shellfish Ecology concludes no significant adverse residual effects in respect of fish and shellfish ecological receptors from decommissioning activities. In general, impacts were considered to be comparable to that described during the construction phase.

5.15.22 Since there is expected to be no significant impacts on fish species, the potential magnitude of impact on marine mammals is rated as **Negligible** (Table 72, Table 76).

5.15.23 The sensitivity of all marine mammals was assessed as Low (Table 73).

5.15.24 The magnitude of the impact has been assessed as **Negligible**, with the maximum sensitivity of the receptors being **Low**. Therefore, the significance of effect from changes in prey abundance occurring as a result of decommissioning the proposed development is **Negligible**, which is not significant in EIA terms.

5.15.25 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Residual effect assessment

The significance of effect from changes in prey availability and abundance is not significant in EIA terms. Therefore, no additional mitigation to that already identified in Table 13 are considered necessary. Therefore, ***no significant adverse residual effects*** *have been predicted in respect of marine mammals.*

5.16 Environmental assessment: cumulative effects

Methodology

5.16.1 This section outlines the Cumulative Effect Assessment for marine mammals and takes in account the impacts of the proposed development alone, together with other plans and projects. As outlined in the Cumulative Effect Assessment Methodology chapter (Volume 2, Chapter 4: Annex A Offshore long-list), the screening process involved determination of appropriate search areas for projects, plans and activities and Zones of Influence (ZoIs) for potential cumulative effects. These were then screened according to the level of detail publicly available and the potential for interactions with regard to the presence of an impact pathway as well as spatial and temporal overlap. The full list of plans and projects considered, including those screened out, are presented in (Volume 2, Chapter 4: Annex A Offshore long-list). For the purposes of the Cumulative Effects Assessment, a precautionary construction period has been assumed between the years 2029 to 2032, with offshore construction (excluding preparation works) lasting up 30 months as a continuous phase within this period (refer to Volume 2, Chapter 6: Project Description). After construction, Dublin Array will be operational for 35 years.

5.16.2 The CEA long list of projects, plans and activities with which Dublin Array's offshore infrastructure has the potential to interact with to produce a cumulative effect is presented within the Cumulative Effect Assessment Methodology chapter (Volume 2, Chapter 4: Annex A Offshore Long-list). Each plan and project has been considered on case by case basis with the maximum suite of projects identified from a long list within a search area defined by the extent of the relevant marine mammal reference population area (MU) for the potential effects for large scale developments such as planned offshore wind farm projects. This accounts for the often long construction periods for offshore wind farms, and the fact that, given marine mammals are wide ranging species, they may be exposed to construction at multiple wind farms within their MU.

5.16.3 For all other types of planned offshore projects (e.g. coastal assets, cables) the screening range was the OSPAR Region III: Celtic Seas (see Figure 37) due to the smaller scale nature of the projects compared to large commercial scale offshore wind farms.

5.16.4 The following impacts were scoped out of the CEA:

- Auditory injury (PTS): since suitable mitigation will be put in place to reduce injury risk to marine mammals to negligible levels (as a requirement of European Protected Species legislation);

- Collision risk from vessel activity: since project specific Vessel Management Plans will be in place to reduce this already low risk of impact; and
- Any other impacts that are assessed as having a negligible magnitude during the project alone assessment (this includes: increases in suspended sediment concentrations, and changes in prey availability and distribution)[42].

5.16.5 Therefore, the CEA for marine mammals will cover the following impacts:

- Disturbance from underwater noise during construction activities and disturbance from potential large-scale oil and gas seismic airgun surveys; and
- Disturbance from vessel activities.

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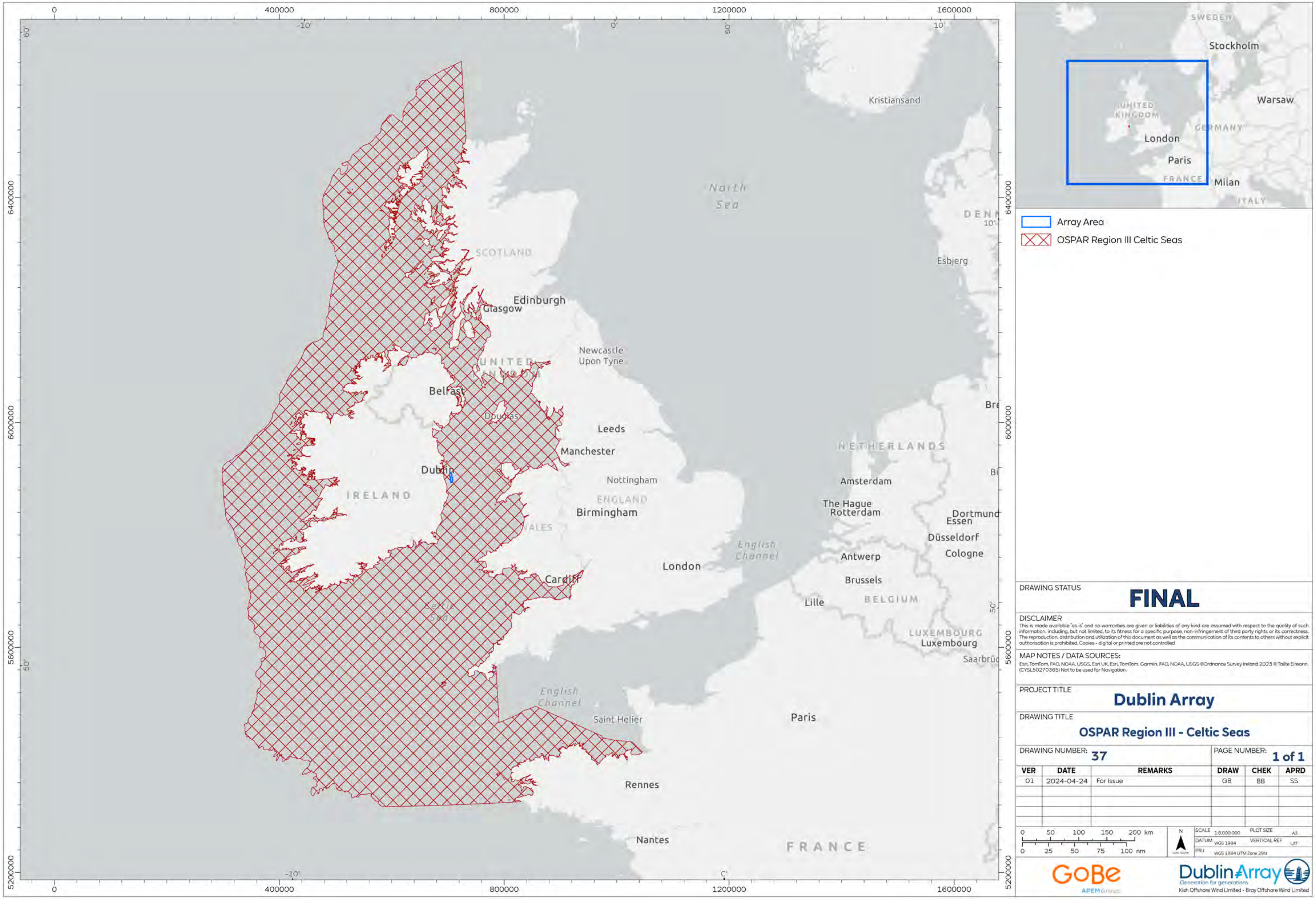
[42] Impacts with a negligible magnitude are not expected to contribute significantly to a Cumulative Effect Assessment. Any cumulative level effect would be expected even in the absence of Dublin Array since the contribution of Dublin Array is negligible.



▭	Array Area
▨	OSPAR Region III Celtic Seas

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PROJECT TITLE

Dublin Array

DRAWING TITLE

OSPAR Region III - Celtic Seas

DRAWING NUMBER: 37

PAGE NUMBER: 1 of 1

VER	DATE	REMARKS	DRAW	CHEK	APRD
01	2024-04-24	For Issue	GB	BB	SS

SCALE	1:6,000,000	PLOT SIZE	A3
DATUM	WGS 1984	VERTICAL REF	LAT
PRJ	WGS 1984 UTM Zone 29N		

GoBe APEM Group

Dublin Array Generation for generations

Kish Offshore Wind Limited - Bray Offshore Wind Limited

Projects for cumulative assessment

5.16.6 The specific projects scoped into this Cumulative Effect Assessment, and the tiers into which they have been allocated are presented in the tables below for each species assessed.

Effect 19: Disturbance from underwater noise

Approach – Phase 1 Offshore wind projects in Ireland

5.16.7 Additional modelling was conducted to assess whether cumulative disturbance resulting from pile driving activities across the five Irish Phase 1 Offshore Windfarm Projects (Dublin Array, NISA, Codling, Oriel, Arklow) is predicted to result in population level impacts to four marine mammal species (harbour porpoise, bottlenose dolphins, harbour and grey seals). For this assessment each Phase 1 Project provided an indicative piling schedule and the number of animals predicted to be disturbed per piling day.

5.16.8 For full details of the methodology and the key limitations of the iPCoD model approach, please see the Cumulative iPCoD modelling report (Volume 4, Appendix 4.3.5-6).

5.16.9 The following Management Units (MUs) were assumed in the assessment:

- Harbour porpoise: Celtic and Irish Sea MU, as advised in IAMMWG (2023): 62,517 porpoise
- Bottlenose dolphin: Irish Sea MU, total abundance obtained by summing the two SCANS IV blocks within the MU: 8,199 in CS-D + 127 in CS-E = 8,326 bottlenose dolphins
- Harbour seal: Southeast & East RoI & Northern Ireland MU: August haul-out counts from Morris and Duck (2019) and SCOS (2023) scaled to account for animals at sea: 1,365 seals
- Grey seal: Southeast & East RoI & Northern Ireland MU: August haul-out counts from Morris and Duck (2019) and SCOS (2023) scaled to account for animals at sea: 6,056 seals.

5.16.10 For the purposes of a comparative assessment between the Phase 1 projects, and assuming a precautionary construction period between the years 2029 to 2032, the construction profile of each the five phase 1 projects was ascertained in order to establish the indicative piling schedules (with information provided to the Applicant by the other four phase 1 projects). The indicative piling schedules are presented within the modelling report. Where Projects had different piling schedules for monopiles and pin-piled jacket foundations, both were provided:

- Piling schedule 1 (Figure 38): Monopiles at all five Projects, Piling January 2027 to December 2029 inclusive
- Piling schedule 2 (Figure 39): Monopiles at Arklow, Oriel and Codling, Pin-pile jackets at NISA and Dublin, Piling January 2027 to March 2031 inclusive.

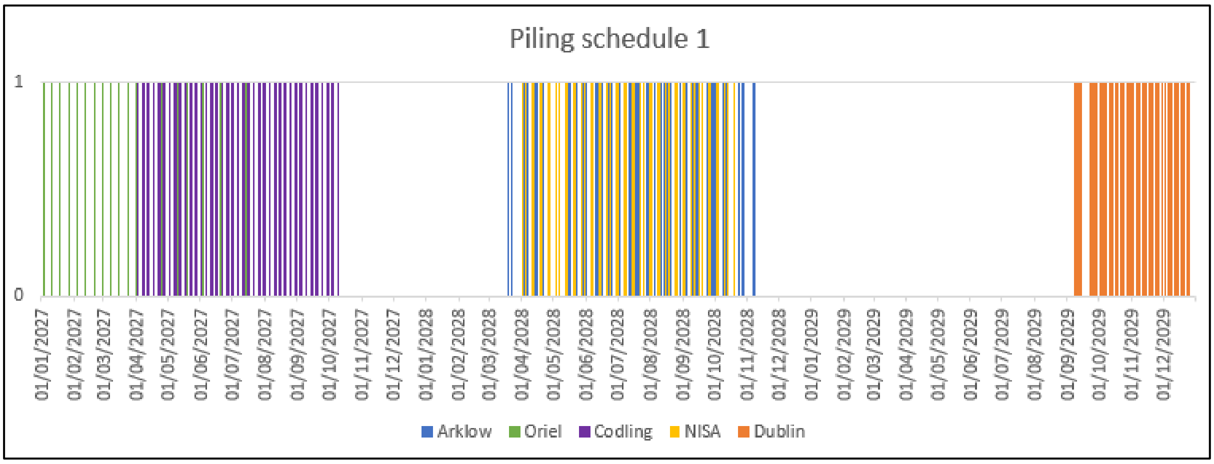

Figure 38 Piling schedule 1: Monopiles at all five Phase 1 Projects.

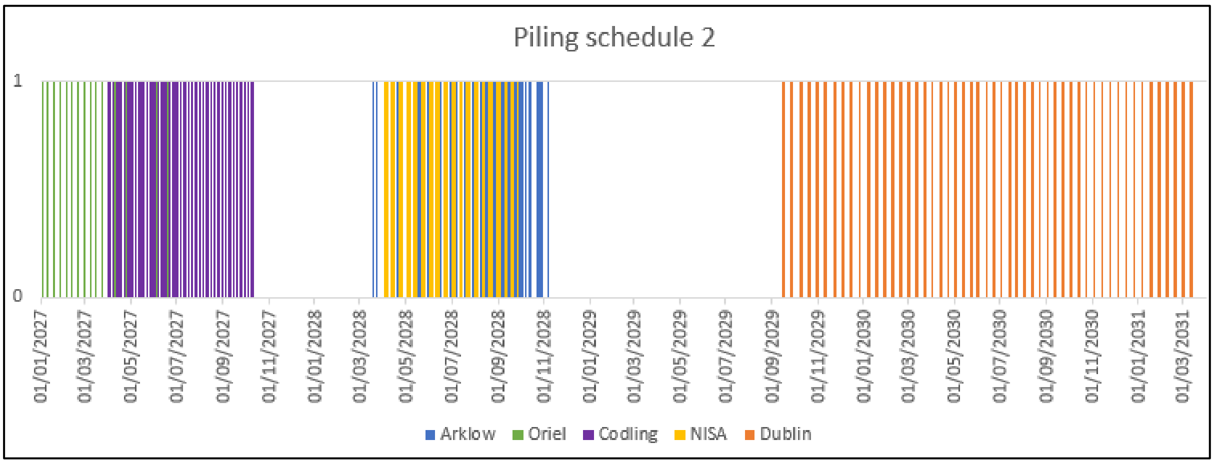

Figure 39 Piling schedule 2: Monopiles at Arklow, Oriel and Codling, pin-piled jackets at NISA and Dublin.

Approach – All projects

5.16.11 Where a quantitative impact assessment has been provided for marine mammals in a project EIAR chapter or equivalent (i.e., ES, PEIR), the maximum number of animals disturbed per day presented in the assessment is used in the quantitative cumulative assessment here.

5.16.12 For all offshore projects where there is no quantitative impact assessment available (pre-application stage projects or non-UK/Ireland projects), an indicative number of animals disturbed per day has been calculated for each project during construction, as follows:

- For cetaceans:
  - fixed OWF in the UK/Ireland: 26 km EDR[43] (impact area of 2,124 km^2);
  - floating OWF in the UK/Ireland: 15 km EDR[44] (impact area of 707 km^2);

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[43] Using monopile EDR from JNCC (2010)

[44] Using pinpile EDR from JNCC (2010)

  - non-UK/Ireland OWF projects: 15 km EDR[45] (impact area of 707 km^2);
  - tidal, cable and coastal projects: 5 km EDR (impact area of 79 km^2); and
  - SCANS IV block density (or ObSERVE strata density).
- For seals:
  - fixed OWF in the UK/Ireland: 25 km EDR[46] (impact area of 1,964 km^2);
  - floating OWF in the UK/Ireland: 15 km EDR[47] (impact area of 707 km^2);
  - tidal, cable and coastal projects: 5 km EDR (impact area of 79 km^2);
  - OWF projects used average at-sea density across the array area; and
  - Other projects assumed average density across MU.

5.16.13 There are very high levels of uncertainty associated with all projects that do not yet have a quantitative impact assessment available.

5.16.14 Seismic surveys take place within different industries, particularly oil and gas (O&G). The potential number of large-scale seismic airgun surveys that could be undertaken is unknown. It has therefore been assumed that there could be:

- One large-scale seismic airgun survey occurring on any given day in the Irish Sea (bottlenose dolphin);
- Two large-scale seismic airgun surveys occurring on any given day in the Celtic Sea MU (harbour porpoise); and
- Four large-scale seismic airgun surveys occurring on any given day in the Celtic and Greater North Seas MU (minke whale and common dolphin).

5.16.15 The daily impacted area from a large-scale seismic airgun survey has precautionarily been assumed to be 1,759 km^2 based on advice provided by JNCC (2023) for harbour porpoise.

Project screening

5.16.16 Projects were screened out of the cumulative assessment short-list for underwater noise during the construction if:

- They are not expected to construct between 2024 and 2034 inclusive
- There is no timeline available for the construction period of the project.

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[45] Using mitigated piling for monopiles EDR from JNCC (2010)

[46] Using disturbance ranges from Russell et al. (2016b)

[47] Using pinpile EDR from JNCC (2010)

5.16.17 The projects screened into the cumulative assessment of underwater noise during the construction of the proposed development cumulatively with other plans and projects are listed in Table 77 (projects with a quantitative impact assessment available), Table 78 (non-UK/Irish projects) and Table 79 (projects without a quantitative impact assessment available). These three tables detail the offshore construction period for each project, within which offshore construction may take place.

5.16.18 Survey projects and subsea cables associated with offshore renewable energy projects were included in the long-list but are not assessed quantitatively here due to the fact that these projects are already screened in under offshore wind or offshore energy where the highest level of disturbance during construction is assumed (e.g. pile driving).

5.16.19 O&G decommissioning projects were included in the long-list but are not assessed quantitatively here due to the fact that most O&G decommissioning schedules either screen out underwater noise impacts on marine mammals or state that the impacts will be driven by vessel noise.

Table 77 Projects included in the quantitative cumulative assessment for marine mammals: with a quantitative impact assessment available [48]

Type	Project Name	Tier	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	PEIR/ES	CGNS MU	CIS MU	IS MU	EI MU
OWF	Dogger Bank A	1	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No
OWF	Dogger Bank B	1	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No
OWF	Dogger Bank C	1	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No
OWF	East Anglia One North	1	🟦	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No
OWF	East Anglia Three	1	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No
OWF	East Anglia Two	1	🟦	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No
OWF	Inch Cape	1	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No
OWF	Moray West	1	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No
OWF	Neart Na Gaoithe	1	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No
OWF	Norfolk Vanguard East	1	🟦	🟦	🟦	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No
OWF	Norfolk Vanguard West	1	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No
Power	Orkney-Caithness	1	🟦	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No
OWF	Sofia	1	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No
OWF	Awel y Môr	2	⬜	⬜	🟦	🟦	🟦	🟦	🟦	⬛	⬛	⬛	⬛	Yes	Yes	Yes	Yes	No
OWF	Berwick Bank	2	🟦	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No
Power	Cambo (FPSO)	2	⬜	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No
Coastal	Dublin Port Company MP2	2	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	Yes	Yes	Yes	Yes	Yes
OWF	Dudgeon Extension	2	⬜	⬜	🟦	🟦	🟦	🟦	🟦	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No
Coastal	Dún Laoghaire Harbour	2	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	Yes	Yes	Yes	Yes	Yes
Wave	EMEC Bilia Croo	2	⬜	🟦	🟩	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	Yes	Yes	No	No	No
OWF float	Erebus	2	⬜	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	Yes	No	No

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[48] Key:

⬜ Not yet/no longer operational	🟦 Construction	⬛ Operation and Maintenance	Yes – project within Management Unit (MU) (CGNS = Celtic and Greater North Sea, CIS = Celtic and Irish Sea, IS = Irish Sea, EI = East Ireland)	No – project not in MU

Type	Project Name	Tier	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	PEIR/ES	CGNS MU	CIS MU	IS MU	EI MU
OWF	Five Estuaries	2	▒	▒	▒	🟦	🟦	🟦	🟦	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No
OWF	Forthwind	2	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No
Coastal	Greater Dublin Drainage	2	🟦	🟦	🟦	▒	▒	▒	▒	▒	▒	▒	▒	Yes	Yes	Yes	Yes	Yes
OWF	Hornsea Project Four	2	🟦	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No
OWF	Hornsea Project Three	2	🟦	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No
OWF	North Falls	2	▒	🟦	🟦	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No
OWF	Outer Dowsing	2	▒	▒	🟦	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No
OWF float	Pentland Floating	2	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No
OWF	Rampion 2	2	▒	▒	🟦	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No
Power	Rosebank FPSO	2	▒	▒	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No
OWF	Arklow Bank	3	▒	▒	🟦	🟦	🟦	🟦	🟦	⬛	⬛	⬛	⬛	Yes	Yes	Yes	Yes	Yes
OWF	Codling Wind Park	3	▒	▒	▒	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	Yes	Yes	Yes
OWF float	Culzean	3	▒	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No
OWF	Dogger Bank South (East)	3	▒	🟦	🟦	🟦	🟦	🟦	🟦	🟦	⬛	⬛	⬛	Yes	Yes	No	No	No
OWF	Dogger Bank South (West)	3	▒	🟦	🟦	🟦	🟦	🟦	🟦	🟦	⬛	⬛	⬛	Yes	Yes	No	No	No
Coastal	Dublin Port Company 3FM[49]	3	▒	▒	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	Yes	Yes	Yes	Yes	Yes
OWF float	Green Volt	3	▒	🟦	🟦	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No
Power	Greenlink Interconnector	3	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	Yes	Yes	Yes
OWF	Mona	3	▒	▒	🟦	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	Yes	Yes	Yes	Yes	No
OWF	Morecambe	3	▒	▒	🟦	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	Yes	Yes	Yes	Yes	No
OWF	Morgan	3	▒	▒	🟦	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	Yes	Yes	Yes	Yes	No
OWF	North Irish Sea Array	3	▒	▒	▒	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	Yes	Yes	Yes	Yes	Yes
OWF	Oriel	3	▒	▒	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	Yes	Yes	Yes
Power	Orkney Interconnector	3	▒	🟦	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No
OWF float	Salamander	3	▒	▒	🟦	🟦	🟦	🟦	🟦	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No

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[49] No quantitative impact assessment of marine mammals was undertaken within the EIAR for this project

Type	Project Name	Tier	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	PEIR/ES	CGNS MU	CIS MU	IS MU	EI MU
OWF	Sheringham Shoal Extension	3	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No
OWF	West of Orkney	3	▨	▨	▨	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No	No
OWF float	White Cross	3	▨	▨	▨	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	Yes	Yes	Yes	No	No

Table 78 Projects included in the quantitative cumulative assessment for marine mammals: non-UK[50]

Type	Project Name	Tier	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	CGNS MU	CIS MU	IS MU	EI MU
OWF	Courseulles-sur-mer	1	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
OWF	Dieppe Le Tréport	1	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
OWF	Eoliennes en Mer des îles d'Yeu et de Noirmoutier	1	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
OWF	Hollandse Kust (West)	1	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	🟦	🟦	🟦	Yes	No	No	No
OWF	NC2	1	⬜	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	Yes	No	No	No
OWF	Borkum Riffgrund 3	2	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
OWF	Centre-Manche 2	2	⬜	⬜	⬜	⬜	⬜	⬜	🟦	⬛	⬛	⬛	⬛	Yes	No	No	No
OWF	Dunkerque	2	⬜	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
OWF	EnBW He Dreiht	2	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
OWF	IJmuiden Ver	2	⬜	⬜	⬜	⬜	🟦	🟦	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
OWF	N-10.1	2	⬜	⬜	⬜	⬜	⬜	⬜	🟦	🟦	🟦	🟦	🟦	Yes	No	No	No
OWF	N-10.2	2	⬜	⬜	⬜	⬜	⬜	⬜	🟦	🟦	🟦	🟦	🟦	Yes	No	No	No
OWF	N-6.6	2	⬜	⬜	⬜	⬜	🟦	🟦	🟦	🟦	🟦	🟦	🟦	Yes	No	No	No
OWF	N-6.7	2	⬜	⬜	⬜	⬜	🟦	🟦	🟦	🟦	🟦	🟦	🟦	Yes	No	No	No
OWF	N-7.2	2	⬜	⬜	⬜	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
OWF	N-9.1	2	⬜	⬜	⬜	⬜	⬜	🟦	🟦	🟦	🟦	🟦	🟦	Yes	No	No	No
OWF	N-9.2	2	⬜	⬜	⬜	⬜	⬜	🟦	🟦	🟦	🟦	🟦	🟦	Yes	No	No	No
OWF	N-9.3	2	⬜	⬜	⬜	⬜	⬜	🟦	🟦	🟦	🟦	🟦	🟦	Yes	No	No	No
OWF	NC1	2	⬜	⬜	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	Yes	No	No	No
OWF	Sud de la Bretagne	2	⬜	⬜	⬜	⬜	⬜	🟦	🟦	⬛	⬛	⬛	⬛	Yes	No	No	No
OWF	Ten Noorden van de Wadden	2	⬜	⬜	⬜	⬜	⬜	⬜	⬜	🟦	🟦	🟦	🟦	Yes	No	No	No

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[50] Key:

⬜	🟦	⬛	🟩	🟥
Not yet/no longer operational	Construction	Operation and Maintenance	Yes – project within MU	no – project not in MU

Type	Project Name	Tier	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	CGNS MU	CIS MU	IS MU	EI MU
OWF	Thor	2	▨	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
OWF	Centre-Manche 1	3	▨	▨	▨	▨	▨	▨	🟦	⬛	⬛	⬛	⬛	Yes	No	No	No
OWF	NC3	3	▨	▨	▨	▨	🟦	🟦	🟦	🟦	🟦	🟦	🟦	Yes	No	No	No
OWF	NC4	3	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
OWF	Sørlige Nordsjø II	3	▨	▨	▨	▨	▨	▨	🟦	⬛	⬛	⬛	⬛	Yes	No	No	No
OWF	Vest Nordsøen III	3	▨	▨	▨	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No

Table 79 Projects included in the quantitative cumulative assessment for marine mammals: without a quantitative impact assessment available[51]

Type	Project Name	Tier	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	CGNS MU	CIS MU	IS MU	EI MU
OWF float	AMETS floating	1	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No
Coastal	Dublin Port dredging	1	🟦	🟦	🟦	🟦	🟦	🟦	▨	▨	▨	▨	▨	Yes	Yes	Yes	Yes
Power	Eriskay – Barra 2	1	⬛	⬛	⬛	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
OWF	Gode Wind 3	1	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
Coastal	Maintenance dredging River Boyne, Drogheda	1	🟦	🟦	🟦	🟦	🟦	🟦	▨	▨	▨	▨	▨	Yes	Yes	Yes	Yes
Power	Pentland Firth West	1	⬛	⬛	⬛	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
Power	Shetland - Papa Stour	1	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
Power	Shetland HVDC Link	1	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
Power	Skye - South Uist	1	⬛	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
Power	South Uist – Eriskay	1	▨	▨	▨	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
Tidal	West Anglesey Demo Zone	1	▨	▨	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	Yes	No
Tidal	Cardiff Bay Tidal Lagoon	*2*	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No
Coastal	Development south of South Quay Arklow- ABWP2 OMF	2	▨	▨	▨	▨	▨	🟦	🟦	🟦	🟦	▨	▨	Yes	Yes	Yes	Yes
Power	Laxay to Kershader 2	2	⬛	⬛	⬛	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
Power	Mainland Orkney – Hoy South	2	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
Power	Pentland Firth East 3	2	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
Power	Skye - Harris	2	▨	▨	▨	▨	▨	▨	▨	▨	🟦	⬛	⬛	Yes	No	No	No
Power	Skye - Uist	2	▨	▨	▨	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
OWF float	Arven	3	🟦	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
OWF float	Aspen	3	▨	▨	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No

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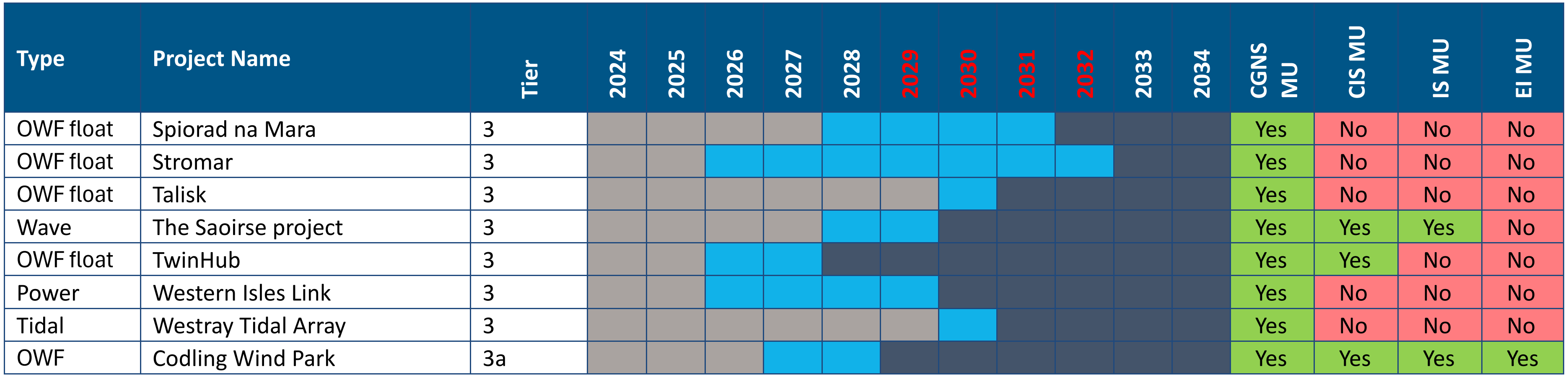
[51] Key:

▨ Not yet/no longer operational	🟦 Construction	⬛ Operation and Maintenance	🟩 Yes – project within MU	🟥 no – project not in MU

Type	Project Name	Tier	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	CGNS MU	CIS MU	IS MU	EI MU
OWF float	Ayre	3	▨	▨	▨	▨	▨	🟦	🟦	🟦	🟦	🟦	⬛	Yes	No	No	No
OWF float	Beech	3	▨	▨	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
OWF float	Bellrock	3	▨	▨	▨	▨	🟦	🟦	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
OWF float	Bowdun	3	▨	▨	▨	▨	▨	🟦	🟦	🟦	🟦	⬛	⬛	Yes	No	No	No
Port	Bremore Port Project	3	▨	▨	▨	▨	🟦	🟦	🟦	⬛	⬛	⬛	⬛	Yes	Yes	Yes	Yes
OWF float	Broadshore	3	🟦	🟦	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
OWF float	Buchan	3	▨	▨	▨	▨	▨	🟦	🟦	🟦	🟦	⬛	⬛	Yes	No	No	No
OWF	Caledonia	3	▨	▨	▨	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
OWF float	Campion	3	🟦	🟦	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
OWF float	Cedar	3	▨	▨	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
OWF float	Cenos	3	▨	▨	▨	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
OWF float	Central North Sea Electrification	3	▨	▨	▨	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
OWF float	Havbredey	3	▨	▨	▨	▨	▨	▨	▨	▨	🟦	🟦	🟦	Yes	No	No	No
Power	IceLink	3	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
OWF float	Llyr 1	3	▨	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No
OWF float	Llyr 2	3	▨	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No
Power	Mares Connect	3	▨	▨	🟦	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	Yes	Yes	Yes	Yes
OWF float	Marram	3	▨	🟦	🟦	🟦	🟦	🟦	🟦	⬛	⬛	⬛	⬛	Yes	No	No	No
Tidal	Mersey Tidal Power	3	▨	▨	▨	▨	🟦	🟦	🟦	🟦	🟦	🟦	🟦	Yes	Yes	Yes	Yes
OWF float	Mooir Vannin	3	▨	▨	▨	▨	▨	▨	🟦	🟦	🟦	⬛	⬛	Yes	Yes	Yes	No
OWF	Morven	3	▨	▨	▨	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
OWF float	Muir Mhòr	3	▨	▨	▨	▨	▨	🟦	🟦	⬛	⬛	⬛	⬛	Yes	No	No	No
OWF	North Channel Wind 1	3	▨	▨	▨	▨	▨	🟦	🟦	⬛	⬛	⬛	⬛	Yes	Yes	Yes	Yes
OWF	North Channel Wind 2	3	▨	▨	▨	▨	▨	🟦	🟦	⬛	⬛	⬛	⬛	Yes	Yes	Yes	Yes
Port	ROSSLARE	3	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	Yes	Yes
OWF	Sceirde Rocks	3	▨	▨	🟦	🟦	🟦	🟦	🟦	⬛	⬛	⬛	⬛	Yes	Yes	No	No



Type	Project Name	Tier	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	CGNS MU	CIS MU	IS MU	EI MU
OWF float	Spiorad na Mara	3	🟫	🟫	🟫	🟫	🟦	🟦	🟦	🟦	⬛	⬛	⬛	Yes	No	No	No
OWF float	Stromar	3	🟫	🟫	🟦	🟦	🟦	🟦	🟦	🟦	🟦	⬛	⬛	Yes	No	No	No
OWF float	Talisk	3	🟫	🟫	🟫	🟫	🟫	🟫	🟦	⬛	⬛	⬛	⬛	Yes	No	No	No
Wave	The Saoirse project	3	🟫	🟫	🟫	🟫	🟦	🟦	⬛	⬛	⬛	⬛	⬛	Yes	Yes	Yes	No
OWF float	TwinHub	3	🟫	🟫	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	No	No
Power	Western Isles Link	3	🟫	🟫	🟦	🟦	🟦	🟦	⬛	⬛	⬛	⬛	⬛	Yes	No	No	No
Tidal	Westray Tidal Array	3	🟫	🟫	🟫	🟫	🟫	🟫	🟦	⬛	⬛	⬛	⬛	Yes	No	No	No
OWF	Codling Wind Park	3a	🟫	🟫	🟫	🟦	🟦	⬛	⬛	⬛	⬛	⬛	⬛	Yes	Yes	Yes	Yes

Conservatism

5.16.20 There are significant levels of precaution/conservatism within this CEA, resulting in the estimated effects being highly precautionary and unrealistic. The main areas of precaution/conservatism in the assessment include:

- The approach of summing across concurrent activities assumes that there is no spatial overlap in the impact footprints between individual activities, which is highly unrealistic considering the proximity of some of the offshore wind farm projects to each other;
- The exact timing of piling driving for each development is unknown, therefore it has been assumed that these activities could occur at any point throughout the construction window. This has resulted in piling activities occurring over multiple consecutive years with associated estimated disturbance levels far greater than would occur in reality;
- The EDRs used are advised for harbour porpoise. No such advice is available for other species and so the same EDRs have been assumed across all species. This is considered conservative since most species show less of a disturbance response compared to harbour porpoise;
- The inclusion of large-scale oil and gas seismic airgun surveys is highly precautionary and should be considered as an unrealistic worst-case scenario;
- The assumption that all fixed OWF will install pile driven monopile foundations. The project envelope for most of these developments includes options for pin-piles or monopiles. As a worst-case assumption monopiles have been assumed; however, it is likely that a portion of these projects will use jacket foundations with pin-piles, which have a much lower recommended effective deterrence range (15 km instead of 26 km, equating to a 66% smaller area) (JNCC 2020), and will therefore disturb far fewer animals;
- Including projects with no quantitative impact assessment currently available is highly precautionary as there is little confidence in the data presented given the assumptions that have had to be made to calculate indicative numbers of animals disturbed by each project.

Harbour porpoise

Phase 1 projects

5.16.21 The iPCoD results show that the level of disturbance predicted under either piling schedule 1 or 2 is not sufficient to result in any changes at the population level, since the impacted population is predicted to continue at a stable trajectory at 99.6 - 99.7% of the size of the un-impacted population (Figure 40 and Figure 41). The overall magnitude is assessed as **Medium** (Table 80). As per the project alone assessment, the sensitivity of harbour porpoise to pile driving is **Low**. Therefore, the overall significance of the cumulative effect of disturbance from piling across the Phase 1 projects is **Slight adverse (not significant)**.

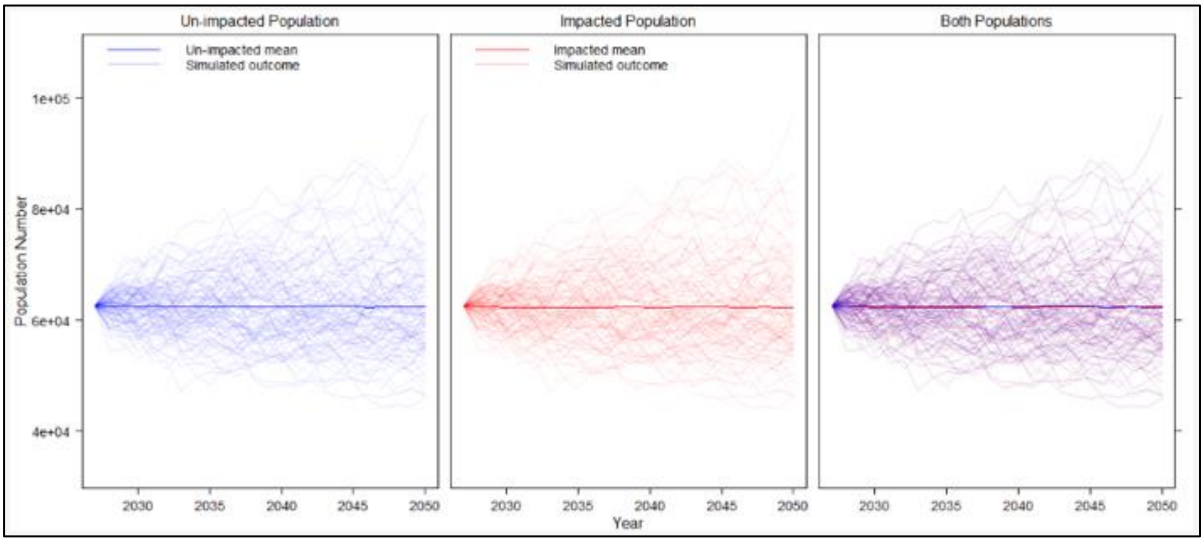


Figure 40 Predicted population trajectories for the un-impacted (baseline) and impacted harbour porpoise iPCoD simulations for piling schedule 1.

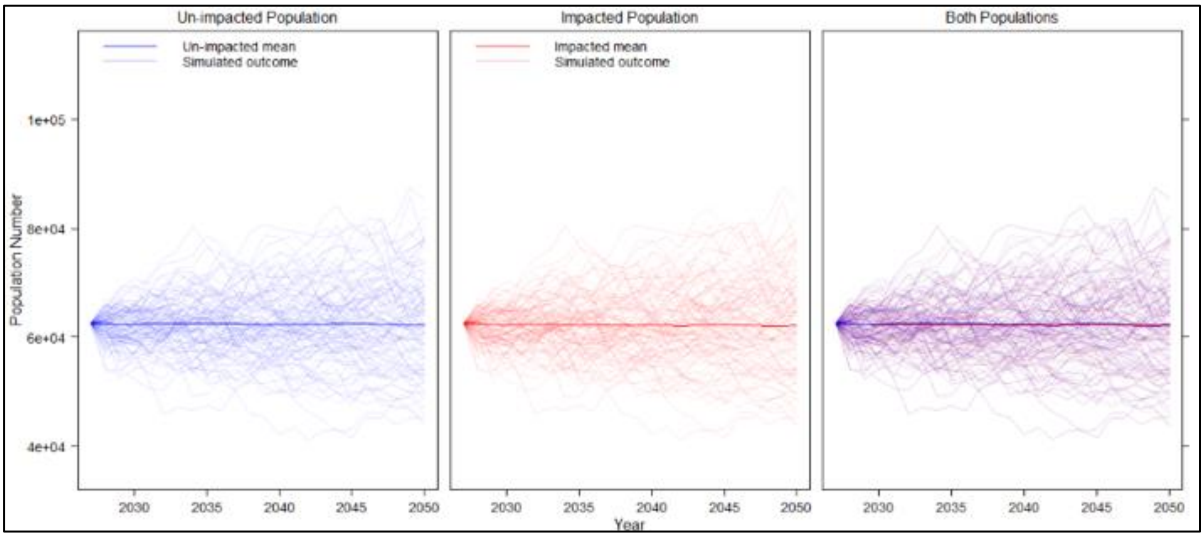


Figure 41 Predicted population trajectories for the un-impacted (baseline) and impacted harbour porpoise iPCoD simulations for piling schedule 2.

Table 80 Determination of magnitude for harbour porpoise for disturbance from foundation piling activity across the Phase 1 projects.

Harbour porpoise	Justification
Duration	Low –behavioural changes as a result of disturbance are expected to last days at the most.
Frequency	High – piling across the Phase 1 projects is expected to extend over 3 to 5 years.
Probability	High – there are extensive studies on pile driving activities causing disturbance in harbour porpoise.
Consequence	Low - No change to the population trajectory.
Overall magnitude	*The potential magnitude of disturbance from piling of Phase 1 projects is rated as Medium.*

All Projects

Tier 1 Projects

5.16.22 In total, four *Tier 1* projects were screened into the Cumulative Effect Assessment for harbour porpoise, none of which had a quantitative impact assessment available. The maximum cumulative number of harbour porpoise predicted to be disturbed across *Tier 1* projects in 2029 when up to 1,029 individuals (1.6% of the MU) are predicted to be impacted (assuming projects construct on the same day).

Tiers 1 & 2

5.16.23 In total, 11 *Tier 1 & 2* projects were screened into the Cumulative Effect Assessment for harbour porpoise. The maximum cumulative number of harbour porpoise predicted to be disturbed across *Tier 1 & 2* projects was in 2026 where 2,294 individuals (3.7% of the MU) are predicted to be impacted. The environmental assessment of project pile driving (2029-2032 inclusive) concludes the maximum cumulative number of harbour porpoise predicted to be disturbed across *Tier 1 and 2* projects is 1,321 porpoise (2.1% MU) (assuming projects construct on the same day).

Tiers 1, 2 & 3

5.16.1 In total, 36 *Tier 1, 2 & 3* projects were screened into the Cumulative Effect Assessment for harbour porpoise. The maximum number of harbour porpoise predicted to be disturbed across *Tier 1, 2 and 3* projects occurs in 2027 when it is assumed that 18 offshore projects are constructing at the same time, as well as two large-scale oil and gas seismic airgun surveys. If the disturbance is additive, then 16,225 harbour porpoise are predicted to be disturbed in a single day (26.0% MU) (assuming projects construct on the same day (

5.16.2 Table 82)). This is largely driven by the high number of porpoise predicted to be disturbed by Codling Wind Park, Arklow Bank and NISA (each >2,500 porpoise per piling day).

5.16.3 The environmental assessment of project pile driving (2029-2032 inclusive) concludes the maximum cumulative number of porpoise predicted to be disturbed across Tier 1, 2 & 3 projects is 14,786 porpoise (23.7% MU) in 2029 (assuming projects construct on the same day).

Conclusion

5.16.4 While there is insufficient information on piling/construction schedules across all projects to undertake a population modelling assessment, it is possible to infer the potential for a population-level effect based on previous theoretical modelling. For example, previous population modelling (using iPCoD) of offshore wind farms in eastern English waters has demonstrated low probabilities of population-level impacts, even when 16 piling operations were modelled over a 12-year period (disturbing up to a total of 34,396 porpoise per day, equating to 15% MU) (Booth *et al*., 2017). The proportion of the MU assumed to be disturbed by construction across the Tier 1-3 projects in this CEA is lower than was modelled in Booth *et al*., (2017) in most years. Therefore, with a lower proportion of the MU disturbed per day, across fewer years than the previous modelling, the likelihood of population level effects is expected to be very low.

5.16.5 More recently, the iPCoD model was used to explore noise management in the Southern North Sea SAC for harbour porpoise (Brown et al., 2023). This study provided a wide range of iPCoD simulations including disturbance to harbour porpoise over a 10-year period at the scale of the North Sea MU. One of the most extreme disturbance scenarios assumed a seasonally variable base-level daily disturbance of c. 3,500 - 7,000 porpoise throughout the MU, in addition to disturbance at up to twice the Southern North Sea SAC seasonal disturbance thresholds (up to c. 16,000 porpoise disturbed per day in summer, averaging c. 8,000 disturbed across the season). Even at these persistently high disturbance levels, the predicted declines were low, generally ≤5% after 10 years of disturbance, and in each case, the population remained at a stable size once piling disturbance ended, indicating no long-term effect on the population trajectory (it is important to note here that iPCoD does not allow for density dependence and as such the population cannot increase back to baseline levels after disturbance has ceased).

5.16.6 Similarly, the DEPONS model has been used to predict the potential population-level effects of cumulative OWF construction in the North Sea. Nabe-Nielsen *et al*., (2018) showed that the North Sea porpoise population was unlikely to be significantly impacted by the construction of 60 wind farms each with 65 turbines resulting in 3,900 disturbance days between 2011-2020, unless impact ranges were assumed to be much larger (exceeding 50 km) than that indicated by existing studies. Even at these extreme disturbance scenarios, the modelled North Sea population showed a quick recovery to baseline size (within 6-7 years) despite up to a 20% decline in population size.

5.16.7 While cumulative population modelling has not been specifically conducted here for all projects[52], results from previous large-scale cumulative population modelling studies show that persistent (i.e. 10+ years) high levels of disturbance, which are higher per day and/or over longer timescales than assumed in this CEA, are unlikely to result in long-term populations declines. Further, these previous modelling studies have shown that, even under extreme scenarios, the North Sea population is expected to recover quickly from any short-term decline. While these modelling scenarios were conducted for the North Sea, the results are comparable to potential impacts to other stable harbour porpoise populations such as the Celtic and Irish Sea MU.

5.16.8 The level of disturbance predicted to occur within the Celtic and Irish Sea MU between 2024 – 2034 is expected to result in temporary changes in behaviour and/or distribution of individuals at a scale that could result in potential reductions to lifetime reproductive success to some individuals although not enough to affect the population trajectory over a generational scale. There is not expected to be any effect on the favourable conservation status and/or the long-term viability of the population. This is therefore a **Medium** magnitude.

5.16.9 As per the project alone assessment, the sensitivity of harbour porpoise to pile driving is **Low**. Therefore, the overall significance of the cumulative effect is **Slight adverse (not significant in EIA terms)**.

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[52] Due to the fact that detailed project information is not available for most projects in the CEA (ie: piling schedule)

Table 81 Number of harbour porpoise disturbed by underwater noise in the cumulative effects assessment – all projects

Name	Type	Source	Tier	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Dublin Array	OWF	ES	1						995	995	995	995		
Atlantic Marine Energy Test Site	OWF float	Calculated	1	17	17									
Dublin Port maintenance dredging	Coastal	Calculated	1	17	17	17	17	17	17					
Maintenance dredging River Boyne, Drogheda	Coastal	Calculated	1	17	17	17	17	17	17					
West Anglesey Demonstration Zone	Tidal	Calculated	1			17	17							
Awel y Môr	OWF	ES	2			275	275	275	275	275				
Cardiff Bay Tidal Lagoon	Tidal	Calculated	*2*	1	1	1								
Development to the south of South Quay Arklow- ABWP2 OMF	Coastal	Calculated	2						17	17	17	17		
Dublin Port Company MP2 Project	Coastal	ES	2	0	0	0	0	0	0	0	0	0	0	0
Dún Laoghaire Harbour Company	Coastal	ES	2	0	0	0	0	0	0	0	0	0	0	0
Erebus	OWF float	ES	2		1967	1967								
Greater Dublin Drainage Outfall	Coastal	ES	2	0	0	0								
Arklow Bank	OWF	ES	3			3380	3380	3380	3380	3380				
Bremore Port Project	Port	Calculated	3					17	17	17				
Dublin Port Company 3FM Project	Coastal	ES	3			0	0	0	0	0	0	0	0	0
Greenlink Interconnector	Power	ES	3	17										

Name	Type	Source	Tier	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Llyr 1	OWF float	Calculated	3		11	11								
Llyr 2	OWF float	Calculated	3		11	11								
Mares Connect	Power	Calculated	3			35	35	35	35					
Mersey Tidal Power	Tidal	Calculated	3					35	35	35	35	35	35	35
Mona	OWF	ES	3			1142	1142	1142	1142					
Mooir Vannin	OWF float	Calculated	3							948	948	948		
Morecambe	OWF	ES	3			1279	1279	1279	1279					
Morgan	OWF	ES	3			979	979	979	979					
North Channel Wind 1	OWF	Calculated	3						448	448				
North Channel Wind 2	OWF	Calculated	3						448	448				
North Irish Sea Array	OWF	ES	3				3896	3896	3896					
Oriel	OWF	ES	3			725	725	725						
ROSSLARE	Port	Calculated	3	17	17	17								
Sceirde Rocks	OWF	Calculated	3			150	150	150	150	150				
The Saoirse project	Wave	Calculated	3					21	21					
TwinHub	OWF float	Calculated	3			11	11							
White Cross	OWF float	ES	3				649	649	649					
1x indicative seismic airgun survey	seismic	Calculated	3	493	493	493	493	493	493	493	493	493	493	493
1x indicative seismic airgun survey	seismic	Calculated	3	493	493	493	493	493	493	493	493	493	493	493
Codling Wind Park	OWF	Calculated	3				2667							
TOTAL Tier 1 Projects				51	51	51	51	34	1029	995	995	995	0	0
% MU				0.1%	0.1%	0.1%	0.1%	0.1%	1.6%	1.6%	1.6%	1.6%	0.0%	0.0%
TOTAL Tier 1 & 2 Projects				52	2019	2294	326	309	1321	1287	1012	1012	0	0

Name	Type	Source	Tier	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
% MU				0.1%	3.2%	3.7%	0.5%	0.5%	2.1%	2.1%	1.6%	1.6%	0.0%	0.0%
TOTAL Tier 1, 2 & 3 Projects				1072	3044	11020	16225	13603	14786	7699	2981	2981	1021	1021
% MU				1.7%	4.9%	17.6%	26.0%	21.8%	23.7%	12.3%	4.8%	4.8%	1.6%	1.6%

Bottlenose dolphin

Phase 1 projects

5.16.10 The results of the iPCoD modelling show a slight deviation from the baseline resulting from the pile driving disturbance across the five Phase 1 Projects. Using the harbour porpoise dose-response function to estimate disturbance, the mean impacted population size initially decreases very slightly from the mean un-impacted population size in response to piling, after which it continues on the same, stable trajectory at 95-96% of the mean un-impacted population size (Figure 42 and Figure 43). Using the level B harassment threshold, the mean impacted population size initially decreases very slightly from the mean un-impacted population size in response to piling, after which it continues on the same, stable trajectory at 98% of the mean un-impacted population size (Figure 44 and Figure 45). As the iPCoD model does not currently allow for a density-dependent response, there is no way for the impacted population to increase in size after the piling disturbance. The impacted population does, however, continue on a stable trajectory in the long-term irrespective of the disturbance threshold used. The overall magnitude is assessed as **Medium** (

5.16.11 Table 82). As per the project alone assessment, the sensitivity of bottlenose dolphins to pile driving is **Low**. Therefore, the overall significance of the cumulative effect of disturbance from piling across the Phase 1 projects is **Slight adverse (not significant)**.

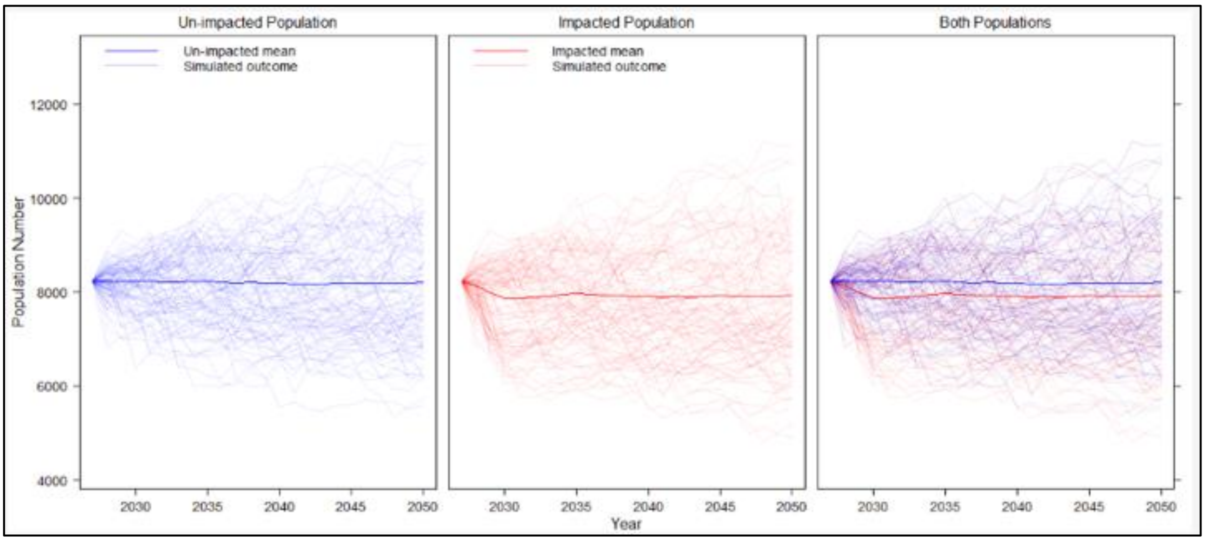

Figure 42 Predicted population trajectories for the un-impacted (baseline) and impacted bottlenose dolphin iPCoD simulations for piling schedule 1 using the dose-response function.

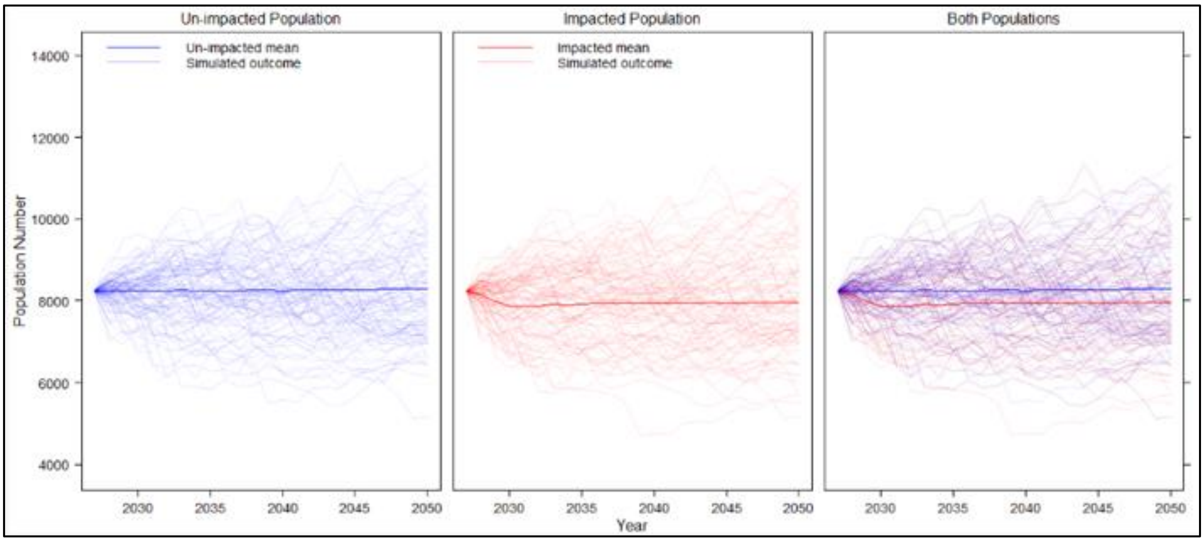

Figure 43 - Predicted population trajectories for the un-impacted (baseline) and impacted bottlenose dolphin iPCoD simulations for piling schedule 2 using the dose-response function.

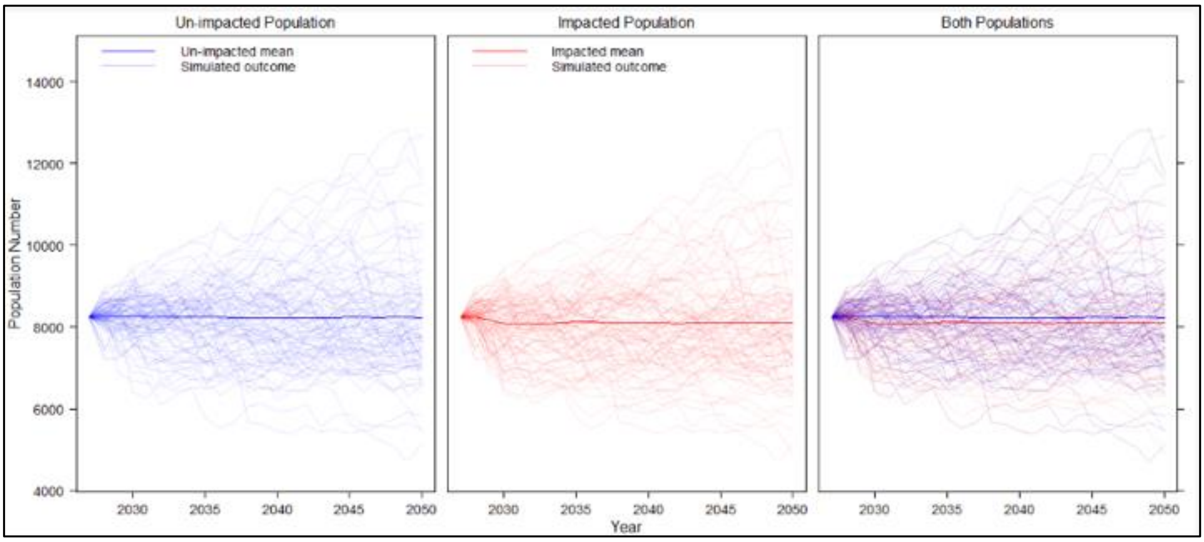

Figure 44 Predicted population trajectories for the un-impacted (baseline) and impacted bottlenose dolphin iPCoD simulations for piling schedule 1 using the level B harassment threshold.

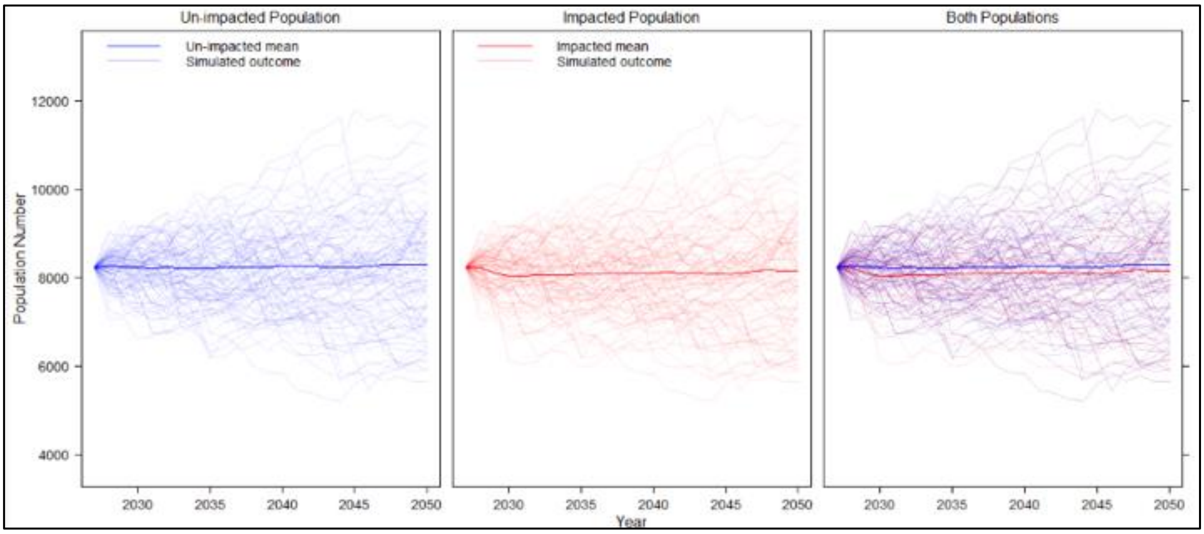

Figure 45 Predicted population trajectories for the un-impacted (baseline) and impacted bottlenose dolphin iPCoD simulations for piling schedule 2 using the level B harassment threshold.

Table 82 Determination of magnitude for bottlenose dolphin for disturbance from foundation piling activity across the Phase 1 projects.

Bottlenose dolphin	Justification
Duration	Low – behavioural changes as a result of disturbance are expected to last days at the most.
Frequency	High – piling across the Phase 1 projects is expected to extend over 3 to 5 years.
Probability	Medium – there are some studies on pile driving activities causing disturbance in bottlenose dolphins.
Consequence	Medium - there is a slight decrease in the impacted population size as a result of disturbance from piling, though the population modelling shows that the population is expected to continue on a stable trajectory in the long-term.
Overall magnitude	*The potential magnitude of disturbance from piling of Phase 1 projects is rated as Medium.*

All Projects

5.16.12 OWF projects with a quantitative impact assessment available have used the SCANS III densities or similar in their respective assessments, which are in no way comparable to the SCANS IV Irish Sea population abundance and density estimates used for Dublin Array. To attempt to make the assessments more comparable, the following approach was applied: The SCANS IV block density results for Dublin Array have been used along with calculated disturbance numbers assuming the SCANS IV block density for each specific project with an assumed population size of 8,326 bottlenose dolphins in the Irish Sea MU.

Tier 1 Projects

5.16.13 In total, three *Tier 1* projects were screened into the Cumulative Effect Assessment for bottlenose dolphins (Table 83). The maximum cumulative number of bottlenose dolphin predicted to be disturbed across *Tier 1* projects occurs in 2029 where 753 individuals (8.8% of the MU) are predicted to be impacted (assuming projects construct on the same day).

Tiers 1 & 2

5.16.14 In total, eight *Tier 1 & 2* projects were screened into the Cumulative Effect Assessment for bottlenose dolphins (Table 83). The maximum cumulative number of bottlenose dolphin predicted to be disturbed across *Tier 1 & 2* projects occurred in 2029 where 811 individuals (9.7% of the MU) are predicted to be impacted (assuming projects construct on the same day).

Tiers 1, 2 & 3

5.16.15 There were 27 *Tier 1, 2 & 3* projects screened into the Cumulative Effect Assessment for bottlenose dolphins (Table 83). The maximum cumulative number of bottlenose dolphin predicted to be disturbed across *Tier 1, 2 & 3* projects occurs in 2027 when 7,237 dolphins are predicted to be disturbed (86.9% MU) (assuming projects construct on the same day). The environmental assessment of project pile driving (2029-2032 inclusive) concludes the maximum cumulative number of bottlenose dolphins predicted to be disturbed across Tier 1, 2 & 3 projects is 6,849 dolphins (82.3% MU) in 2029 (assuming projects construct on the same day).

Summary

5.16.16 Overall, the number of bottlenose dolphins predicted to be disturbed by all projects is driven largely by the predictions of disturbance at offshore wind farms in the western Irish Sea: Dublin Array, Arklow Bank, Oriel, NISA, North Channel Wind 1 and North Channel Wind 2 and by the indicative large-scale oil and gas seismic air gun survey. This is due to the fact that the bottlenose dolphin density in the western Irish Sea (SCANS IV block CS-D: 0.2352 dolphins/km^2) was predicted to be much higher than that in the eastern Irish Sea (SCANS IV block CS-E: 0.0104 dolphins/km^2). Population modelling across the five Phase 1 projects using the project specific disturbance numbers has already shown no significant impact to the bottlenose dolphin population. It is therefore expected that with the addition of other projects, there is likely to be temporary changes in behaviour and/or distribution of individuals at a scale that could result in potential reductions to lifetime reproductive success to some individuals, although likely not enough to affect the population trajectory over a generational scale. The magnitude is therefore **Medium**. As per the project alone assessment, the sensitivity of bottlenose dolphins to pile driving is **Low**. Therefore, the overall significance of the cumulative effect is **Slight adverse (not significant in EIA terms)**.

Table 83 Number of bottlenose dolphins disturbed by underwater noise in the cumulative effects assessment – all projects (assuming SCANS IV density)

Name	Type	Source	Tier	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Dublin Array	OWF	ES							699	699	699	699		
Dublin Port maintenance dredging	Coastal	Calculated	1	18	18	18	18	18	18					
Maintenance dredging River Boyne, Drogheda	Coastal	Calculated	1	18	18	18	18	18	18					
West Anglesey Demonstration Zone	Tidal	Calculated	1			18	18							
Awel y Môr	OWF	Calculated	2			22	22	22	22	22				
Development to the south of South Quay Arklow- ABWP2 OMF	Coastal	Calculated	2						18	18	18	18		
Dublin Port Company MP2 Project	Coastal	Calculated	2	18	18	18	18	18	18	18	18	18	18	18
Dún Laoghaire Harbour Company	Coastal	Calculated	2	18	18	18	18	18	18	18	18	18	18	18
Greater Dublin Drainage Outfall	Coastal	Calculated	2	18	18	18								
Arklow Bank	OWF	ES	3			2092	2092	2092	2092	2092				
Bremore Port Project	Port	Calculated	3					18	18	18				
Dublin Port Company 3FM Project	Coastal	ES	3			0	0	0	0	0	0	0	0	0
Greenlink Interconnector	Power	Calculated	3	18										
Mares Connect	Power	Calculated	3			18	18	18	18					
Mersey Tidal Power	Tidal	Calculated	3					1	1	1	1	1	1	1
Mona	OWF	Calculated	3			22	22	22	22					
Mooir Vannin	OWF float	Calculated	3							22	22	22		
Morecambe	OWF	Calculated	3			22	22	22	22					
Morgan	OWF	Calculated	3			22	22	22	22					
North Channel Wind 1	OWF	Calculated	3						499	499				

Name	Type	Source	Tier	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
North Channel Wind 2	OWF	Calculated	3						499	499				
North Irish Sea Array	OWF	ES	3				2346	2346	2346					
Oriel	OWF	ES	3			129	129	129						
ROSSLARE	Port	Calculated	3	18	18	18								
The Saoirse project	Wave	Calculated	3					85	85					
1x indicative seismic airgun survey	seismic	Calculated	3	414	414	414	414	414	414	414	414	414	414	414
Codling Wind Park	OWF	Calculated	3				2060							
TOTAL Tier 1 Projects				36	36	54	54	36	735	699	699	699	0	0
% MU				0.4%	0.4%	0.6%	0.6%	0.4%	8.8%	8.4%	8.4%	8.4%	0.0%	0.0%
TOTAL Tier 1 & 2 Projects				90	90	130	112	94	811	775	753	753	36	36
% MU				1.1%	1.1%	1.6%	1.3%	1.1%	9.7%	9.3%	9.0%	9.0%	0.4%	0.4%
TOTAL Tier 1, 2 & 3 Projects				540	522	2867	7237	5263	6849	4320	1190	1190	451	451
% MU				6.5%	6.3%	34.4%	86.9%	63.2%	82.3%	51.9%	14.3%	14.3%	5.4%	5.4%

Common dolphin

All Projects

5.16.17 Note, many of the projects screened into the assessment for common dolphins are located in a SCANS IV block with either no common dolphins present, or a very low density of common dolphins resulting in impact to 0 common dolphins for many projects (Table 84).

Tier 1 Projects

5.16.18 In total of 29 *Tier 1* projects were screened into the cumulative effects assessment for common dolphins (in addition to Dublin Array) (Table 84). The maximum cumulative number of common dolphins predicted to be disturbed across *Tier 1* projects was in 2024 where 423 individuals (0.4% of the MU) are predicted to be impacted. The environmental assessment of project pile driving (2029-2032 inclusive), concluded that the cumulative number of common dolphins predicted to be disturbed across *Tier 1* projects was 85 individuals (0.1% of the MU) in 2029 (assuming projects construct on the same day).

Tiers 1 & 2

5.16.19 In total, 68 *Tier 1 & 2* projects were screened into the Cumulative Effect Assessment for common dolphins (in addition to Dublin Array). The maximum cumulative number of common dolphins predicted to be disturbed across *Tier 1 & 2* projects was in 2024 where 506 individuals (0.5% of the MU) are predicted to be impacted. The environmental assessment of project pile driving (2029-2032 inclusive) concludes the maximum cumulative number of common dolphins predicted to be disturbed across *Tier 1 & 2* projects is 156 dolphins (0.2% MU) in 2032 (assuming projects construct on the same day).

Tiers 1, 2 & 3

5.16.20 In total, 134 *Tier 1, 2 & 3* projects were screened into the Cumulative Effect Assessment for common dolphins (in addition to Dublin Array). The maximum number of common dolphins predicted to be disturbed across *Tier 1, 2 & 3* projects occurs in 2027 (prior to assessments of construction at Dublin), where 5,675 individuals (5.5% of the MU) are predicted to be impacted. The environmental assessment of project pile driving (2029-2032 inclusive) concludes the maximum cumulative number of common dolphins predicted to be disturbed across *Tier 1, 2 & 3* projects is 2,853 dolphins (2.8% MU) in 2029 (assuming projects construct on the same day).

Summary

5.16.21 What is important to consider here is the residency of animals within the impacted area, and the likelihood that they will remain in the impacted area long-term to obtain high levels of repeated disturbance over time. Based on tag and genetic data, common dolphins are generally considered to be wide-ranging, capable of travelling large distances (e.g. Evans 1982, Natoli *et al*., 2006, Genov *et al*., 2012). Therefore, it is highly unlikely that individuals would remain in the impacted area over a sufficient number of days for any disturbance effect to result in changes to vital rates. Temporary changes in behaviour and/or distribution of individuals may be at a scale that could result in potential reductions to lifetime reproductive success to some individuals, although likely not enough to affect the population trajectory over a generational scale. The magnitude is therefore **Medium**. As per the project alone assessment, the sensitivity of common dolphins to pile driving is **Low**. Therefore, the overall significance of the cumulative effect is **Slight adverse (not significant in EIA terms)**.

Table 84 Number of common dolphins disturbed by underwater noise in the cumulative effects assessment – all projects

Name	Type	Source	Tier	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Dublin Array	OWF	ES	-						81	81	81	81		
Atlantic Marine Energy Test Site	OWF float	Calculated	1	0	0									
Courseulles-sur-mer	OWF	Calculated	1	10										
Dieppe Le Tréport	OWF	Calculated	1	10	10	10								
Dogger Bank A	OWF	ES	1	0										
Dogger Bank B	OWF	ES	1	0	0									
Dogger Bank C	OWF	ES	1	0	0	0								
Dublin Port maintenance dredging	Coastal	Calculated	1	2	2	2	2	2	2					
East Anglia One North	OWF	ES	1	0	0	0	0							
East Anglia Three	OWF	ES	1	0	0	0								
East Anglia Two	OWF	ES	1	0	0	0	0							
Eoliennes en Mer des îles d'Yeu et de Noirmoutier	OWF	Calculated	1	336	336									
Eriskay – Barra 2	Power	Calculated	1				73	73						
Gode Wind 3	OWF	Calculated	1	0										
Hollandse Kust (West)	OWF	Calculated	1	0	0	0						0	0	0
Inch Cape	OWF	ES	1	0										
Maintenance dredging River Boyne, Drogheda	Coastal	Calculated	1	2	2	2	2	2	2					
Moray West	OWF	ES	1	0										
NC2	OWF	Calculated	1		0	0	0	0	0	0	0	0	0	0
Neart Na Gaoithe	OWF	ES	1	0										
Norfolk Vanguard East	OWF	ES	1	0	0	0	0	0						
Norfolk Vanguard West	OWF	ES	1	0	0									
Orkney-Caithness	Power	ES	1	0	0	0	0							
Pentland Firth West	Power	Calculated	1				0	0						
Shetland - Papa Stour	Power	Calculated	1	0										

Name	Type	Source	Tier	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Shetland HVDC Link	Power	Calculated	1	0										
Skye - South Uist	Power	Calculated	1		73	73								
Sofia	OWF	ES	1	0	0	0								
South Uist – Eriskay	Power	Calculated	1				73							
West Anglesey DemoZone	Tidal	Calculated	1			2	2							
Awel y Môr	OWF	ES	2			17	17	17	17	17				
Berwick Bank	OWF	ES	2	0	0	0	0							
Borkum Riffgrund 3	OWF	Calculated	2	0	0									
Cambo (FPSO (Power from Shore)	Power	ES	2		7	7	7							
Cardiff Bay Tidal Lagoon	Tidal	Calculated	2	66	66	66								
Centre-Manche 2	OWF	Calculated	2							10				
Development to the south of South Quay Arklow- ABWP2 OMF	Coastal	Calculated	2						2	2	2	2		
Dublin Port Company MP2 Project	Coastal	ES	2	0	0	0	0	0	0	0	0	0	0	0
Dudgeon Extension	OWF	ES	2			0	0	0	0	0				
Dún Laoghaire Harbour Company	Coastal	ES	2	0	0	0	0	0	0	0	0	0	0	0
Dunkerque	OWF	Calculated	2		10	10	10							
EMEC Bilia Croo	Wave	ES	2		0	0								
EnBW He Dreiht	OWF	Calculated	2	0	0									
Erebus Floating Wind Demo	OWF float	ES	2		0	0								
Five Estuaries	OWF	ES	2				0	0	0	0				
Forthwind	OWF	ES	2	0										
Greater Dublin Drainage Outfall	Coastal	ES	2	0	0	0								

Name	Type	Source	Tier	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Hornsea Project Four	OWF	ES	2	0	0	0	0							
Hornsea Project Three	OWF	ES	2	0	0	0	0							
IJmuiden Ver	OWF	Calculated	2					0	0					
Laxay to Kershader 2	Power	Calculated	2				73	73						
Mainland Orkney – Hoy South	Power	Calculated	2	0	0									
N-10.1	OWF	Calculated	2							0	0	0	0	0
N-10.2	OWF	Calculated	2							0	0	0	0	0
N-6.6	OWF	Calculated	2					0	0	0	0	0	0	0
N-6.7	OWF	Calculated	2					0	0	0	0	0	0	0
N-7.2	OWF	Calculated	2				0							
N-9.1	OWF	Calculated	2						0	0	0	0	0	0
N-9.2	OWF	Calculated	2						0	0	0	0	0	0
N-9.3	OWF	Calculated	2						0	0	0	0	0	0
NC1	OWF	Calculated	2			0	0	0	0	0	0	0	0	0
Outer Dowsing	OWF	ES	2			0	0	0	0					
Pentland Firth East 3	Power	Calculated	2	0	0									
Rosebank FPSO	Power	ES	2			0	0							
Skye - Harris	Power	Calculated	2									73		
Skye - Uist	Power	Calculated	2				73	73						
Sud de la Bretagne	OWF	Calculated	2						10	10				
Ten Noorden van de Wadden	OWF	Calculated	2								0	0	0	0
Thor	OWF	Calculated	2		0	0								
Arklow Bank	OWF	ES	3			242	242	242	242	242				
Arven	OWF float	Calculated	3	0	0	0	0							
Aspen	OWF float	Calculated	3			0	0							
Ayre	OWF float	Calculated	3						0	0	0	0	0	

Name	Type	Source	Tier	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Beech	OWF float	Calculated	3			0	0							
Bellrock	OWF float	Calculated	3					0	0					
Bowdun	OWF float	Calculated	3						0	0	0	0		
Bremore Port Project	Port	Calculated	3					2	2	2				
Broadshore	OWF float	Calculated	3	0	0	0	0	0						
Buchan	OWF float	Calculated	3						0	0	0	0		
Caledonia	OWF	Calculated	3				0	0	0					
Campion	OWF float	Calculated	3	0	0	0	0	0						
Cedar	OWF float	Calculated	3			0	0							
Cenos	OWF float	Calculated	3				0	0	0					
Central North Sea Electrification	OWF	Calculated	3				0	0						
Centre-Manche 1	OWF	Calculated	3							10				
Culzean	OWF float	ES	3		0									
Dogger Bank South (East)	OWF	ES	3		0	0	0	0	0	0	0			
Dogger Bank South (West)	OWF	ES	3		0	0	0	0	0	0	0			
Dublin Port Company 3FM Project	Coastal	ES	3			0	0	0	0	0	0	0	0	0
Green Volt	OWF float	ES	3		0	0	0	0	0					

Name	Type	Source	Tier	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Greenlink Interconnector	Power	ES	3	2										
Havbredey	OWF float	Calculated	3									594	594	594
IceLink (Interco Iceland-UK)	Power	Calculated	3	0										
Llyr 1	OWF float	Calculated	3		594	594								
Llyr 2	OWF float	Calculated	3		594	594								
Mares Connect	Power	Calculated	3			2	2	2	2					
Marram	OWF float	Calculated	3		0	0	0	0	0	0				
Mersey Tidal Power	Tidal	Calculated	3					0	0	0	0	0	0	0
Mona	OWF	ES	3			3	3	3	3					
Mooir Vannin	OWF float	Calculated	3							0	0	0		
Morecambe	OWF	ES	3			128	128	128	128					
Morgan	OWF	ES	3			0	0	0	0					
Morven	OWF	Calculated	3				0	0	0					
Muir Mhòr	OWF	Calculated	3						0	0				
NC3	OWF	Calculated	3					0	0	0	0	0	0	0
NC4	OWF	Calculated	3	0	0	0								
North Channel Wind 1	OWF	Calculated	3						116	116				
North Channel Wind 2	OWF	Calculated	3						116	116				
North Falls	OWF	ES	3		0	0	0	0	0					
North Irish Sea Array	OWF	ES	3				410	410	410					
Oriel	OWF	ES	3			15	15	15						
Orkney Interconnector	Power	ES	3		0	0	0	0						
Pentland Floating	OWF float	ES	3	0	0	0								

Name	Type	Source	Tier	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Rampion 2	OWF	ES	3			0	0	0	0					
ROSSLARE	Port	Calculated	3	2	2	2								
Salamander	OWF float	ES	3			0	0	0	0	0				
Sceirde Rocks	OWF	Calculated	3			1223	1223	1223	1223	1223				
Sheringham Shoal Extension	OWF	ES	3	0	0	0								
Sørlige Nordsjø II	OWF	Calculated	3							0				
Spiorad na Mara	OWF float	Calculated	3					119	119	119	119			
Stromar	OWF float	Calculated	3			0	0	0	0	0	0	0		
Talisk	OWF float	Calculated	3							0				
The Saoirse project	Wave	Calculated	3					45	45					
TwinHub	OWF	Calculated	3			594	594							
Vest Nordsøen III	OWF	Calculated	3				0							
West of Orkney	OWF	ES	3				2	2	2					
Western Isles Link	Power	Calculated	3			73	73	73	73					
Westray Tidal Array	Tidal	Calculated	3							0				
White Cross	OWF	ES	3				66	66	66					
1x indicative seismic airgun survey	seismic	Calculated	3	48	48	48	48	48	48	48	48	48	48	48
1x indicative seismic airgun survey	seismic	Calculated	3	48	48	48	48	48	48	48	48	48	48	48
1x indicative seismic airgun survey	seismic	Calculated	3	48	48	48	48	48	48	48	48	48	48	48
1x indicative seismic airgun survey	seismic	Calculated	3	48	48	48	48	48	48	48	48	48	48	48
Codling Wind Park	OWF	Calculated	3				2393							
TOTAL Tier 1 Projects				360	423	89	152	77	85	81	81	81	0	0

Name	Type	Source	Tier	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
% MU				0.4%	0.4%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.0%	0.0%
TOTAL Tier 1 & 2 Projects				426	506	189	332	240	114	120	83	156	0	0
% MU				0.4%	0.5%	0.2%	0.3%	0.2%	0.1%	0.1%	0.1%	0.2%	0.0%	0.0%
TOTAL Tier 1, 2 & 3 Projects				622	1888	3851	5675	2762	2853	2140	394	942	786	786
% MU				0.6%	1.8%	3.8%	5.5%	2.7%	2.8%	2.1%	0.4%	0.9%	0.8%	0.8%

Minke whale

All Projects

5.16.22 Note, many of the projects screened into the assessment for minke whales are located in a SCANS IV block with either no minke whales present, or a very low density of minke whales resulting in impact to 0 minke whales for many projects (Table 84).

Tier 1 Projects

5.16.23 In total of 29 *Tier 1* projects were screened into the cumulative effects assessment for minke whale (in addition to Dublin Array) (Table 85). The maximum cumulative number of minke whale predicted to be disturbed across *Tier 1* projects was in 2024 where 428 individuals (2.1% of the MU) are predicted to be impacted. The environmental assessment of project pile driving (2029-2032 inclusive) concludes the maximum cumulative number of minke whale predicted to be disturbed across *Tier 1* projects was in 2032 where 68 individuals (0.3% of the MU) are predicted to be impacted (assuming projects construct on the same day).

Tiers 1 & 2

5.16.24 In total, 68 *Tier 1 & 2* projects were screened into the Cumulative Effect Assessment for minke whales (in addition to Dublin Array) (Table 85). The maximum cumulative number of minke whales predicted to be disturbed across *Tier 1 & 2* projects was in 2024 where 682 individuals (3.4% of the MU) are predicted to be impacted. The environmental assessment of project pile driving (2029-2032 inclusive) concludes the maximum cumulative number of minke whales predicted to be disturbed across *Tier 1 & 2* projects is 141 minke whales (0.7% MU) in 2029 (assuming projects construct on the same day).

Tiers 1, 2 & 3

5.16.25 In total, 134 *Tier 1, 2 & 3* projects were screened into the Cumulative Effect Assessment for minke whale (in addition to Dublin Array) (Table 85). The maximum number of minke whale predicted to be disturbed across *Tier 1, 2 & 3* projects occurs in 2027 where 2,887 individuals (14.4% of the MU) are predicted to be impacted. The environmental assessment of project pile driving (2029-2032 inclusive) concludes the maximum cumulative number of minke whales predicted to be disturbed across *Tier 1, 2 & 3* projects is 2,537 minke whales (12.6% MU) in 2029 (assuming projects construct on the same day).

Summary

5.16.26 It is important to note that minke whale densities are higher in the spring/summer, and significantly fewer minke whales will be present to be disturbed outside of the key summer months. Nonetheless, the predicted extent of the cumulative disturbance is still to a low proportion of the MU across most years, with short-term behavioural changes expected from each disturbance event an individual is exposed to, with the overall disturbance effect occurring across the OWFs over several years. The temporary changes in behaviour and/or distribution of individuals may be at a scale that could result in potential reductions to lifetime reproductive success to some individuals, although not enough to affect the population trajectory over a generational scale. The magnitude is therefore assessed as **Medium**. As per the project alone assessment, the sensitivity of minke whales to pile driving is **Low**. Therefore, the overall significance of the cumulative effect is **Slight adverse (not significant in EIA terms)**.

Table 85 Number of minke whales disturbed by underwater noise in the cumulative effects assessment – all projects

Name	Type	Source	Tier	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Dublin Array	OWF	ES	-						57	57	57	57		
Atlantic Marine Energy Test Site	OWF float	Calculated	1	0	0									
Courseulles-sur-mer	OWF	Calculated	1	0										
Dieppe Le Tréport	OWF	Calculated	1	0	0	0								
Dogger Bank A	OWF	ES	1	14										
Dogger Bank B	OWF	ES	1	22	22									
Dogger Bank C	OWF	ES	1	69	69	69								
Dublin Port maintenance dredging	Coastal	Calculated	1	1	1	1	1	1	1					
East Anglia One North	OWF	ES	1	0	0	0	0							
East Anglia Three	OWF	ES	1	0	0	0								
East Anglia Two	OWF	ES	1	0	0	0	0							
Eoliennes en Mer des îles d'Yeu et de Noirmoutier	OWF	Calculated	1	0	0									
Eriskay – Barra 2	Power	Calculated	1				3	3						
Gode Wind 3	OWF	Calculated	1	0										
Hollandse Kust (West)	OWF	Calculated	1	11	11	11						11	11	11
Inch Cape	OWF	ES	1	158										
Maintenance dredging River Boyne, Drogheda	Coastal	Calculated	1	1	1	1	1	1	1					
Moray West	OWF	ES	1	29										
NC2	OWF	Calculated	1		0	0	0	0	0	0	0	0	0	0
Neart Na Gaoithe	OWF	ES	1	85										
Norfolk Vanguard East	OWF	ES	1	0	0	0	0	0	0					
Norfolk Vanguard West	OWF	ES	1	0	0									

Name	Type	Source	Tier	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Orkney-Caithness	Power	ES	1	0	0	0	0							
Pentland Firth West	Power	Calculated	1				1	1						
Shetland - Papa Stour	Power	Calculated	1	1										
Shetland HVDC Link	Power	Calculated	1	1										
Skye - South Uist	Power	Calculated	1		3	3								
Sofia	OWF	ES	1	36	36	36								
South Uist – Eriskay	Power	Calculated	1				1							
West Anglesey DemoZone	Tidal	Calculated	1			1	1							
Awel y Môr	OWF	ES	2			36	36	36	36	36				
Berwick Bank	OWF	ES	2	132	132	132	132							
Borkum Riffgrund 3	OWF	Calculated	2	11	11									
Cambo (FPSO (Power from Shore)	Power	ES	2		11	11	11							
Cardiff Bay Tidal Lagoon	Tidal	Calculated	2	1	1	1								
Centre-Manche 2	OWF	Calculated	2							0				
Development to the south of South Quay Arklow- ABWP2 OMF	Coastal	Calculated	2						1	1	1	1		
Dublin Port Company MP2 Project	Coastal	ES	2	0	0	0	0	0	0	0	0	0	0	0
Dudgeon Extension	OWF	ES	2			11	11	11	11	11				
Dún Laoghaire Harbour Company	Coastal	ES	2	0	0	0	0	0	0	0	0	0	0	0
Dunkerque	OWF	Calculated	2		0	0	0							
EMEC Bilia Croo	Wave	ES	2		0	0								
EnBW He Dreiht	OWF	Calculated	2	11	11									
Erebus Floating Wind Demo	OWF float	ES	2		55	55								
Five Estuaries	OWF	ES	2				0	0	0	0				

Name	Type	Source	Tier	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Forthwind	OWF	ES	2	0										
Greater Dublin Drainage Outfall	Coastal	ES	2	0	0	0								
Hornsea Project Four	OWF	ES	2	46	46	46	46							
Hornsea Project Three	OWF	ES	2	51	51	51	51							
IJmuiden Ver	OWF	Calculated	2					11	11					
Laxay to Kershader 2	Power	Calculated	2				3	3						
Mainland Orkney – Hoy South	Power	Calculated	2	1	1									
N-10.1	OWF	Calculated	2							0	0	0	0	0
N-10.2	OWF	Calculated	2							0	0	0	0	0
N-6.6	OWF	Calculated	2					0	0	0	0	0	0	0
N-6.7	OWF	Calculated	2					0	0	0	0	0	0	0
N-7.2	OWF	Calculated	2				0							
N-9.1	OWF	Calculated	2						0	0	0	0	0	0
N-9.2	OWF	Calculated	2						0	0	0	0	0	0
N-9.3	OWF	Calculated	2						0	0	0	0	0	0
NC1	OWF	Calculated	2			0	0	0	0	0	0	0	0	0
Outer Dowsing	OWF	ES	2			23	23	23	23					
Pentland Firth East 3	Power	Calculated	2	1	1									
Rosebank FPSO	Power	ES	2			0	0							
Skye - Harris	Power	Calculated	2									3		
Skye - Uist	Power	Calculated	2				3	3						
Sud de la Bretagne	OWF	Calculated	2						0	0				
Ten Noorden van de Wadden	OWF	Calculated	2								11	11	11	11
Thor	OWF	Calculated	2		0	0								
Arklow Bank	OWF	ES	3			400	400	400	400	400				
Arven	OWF float	Calculated	3	9	9	9	9							
Aspen	OWF float	Calculated	3			30	30							

Name	Type	Source	Tier	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Ayre	OWF float	Calculated	3						9	9	9	9	9	
Beech	OWF float	Calculated	3			30	30							
Bellrock	OWF float	Calculated	3					30	30					
Bowdun	OWF float	Calculated	3						89	89	89	89		
Bremore Port Project	Port	Calculated	3					1	1	1				
Broadshore	OWF float	Calculated	3	8	8	8	8	8						
Buchan	OWF float	Calculated	3						9	9	9	9		
Caledonia	OWF	Calculated	3				25	25	25					
Campion	OWF float	Calculated	3	30	30	30	30	30						
Cedar	OWF float	Calculated	3			30	30							
Cenos	OWF float	Calculated	3				30	30	30					
Central North Sea Electrification	OWF	Calculated	3				3	3						
Centre-Manche 1	OWF	Calculated	3							0				
Culzean	OWF float	ES	3		0									
Dogger Bank South (East)	OWF	ES	3		28	28	28	28	28	28	28			
Dogger Bank South (West)	OWF	ES	3		57	57	57	57	57	57	57			
Dublin Port Company 3FM Project	Coastal	ES	3			0	0	0	0	0	0	0	0	0
Green Volt	OWF float	ES	3		2	2	2	2	2					
Greenlink Interconnector	Power	ES	3	1										
Havbredey	OWF float	Calculated	3									16	16	16
IceLink (Interco Iceland-UK)	Power	Calculated	3	3										
Llyr 1	OWF float	Calculated	3		6	6								
Llyr 2	OWF float	Calculated	3		6	6								
Mares Connect	Power	Calculated	3			1	1	1	1					
Marram	OWF float	Calculated	3		9	9	9	9	9	9				

Name	Type	Source	Tier	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Mersey Tidal Power	Tidal	Calculated	3					1	1	1	1	1	1	1
Mona	OWF	ES	3			72	72	72	72					
Mooir Vannin	OWF float	Calculated	3							6	6	6		
Morecambe	OWF	ES	3			25	25	25	25					
Morgan	OWF	ES	3			96	96	96	96					
Morven	OWF	Calculated	3				89	89	89					
Muir Mhòr	OWF	Calculated	3						30	30				
NC3	OWF	Calculated	3					0	0	0	0	0	0	0
NC4	OWF	Calculated	3	0	0	0								
North Channel Wind 1	OWF	Calculated	3						29	29				
North Channel Wind 2	OWF	Calculated	3						29	29				
North Falls	OWF	ES	3		0	0	0	0	0					
North Irish Sea Array	OWF	ES	3				222	222	222					
Oriel	OWF	ES	3			142	142	142						
Orkney Interconnector	Power	ES	3		1	1	1	1						
Pentland Floating	OWF float	ES	3	40	40	40								
Rampion 2	OWF	ES	3			6	6	6	6					
ROSSLARE	Port	Calculated	3	1	1	1								
Salamander	OWF float	ES	3			603	603	603	603	603				
Sceirde Rocks	OWF	Calculated	3			217	217	217	217	217				
Sheringham Shoal Extension	OWF	ES	3	7	7	7								
Sørlige Nordsjø II	OWF	Calculated	3							7				
Spiorad na Mara	OWF float	Calculated	3					21	21	21	21			
Stromar	OWF float	Calculated	3			8	8	8	8	8	8	8		
Talisk	OWF float	Calculated	3							16				
The Saoirse project	Wave	Calculated	3					8	8					
TwinHub	OWF	Calculated	3			6	6							

Name	Type	Source	Tier	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Vest Nordsøen III	OWF	Calculated	3				0							
West of Orkney	OWF	ES	3				90	90	90					
Western Isles Link	Power	Calculated	3			3	3	3	3					
Westray Tidal Array	Tidal	Calculated	3							1				
White Cross	OWF	ES	3				61	61	61					
1x indicative seismic airgun survey	seismic	Calculated	3	24	24	24	24	24	24	24	24	24	24	24
1x indicative seismic airgun survey	seismic	Calculated	3	24	24	24	24	24	24	24	24	24	24	24
1x indicative seismic airgun survey	seismic	Calculated	3	24	24	24	24	24	24	24	24	24	24	24
1x indicative seismic airgun survey	seismic	Calculated	3	24	24	24	24	24	24	24	24	24	24	24
Codling Wind Park	OWF	Calculated	3				134							
TOTAL Tier 1 Projects				428	143	122	8	6	59	57	57	68	11	11
% MU				2.1%	0.7%	0.6%	0.0%	0.0%	0.3%	0.3%	0.3%	0.3%	0.1%	0.1%
TOTAL Tier 1 & 2 Projects				682	463	488	324	93	141	105	69	83	22	22
% MU				3.4%	2.3%	2.4%	1.6%	0.5%	0.7%	0.5%	0.3%	0.4%	0.1%	0.1%
TOTAL Tier 1, 2 & 3 Projects				877	763	2457	2887	2478	2537	1771	393	317	144	135
% MU				4.4%	3.8%	12.2%	14.4%	12.3%	12.6%	8.8%	2.0%	1.6%	0.7%	0.7%

Harbour seal

Phase 1 projects

5.16.27 The iPCoD results show that the level of disturbance predicted under either piling schedule 1 or 2 is not sufficient to result in any changes at the population level, since the impacted population is predicted to continue at a stable trajectory at exactly the same size as the un-impacted population. The overall magnitude is assessed as **Medium** (

5.16.28

5.16.29 Table 86). As per the project alone assessment, the sensitivity of harbour seals to pile driving is **Low**. Therefore, the overall significance of the cumulative effect of disturbance from piling across the Phase 1 projects is **Slight adverse (not significant)**

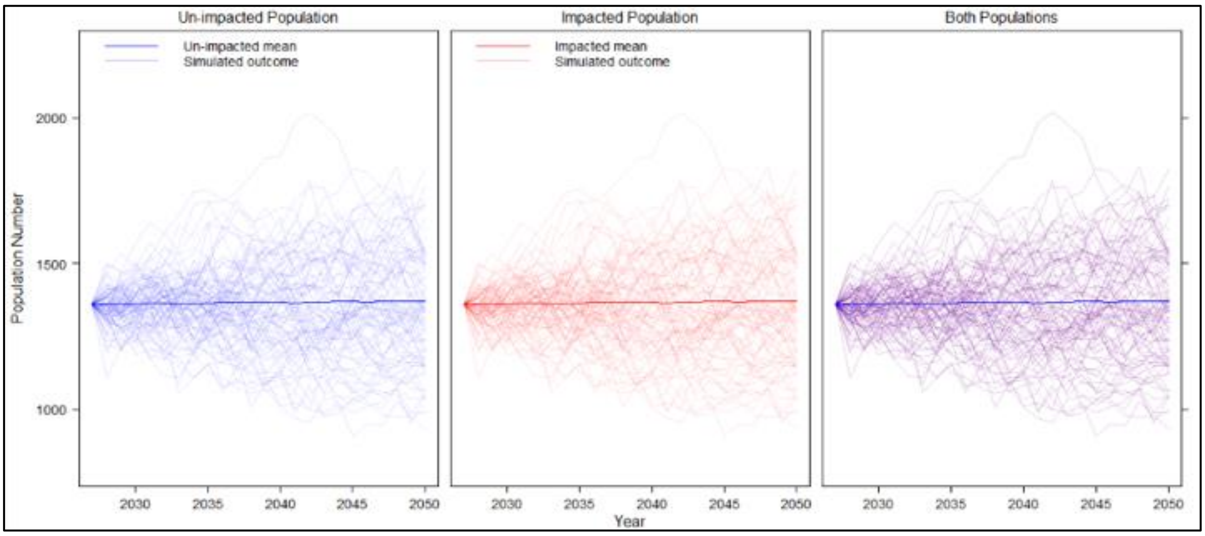

Figure 46 Predicted population trajectories for the un-impacted (baseline) and impacted harbour seal iPCoD simulations for piling schedule 1.

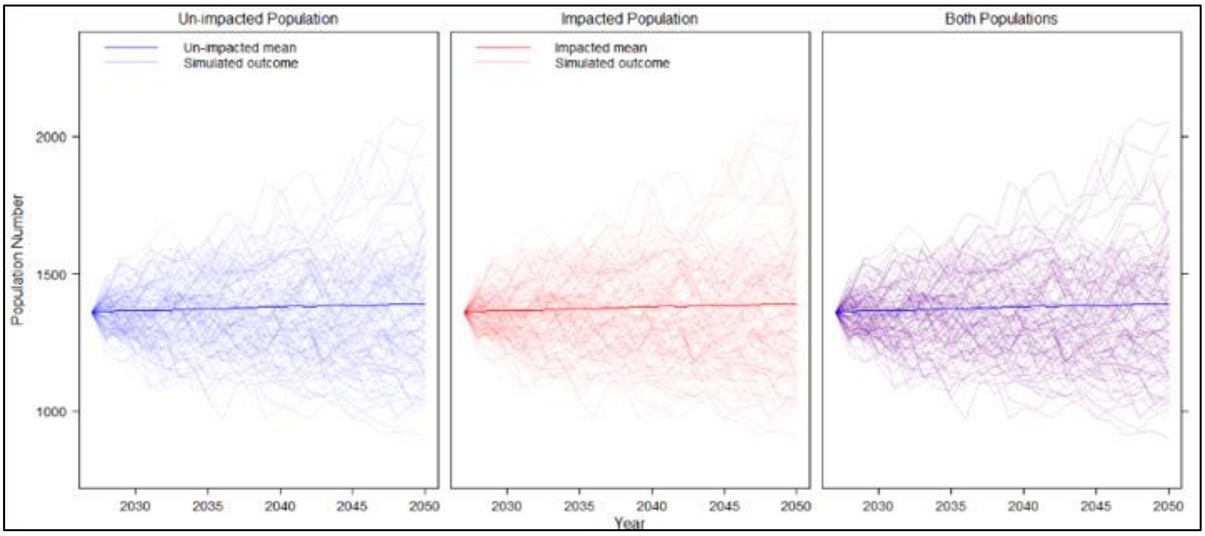

Figure 47 Predicted population trajectories for the un-impacted (baseline) and impacted harbour seal iPCoD simulations for piling schedule 2.

Table 86 Determination of magnitude for harbour seal for disturbance from foundation piling activity across the Phase 1 projects.

Harbour seal	Justification
Duration	Low – behavioural changes as a result of disturbance are expected to last days at the most.
Frequency	High – piling across the Phase 1 projects is expected to extend over 3 to 5 years.
Probability	High – studies show that harbour seals do respond to pile driving (Russell *et al.*, 2016a, Whyte *et al.*, 2020b).
Consequence	Low - No change to the population trajectory.
Overall magnitude	*The potential magnitude of disturbance from piling of Phase 1 projects is rated as Medium.*

All Projects

5.16.30 Overall, the number of harbour seals predicted to be disturbed by each offshore project is generally low (Table 87). This is because most projects are located in areas with relatively low expected harbour seal at-sea usage. The exception is the NISA OWF which is located nearer to the high-density areas around the Strangford Lough and Murlough SACs in Northern Ireland than Dublin, and is located in deeper waters which results in higher noise propagation. Therefore, predicted impacts to the MU are significantly higher in the three years in which NISA is expecting to be piling (2027 – 2029) when up to a maximum of 290 harbour seals are predicted to be impacted (21.2% MU). It is important to note here that when considering the potential impact from the Phase 1 projects, the “Phase 1 projects” assessment above for harbour seals is considered to be the more accurate since it uses project specific noise modelling from all Phase 1 projects to obtain project specific disturbance estimates. The detailed assessment for the Phase 1 projects, based on much higher confidence data, has already concluded no significant impact to harbour seals from piling across the five Phase 1 projects.

5.16.31 When Dublin Array is expected to be piling, temporary changes in behaviour and/or distribution of individuals may be at a scale that could result in potential reductions to lifetime reproductive success to some individuals, although likely not enough to affect the population trajectory over a generational scale. The magnitude is therefore **Medium** in the three years over which Dublin Array may be piling in combination with offshore construction activities off the east coast of Ireland. As per the project alone assessment, the sensitivity of harbour seals to pile driving of WTG is **Low**. Therefore, the overall significance of the cumulative effect to harbour seals is **Slight adverse (not significant in EIA terms)**.

Table 87 Number of harbour seals disturbed across all projects in the CEA (assuming impacts are additive across all projects construction in the same year)

Name	Type	Source	Tier	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Dublin Array	OWF	ES	-						13	13	13	13		
Dublin Port maintenance dredging	Coastal	Calculated	1	1	1	1	1	1	1					
Maintenance dredging River Boyne, Drogheda	Coastal	Calculated	1	5	5	5	5	5	5					
Development to the south of South Quay Arklow-ABWP2 OMF	Coastal	Calculated	2						0	0	0	0		
Dublin Port Company MP2 Project	Coastal	ES	2	0	0	0	0	0	0	0	0	0	0	0
Dún Laoghaire Harbour Company	Coastal	ES	2	0	0	0	0	0	0	0	0	0	0	0
Greater Dublin Drainage Outfall	Coastal	ES	2	0	0	0								
Arklow Bank	OWF	ES	3			1	1	1	1	1				
Bremore Port Project	Port	Calculated	3					4	4	4				
Dublin Port Company 3FM Project	Coastal	ES	3			0	0	0	0	0	0	0	0	0
Greenlink Interconnector	Power	ES	3	0										
Mares Connect	Power	Calculated	3			32	32	32	32					
Mersey Tidal Power	Tidal	Calculated	3					0	0	0	0	0	0	0
North Channel Wind 1	OWF	Calculated	3						22	22				
North Channel Wind 2	OWF	Calculated	3						12	12				
North Irish Sea Array	OWF	ES	3				200	200	200					
Oriel	OWF	ES	3			16	16	16						
ROSSLARE	Port	Calculated	3	3	3	3								
Codling Wind Park	OWF	Calculated	3				6							
TOTAL Tier 1 Projects				6	6	6	6	6	19	13	13	13	0	0
% MU				0.4%	0.4%	0.4%	0.4%	0.4%	1.4%	1.0%	1.0%	1.0%	0.0%	0.0%
TOTAL Tier 1 & 2 Projects				6	6	6	6	6	19	13	13	13	0	0

Name	Type	Source	Tier	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
% MU				0.4%	0.4%	0.4%	0.4%	0.4%	1.4%	1.0%	1.0%	1.0%	0.0%	0.0%
TOTAL Tier 1, 2 & 3 Projects				9	9	58	261	259	290	52	13	13	0	0
% MU				0.7%	0.7%	4.2%	19.1%	19.0%	21.2%	3.8%	1.0%	1.0%	0.0%	0.0%

Grey seal

Phase 1 projects

5.16.32 The iPCoD results show that the level of disturbance predicted under either piling schedule 1 or 2 is not sufficient to result in any changes at the population level, since the impacted population is predicted to continue at an increasing trajectory at exactly the same size as the un-impacted population. The overall magnitude is assessed as **Medium** (

5.16.33 Table 88). As per the project alone assessment, the sensitivity of grey seals to pile driving is **Negligible**. Therefore, the overall significance of the cumulative effect of disturbance from piling across the Phase 1 projects is **Imperceptible (not significant)**.

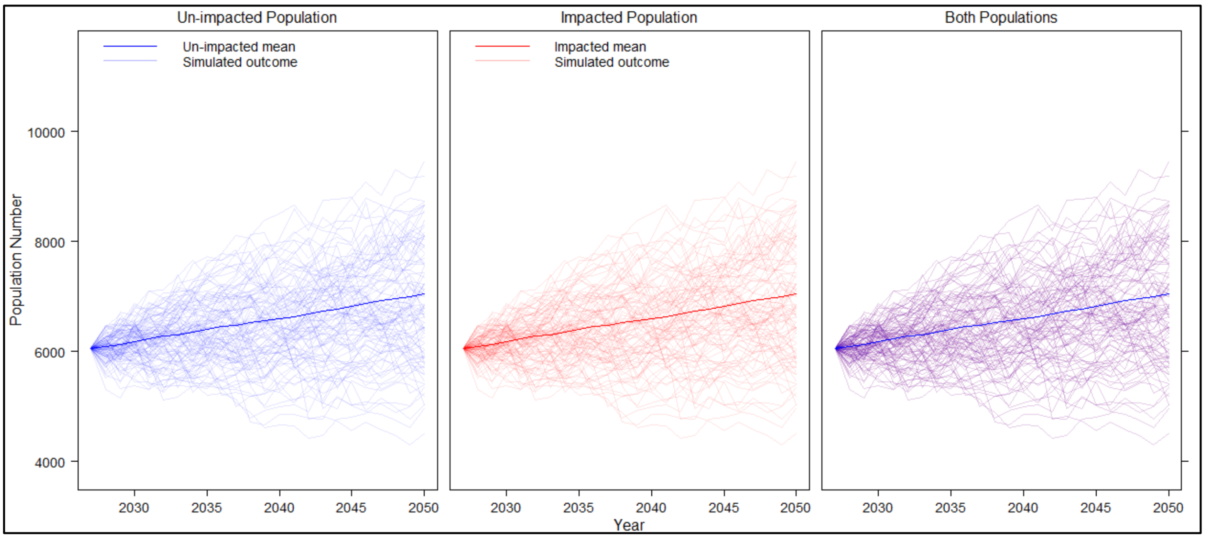

Figure 48 Predicted population trajectories for the un-impacted (baseline) and impacted grey seal iPCoD simulations for piling schedule 1.

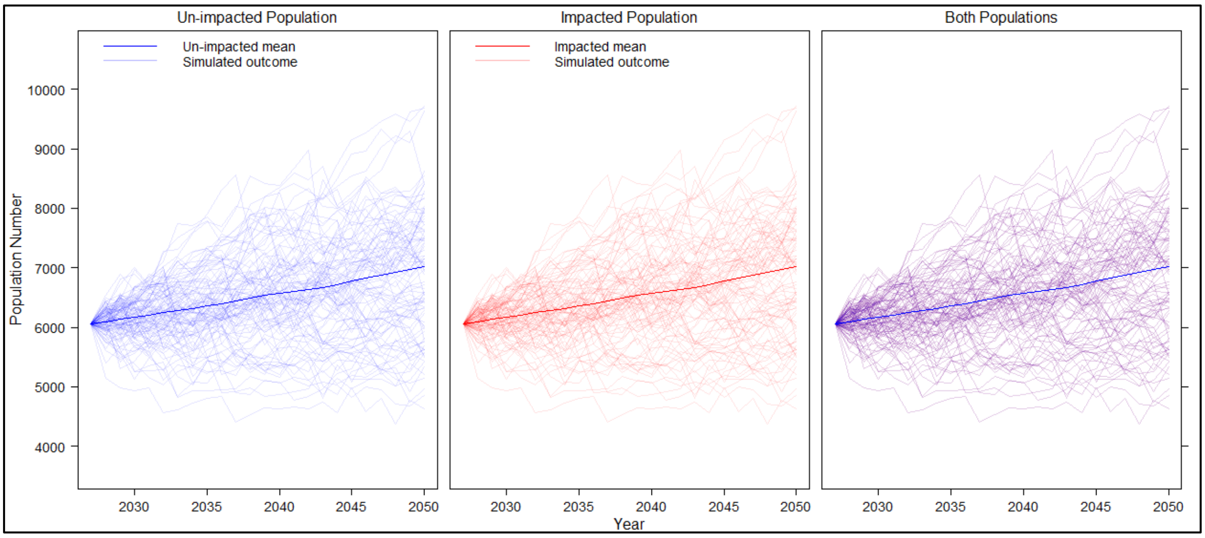

Figure 49 Predicted population trajectories for the un-impacted (baseline) and impacted grey seal iPCoD simulations for piling schedule 2.

Table 88 Determination of magnitude for grey seal for disturbance from foundation piling activity across the Phase 1 projects.

Grey seal	Justification
Duration	Low – behavioural changes as a result of disturbance are expected to last days at the most.
Frequency	High – piling across the Phase 1 projects is expected to extend over 3 to 5 years.
Probability	Medium – grey seals have shown high inter-individual variation in response to piling (Aarts *et al.*, 2018).
Consequence	Low - No change to the population trajectory.
Overall magnitude	*The potential magnitude of disturbance from piling of Phase 1 projects is rated as Medium.*

All Projects

5.16.34 The highest level of predicted disturbance occurs in 2029 when piling is expected to occur at Dublin, NISA, North Channel Wind 1, North Channel Wind 2 and Arklow Bank, alongside various other construction activities along the east coast of Ireland (Table 89). Across all projects in 2029, the number of grey seals disturbed is predicted to be 1,837, which represents 30.3% of the MU. It is noted that it is extremely unlikely that four of the five Irish Phase 1 OWF projects would be piling at the same time.

5.16.35 When Dublin Array is expected to be piling, temporary changes in behaviour and/or distribution of individuals may be at a scale that could result in potential reductions to lifetime reproductive success to some individuals. However, the iPCoD results show that the level of disturbance for the project alone is not sufficient to result in any change at the population level, since the impacted population is predicted to remain the same size and on the same increasing trajectory as the unimpacted population. The magnitude is therefore **Medium** in the years over which Dublin Array may be piling in combination with offshore construction activities off the east coast of Ireland. As per the project alone assessment, the sensitivity of grey seals to pile driving of WTG is **Negligible**. Therefore, the overall significance of the cumulative effect to harbour seals in 2029-2032 is **Imperceptible (not significant in EIA terms)**.

5.16.36 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Table 89 Number of grey seals disturbed across all projects in the CEA (assuming impacts are additive across all projects construction in the same year)

Name	Type	Source	Tier	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Dublin Array	OWF	ES	-						177	177	177	177		
Dublin Port maintenance dredging	Coastal	Calculated	1	18	18	18	18	18	18					
Maintenance dredging River Boyne, Drogheda	Coastal	Calculated	1	10	10	10	10	10	10					
Development to the south of South Quay Arklow- ABWP2 OMF	Coastal	Calculated	2						1	1	1	1		
Dublin Port Company MP2 Project	Coastal	ES	2	0	0	0	0	0	0	0	0	0	0	0
Dún Laoghaire Harbour Company	Coastal	ES	2	0	0	0	0	0	0	0	0	0	0	0
Greater Dublin Drainage Outfall	Coastal	ES	2	0	0	0								
Arklow Bank	OWF	ES	3			300	300	300	300	300				
Bremore Port Project	Port	Calculated	3					52	52	52				
Dublin Port Company 3FM Project	Coastal	ES	3			0	0	0	0	0	0	0	0	0
Greenlink Interconnector	Power	ES	3	3										
Mares Connect	Power	Calculated	3			21	21	21	21					
Mersey Tidal Power	Tidal	Calculated	3					0	0	0	0	0	0	0
North Channel Wind 1	OWF	Calculated	3						145	145				
North Channel Wind 2	OWF	Calculated	3						323	323				
North Irish Sea Array	OWF	ES	3				790	790	790					
Oriel	OWF	ES	3			21	21	21						
ROSSLARE	Port	Calculated	3	19	19	19								
Codling Wind Park	OWF	Calculated	3				394							
TOTAL Tier 1 Projects				28	28	28	28	28	205	177	177	177	0	0
% MU				0.5%	0.5%	0.5%	0.5%	0.5%	3.4%	2.9%	2.9%	2.9%	0.0%	0.0%
TOTAL Tier 1 & 2 Projects				28	28	28	28	28	206	178	178	178	0	0

Name	Type	Source	Tier	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
% MU				0.5%	0.5%	0.5%	0.5%	0.5%	3.4%	2.9%	2.9%	2.9%	0.0%	0.0%
TOTAL Tier 1, 2 & 3 Projects				50	47	389	1554	1212	1837	998	178	178	0	0
% MU				0.8%	0.8%	6.4%	25.7%	20.0%	30.3%	16.5%	2.9%	2.9%	0.0%	0.0%

Residual effect assessment

For all marine mammals, the significance of the cumulative effect of disturbance from underwater noise is not significant in EIA terms. Therefore, no additional mitigation to that already identified in (Table 13) are considered necessary. Therefore, ***no significant adverse residual effects*** *have been predicted in respect of marine mammals.*

Effect 20: Disturbance from vessel activity

5.16.37 It is extremely difficult to reliably quantify the level of increased disturbance to marine mammals resulting from increased vessel activity on a cumulative basis given the large degree of temporal and spatial variation in vessel movements between projects and regions, coupled with the spatial and temporal variation in marine mammal movements across the region.

5.16.38 Although some OWF vessels (such as crew transport and supply vessels) may transit to/from/within wind farm sites at higher speeds, they often travel in repeated/predictable routes within each site. Many other vessels (e.g. jack-up vessels and pilot or attending vessels) travel more slowly within the wind farm site or spend long periods of time jacked-up, at anchor (minimizing movement and acoustic signature from engines) or using dynamic positioning systems (minimizing movement, although still generating noise).

5.16.39 Vessel routes to and from offshore wind farms and other offshore projects will, for the majority, use existing vessel routes for pre-existing vessel traffic which marine mammals will be accustomed to. They may also have become habituated to the volume of regular vessel movements and therefore the additional risk is predominantly confined to construction sites. The vessel movements for offshore wind farms are likely to be limited and slow, resulting in less risk of disturbance to marine mammal receptors. In addition, most projects are likely to adopt environmental VMPs (or comply with existing Marine Wildlife Watching Codes) to minimise any potential effects on marine mammals.

5.16.40 Seismic surveys do not use existing vessel routes, so may risk adding vessel presence to novel areas; however, these are slow-moving and operate their own mitigation measures to protect marine mammals (while mitigating for PTS the mitigation measures will also reduce disturbance impacts). Therefore, increases in disturbance from vessels from offshore projects are likely to be small in relation to current and ongoing levels of shipping.

5.16.41 The cumulative effect of increased disturbance from vessels is predicted to be of local spatial extent, long-term duration (vessel presence is expected throughout the lifespan of a wind farm), intermittent (vessel activity will not be constant) and reversible (disturbance effects are temporary). Therefore, the magnitude of vessel disturbance is considered to be **Low**, indicating that the potential is for short-term and/or intermittent behavioural effects, with survival and reproductive rates very unlikely to be impacted to the extent that the population trajectory would be altered. It is anticipated that any animals displaced from the area will return when vessel disturbance has ended.

5.16.42 The sensitivity of all marine mammals to disturbance from vessel activity was assessed as **Low**. Therefore, significance of the impact is assessed as **Slight adverse (Not significant in EIA terms).**

Residual effect assessment

The significance of the cumulative effect of disturbance from vessels is not significant in EIA terms. Therefore, no additional mitigation to that already identified in Table 13 are considered necessary. Therefore, ***no significant adverse residual effects*** *have been predicted in respect of marine mammals.*

5.17 Interaction of environmental factors

5.17.1 A matrix illustrating where interactions between effects on different factors have been addressed is provided in Volume 8, Chapter 1: Interactions of the Environmental Factors.

5.17.2 Interactions of the foregoing are considered to be the effects and associated effects of different aspects of the proposal on the same receptor. These are considered to be:

- Project lifetime effects: Assessment of the scope for effects that occur throughout more than one phase of the project (construction, O&M and decommissioning) to interact and potentially create a more significant effect on a receptor than if just assessed in isolation in these three key project phases; and
- Receptor led effects: Assessment of the scope for all effects to interact, spatially and temporally, to create inter-related effects on a receptor. As an example, all effects on benthic ecology such as direct habitat loss or disturbance, sediment plumes, scour, jack up vessel use etc., may interact to produce a different, or greater effect on this receptor than when the effects are considered in isolation. Receptor-led effects might be short-term, temporary or transient effects.

5.17.3 As indicated in the interactions matrix (Volume 8, Chapter 1: Interactions of the Environmental Factors) there are linkages between the topic-specific chapters presented within this EIAR, whereby the effects assessed in one chapter have either the potential to result in secondary effects on another receptor (e.g. effects on fish and shellfish ecology have the potential to result in secondary effects on marine mammals prey resources).

5.17.4 The potential effects on marine mammals during construction, operational and maintenance and decommissioning phases of the Project have been assessed in Sections 5.13 to 5.15 above.

5.17.5 Effects on Marine Mammals (i.e. from effects to habitats and prey species) also have the potential to have secondary effects on other receptors which have been fully assessed in the topic-specific chapters. These receptors are:

- Chapter 5: Fish and Shellfish Ecology; and
- Chapter 11: Shipping and Navigation.

5.17.6 For Marine Mammal receptors, the following potential impacts have been considered within the interactions assessment:

- Disturbance from underwater noise;
- Disturbance from other activities;
- Collision risk from vessel activity;

- Increases in suspended sediment concentration; and
- Changes in prey availability and distribution.

Project lifetime effects

5.17.7 Project lifetime effects consider impacts from the construction, operation or decommissioning of the offshore infrastructure on the same receptor (or group). The potential inter-related effects that could arise in relation to marine mammal ecology are presented in Table 90.

Table 90 Project lifetime effects assessment for potential inter-related effects on marine mammals.

Impact Type	Effects (Assessment Alone)			Interaction Assessment
	C	O&M	D	Project lifetime effects
Disturbance (behavioral) or injury from underwater noise (pile driving, geophysical survey, UXO clearance)	Not significant (Behavioral disturbance and PTS-onset as a result of pile driving) Not significant (Behavioral disturbance and PTS-onset as a result of preconstruction geophysical surveys) Not significant (Behavioral disturbance and PTS-onset as a result of UXO clearance)	N/A	N/A	This effect will only arise during the construction phase and as such there will be no interactions between effects across the project phases. In addition, project design features and avoidance measures will be implemented to reduce the risk of injury occurring during construction thereby reducing the potential for long-term effects on individuals.
Disturbance from other activities (dredging, drilling, cable	Slight Adverse	Slight Adverse (vessel noise only)	Slight Adverse (vessel noise only)	While impact piling will be the loudest noise source during the construction phase, there will also be several other construction activities that will

Impact Type	Effects (Assessment Alone)			Interaction Assessment
	C	O&M	D	Project lifetime effects
laying, rock placement and trenching, vessel noise)				produce underwater noise. These include dredging, drilling, cable laying, rock placement and trenching, as well as noise generated by the presence of construction vessels. Excluding vessel noise, these other activities will only arise during the construction phase and as such there will be no interactions between effects across the project phases. The potential for disturbance from vessel noise will arise at all stages of the offshore infrastructure, resulting in a potential project lifetime effect. However, it is not predicted that the significance of any potential effects will increase due to the interaction of this impact across all project stages, rather be maintained at the same level throughout the lifetime of the offshore infrastructure. Therefore, across the project lifetime, the effects on marine mammals are not anticipated to interact in such a way as to result in combined effects of greater significance than the assessments presented for each individual phase.
Collision risk from vessel activity	Negligible	Negligible	Negligible	Consideration of collision risk and disturbance from vessel activities during the construction, operational and maintenance, and decommissioning phases of the offshore infrastructure is presented in this chapter. The potential for injury from collision and/or disturbance effects will arise at all stages of the offshore infrastructure, resulting in a potential project lifetime effect. However, it is not predicted that the significance of any potential

Impact Type	Effects (Assessment Alone)			Interaction Assessment
	C	O&M	D	Project lifetime effects
				effects will increase due to the interaction of this impact across all project stages, rather, it will be maintained at the same level throughout the lifetime of the offshore infrastructure. Therefore, across the project lifetime, the effects on marine mammals are not anticipated to interact in such a way as to result in combined effects of greater significance than the assessments presented for each individual phase.
Increases in suspended sediment concentration	Negligible	Negligible	Negligible	The likelihood of project lifetime effects arising is low given the factored-in measures that will be applied throughout the various project stages which will ensure that the risk of interaction of such effects through time is limited. Therefore, across the project lifetime, the effects on Marine Mammal receptors are not anticipated to interact in such a way as to result in combined effects of greater significance than the assessments presented for each individual phase.
Changes in prey availability and distribution	Negligible	Negligible	Negligible	Impacts to fish and shellfish receptors will not result in an ongoing, additive loss of prey, over the project lifetime. Rather there may be an initial decrease in prey availability during the construction phase (i.e. from underwater noise impacts, temporary habitat loss etc.) followed by recovery of areas, leading to no large-scale and long-term loss of prey items. The implementation of the project design features and avoidance and preventative measures (as defined in the Schedule of Commitments) and avoidance of key habitats throughout the iterative project design informed

Impact Type	Effects (Assessment Alone)			Interaction Assessment
	C	O&M	D	Project lifetime effects
				by survey data willreduce the risk of significant effects on sensitive fish and shellfish receptors. Therefore, the significance of this interaction between effects is not predicted to increase over and above the predictions made for the individual project phases.

Receptor led effects

5.17.8 The greatest potential for spatial and temporal interactions is likely to occur with underwater construction noise impacts (i.e. during the construction phase). The individual impacts were assigned significance of Neutral to Slight adverse. It is noted that some of these interactions are mutually exclusive (i.e. disturbance/displacement resulting from underwater noise will mean reduced potential for more localised impact pathways that may occur at the same time, e.g. vessel interactions and reduced impact from suspended sediment). It is therefore not anticipated that any inter-related effects will be produced that are of greater significance than the assessments presented for each individual phase.

5.17.9 The potential for disturbance and/or collision effects will arise at all stages of the project, resulting in a potential project lifetime effect. However, it is not predicted that the significance of any potential effects will increase due to the interaction of this impact across all project stages, rather be maintained at the same level (i.e. Negligible) or less throughout the project. With the implementation of a VMP, impacts from vessel activity is assessed as Slight adverse and therefore not significant across all three phases. Therefore, across the project lifetime, the effects on marine mammals are not anticipated to interact in such a way as to result in combined effects of greater significance than the assessments presented for each individual phase.

5.17.10 Overall, no interactions of environmental factors have been identified where an accumulation of residual impacts on marine mammals and the relationship between those impacts gives rise to a need for additional mitigation beyond the project design features and avoidance and preventative measures already considered.

5.18 Transboundary statement

5.18.1 Transboundary effects are defined as those effects upon the receiving environment of other European Economic Area (EEA) states, whether occurring from the project alone, or cumulatively with other projects in the wider area.

5.18.2 It should be noted that the mobile nature of marine mammals results in the potential for transboundary effects to occur. Whilst each species has been assessed within the relevant MU, the MUs under which each species has been assessed varies greatly in the area covered, with the MUs for common dolphin and minke whale covering the Celtic and Greater North Sea area. Furthermore, the respective MUs do not represent closed populations. This means that impacts, whilst localised, could potentially affect other MUs if mixing between the assessed populations occurs, for example, bottlenose dolphins in the RoI have been found to travels large distances may demonstrate connectivity to individuals found on the East coast of the UK (Robinson *et al.*, 2012).

5.18.3 There may be behavioural disturbance or displacement of marine mammals from the proposed development site as a result of underwater noise. Behavioural disturbance resulting from underwater noise during construction could occur over large ranges (tens of kilometres) and therefore there is the potential for transboundary effects to occur where subsea noise arising from Dublin Array could extend into waters of other EEA states. Dublin Array is located in close proximity to other States (e.g. Northern Irish waters, Welsh waters, Manx waters and English waters) and therefore there is the potential for transit of certain species between areas. Any transboundary impacts that do occur as a result of underwater noise at the proposed development are predicted to be short-term and intermittent, with the recovery of marine mammal populations to affected areas following the completion of construction activities. Therefore, any impact will be **Negligible**, and will not lead to a significant effect.

5.18.4 Disturbance to prey species from loss of fish spawning and nursery habitat and suspended sediments and deposition may also occur. The effects of reduction in prey availability are predicted to be limited in extent to a number of kilometres from the proposed development and are therefore not predicted to extend into the waters of other EEA states.

5.18.5 Overall, no significant transboundary effects are expected to occur.

5.19 Potential Monitoring Requirements

5.19.1 Assessed project only and cumulative effects on marine mammal receptors as a result of the construction, operation and maintenance and decommissioning phases of the Dublin Array OWF are predicted to be not significant in EIA terms. Based on the assessed impacts it is concluded that no specific monitoring is required.

5.19.2 The Applicant is committed to participating in the ‘East Coast Monitoring Group’ (ECMG), to discuss and agree potential strategic monitoring initiatives in relation to marine mammals. The need for strategic monitoring, and the level of participation by individual projects, will be determined by the conclusions of the EIAR process, in consultation with statutory and technical stakeholders, and with a focus on validation and evidence gathering.

5.20 Summary of effects

5.20.1 This chapter has assessed the potential effects on marine mammal receptors arising from construction, O&M and decommissioning of the offshore infrastructure for Dublin Array. The impacts considered include direct impacts (e.g. disturbance from piling), as well as indirect impacts (e.g. change in prey species abundance), alongside cumulative effects (e.g. underwater noise from various offshore energy developments within the species MU). Potential impacts considered in this chapter, alongside any mitigation and residual effects are summarised in Table 91.

5.20.2 Throughout the construction, operation and decommissioning phases, all impacts assessed were found to have either **Neutral or Slight (adverse)** effects on all marine mammal receptors and thus no impact pathway was considered to be significant.

5.20.3 The assessment of cumulative effects from the project alone and other developments and activities concluded that the effects of any cumulative impacts would be of **Slight adverse** significance at the most, which is not which is not significant in EIA terms. Thus no cumulative impact pathway was considered to be significant.

Table 91 Summary of effects

Impact no	Impact	Additional mitigation measures	Residual impact
Construction			
Impact 1	Auditory injury as a result of geophysical surveys	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 2	Behavioural disturbance from geophysical surveys	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 3	PTS-onset from UXO clearance	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 4	Behavioural disturbance from UXO clearance	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 5	Auditory injury as a result of foundation piling activity	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 6	Behavioural displacement and disturbance from foundation piling activity	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 7	Other construction activities (auditory injury and disturbance)	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 8	Vessel collision risk	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 9	Increases in suspended sediment concentrations	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 10	Changes in prey availability and distribution (construction) - indirect impacts on marine mammals	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Operation and maintenance			
Impact 11	Disturbance from vessel noise (O&M)	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 12	Vessel collision risk (O&M)	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 13	Increases in suspended sediment concentrations (O&M) - indirect impacts on marine mammals	Not Applicable – no additional mitigation identified	No significant adverse residual effects

Impact no	Impact	Additional mitigation measures	Residual impact
Impact 14	Changes in prey availability and distribution (O&M) - indirect impacts on marine mammals	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Decommissioning			
Impact 15	Disturbance (decommissioning)	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 16	Vessel collision risk (decommissioning)	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 17	Increases in suspended sediment concentrations (decommissioning) - indirect impacts on marine mammals	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 18	Changes in prey availability and distribution (decommissioning)	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Cumulative			
Impact 19	Disturbance from underwater noise	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 20	Disturbance from vessel activity	Not Applicable – no additional mitigation identified	No significant adverse residual effects

5.20.4 The Applicant has decided to make an application to NPWS on a precautionary basis for a derogation licence in respect of marine mammals, pursuant to Regulation 54 of the Birds and Natural Habitats Regulations 2011 (transposing Article 16 of the Habitats Directive). The application has been submitted to NPWS and a copy is included in this planning application (Volume 4 of the EIAR, Appendix 4.3.5-8).

5.20.5 This application has been submitted on a precautionary basis because it is the Applicant's view that this is not required in respect of the proposed development. As detailed within Volume 2, Chapter 2, of the EIAR (Consents, Policy and Legislation), the revised Renewable Energy Directive (EU) 2023/2413 (RED III) is materially relevant to any consideration of whether a derogation licence is required for the construction and operation of a renewable infrastructure project. This inserted Article 16b into the 2018 recast Renewable Energy Directive (Directive 2018/2001) which states that where a renewable energy project has adopted necessary mitigation measures, any killing or disturbance of the species protected under Article 12(1) of Directive 92/43/EEC and Article 5 of Directive 2009/147/EC shall not be considered to be 'deliberate'. The Applicant is satisfied that the proposed development incorporates the necessary mitigation measures and, therefore, any killing or disturbance of species protected by the Habitats Directive is not 'deliberate', within the meaning of those Directives, such that there is no requirement for a derogation licence.

5.20.6 Furthermore, Article 3 of the 2022 Temporary Renewable Energy Regulation (Regulation (EU) No.2022/2577) states that the planning, construction and operation of plants and installations for the production of energy from renewable sources, and their connection to the grid, the related grid itself and storage assets shall be presumed as being in the overriding public interest and serving public health and safety when balancing legal interests in the individual case and expressly refers to Article 16 of the Habitats Directive. This is amended by Council Regulation (EU) 2024/223. This is also relevant to any application for a derogation licence.

5.20.7 A copy of the submitted derogation licence application is included with this planning application so that ABP can take it into account, to the extent considered necessary. The Applicant will write to ABP to confirm the outcome of the derogation licence process. If NPWS grants the derogation licence, the Applicant will provide a copy to ABP for consideration, and public consultation if required, so that ABP can reflect the granting of the licence in its reasoned conclusion on the EIA and AA and as part of its assessment of compliance with Biodiversity Policy 4 of the NMPF.

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ES/PEIR chapters considered in the CEA

Project	Reference
Arklow Bank	Arklow Bank Wind Park 2 Environmental Impact Assessment Report Volume II, Chapter 11: Marine Mammals
Awel y Môr	Awel y Môr Offshore Wind Farm Category 6: Environmental Statement Volume 2, Chapter 7: Marine Mammals
Berwick Bank	Berwick Bank Wind Farm Environmental Impact Assessment Report Volume 2, Chapter 10: Marine Mammals; EIA Report (EOR0766)
Cambo (FPSO (Power from Shore)	Cambo Oil Field, UKCS Blocks 204/4a, 204/5a, 204/9a and 204/10a, Environmental Impact Assessment (EIA), Siccar Point Energy (D/4261/2021)
Cardiff Bay Tidal Lagoon	Proposed Tidal Lagoon Development, Cardiff, South Wales Environmental Impact Assessment Scoping Report, March 2015
Culzean	Culzean Floating Offshore Wind Turbine Pilot Project Environmental Impact Assessment Report – Chapter 10 - Marine Mammals and Other Megafauna, Xodus, Report No. GB-CZN-00-XODUS-00001 2
Dogger Bank A	Dogger Bank Creyke Beck Environmental Statement Chapter 14 Marine Mammals, Application Reference 6.14
Dogger Bank B	Dogger Bank Creyke Beck Environmental Statement Chapter 14 Marine Mammals, Application Reference 6.14
Dogger Bank C	Dogger Bank Teesside A & B Environmental Statement Chapter 14 Marine Mammals, Application Reference 6.14
Dogger Bank South (East)	Dogger Bank South Offshore Wind Farms Environmental Statement Volume 7 Chapter 11 – Marine Mammals June 2024 Application ref: 7.11 APFP Regulation: 5(2)(a) Revision: 01
Dogger Bank South (West)	Dogger Bank South Offshore Wind Farms Environmental Statement Volume 7 Chapter 11 – Marine Mammals June 2024 Application ref: 7.11 APFP Regulation: 5(2)(a) Revision: 01
Dublin Port Company MP2 Project	MP2 Project, Volume 2 Environmental Impact Assessment Report Main Document (Part 1), RPS, Report No. IBE1429/EIAR, Rev. F.
Dudgeon Extension	Sheringham Shoal and Dudgeon Offshore Wind Farm Extension Projects Environmental Statement, Volume 1 Chapter 10 - Marine Mammal Ecology, August 2022, Document Reference: 6.1.10, APFP Regulation: 5(2)(a), Doc. No. C282-RH-Z-GA-00030 6.1.10
Dún Laoghaire Harbour Company	Proposed Cruise Berth Facility, Dún Laoghaire Harbour Environmental Impact Statement, Stephen Little and Associates, June 2015 https://www.pleanala.ie/publicaccess/EIAR-NIS/PA0042-PA0051/EIS%20Volume%201%20Written%20Statement/EIS_Chapter_5_2_Flora_and_Fauna.pdf
East Anglia One North	East Anglia ONE North Offshore Windfarm, Chapter 11 Marine Mammals Environmental Statement, Volume 1, Applicant: East Anglia ONE North Limited, Document Reference: 6.1.11, SPR Reference: EA1N-DWF-ENV-REP-IBR-000348 Rev 01
East Anglia Three	East Anglia Three, Chapter 12 Marine Mammal Ecology Environmental Statement, Volume 1, Document Reference – 6.1.12, Rev A.
East Anglia Two	East Anglia TWO Offshore Windfarm, Chapter 11 Marine Mammals Environmental Statement, Volume 1, Applicant: East Anglia TWO Limited, Document Reference: 6.1.11, SPR Reference: EA2-DWF-ENV- REP-IBR-000903, Rev 01.

Project	Reference
EMEC Bilia Croo	EMEC Billia Croo Test Site: Environmental Appraisal, EMEC Document Code: REP666
Erebus Floating Wind Demo	Project Erebus Environmental Statement, Chapter 12: Marine Mammals, MarineSpace
Five Estuaries	Five Estuaries Offshore Wind Farm Environmental Statement, Volume 6, Part 2, Chapter 7: Marine Mammal Ecology, Application Reference EN010115, Application Document Number 6.2.7, Revision A
Forthwind	ForthWind Offshore Demonstration Site, Methil, Fife, Volume 1: Environmental Impact Assessment Report, April 2022
Greater Dublin Drainage Outfall	Greater Dublin Drainage Project (Irish Water), Environmental Impact Assessment Report: Volume 3 Part A of 6, Chapter 9 Biodiversity (Marine), June 2018
Green Volt	Green Volt, Chapter 11 Marine Mammal Ecology, Offshore EIA Report, Volume 1, January 2023
Greenlink Interconnector	Greenlink Marine Environmental Impact Assessment Report- Ireland, P1975_R4500_Revf2 July 2019 Greenlink Marine Environmental Impact Assessment Report- Ireland Appendix C Underwater Sound Modelling P1975_R4500_Revf1 July 2019
Hornsea Project Four	Hornsea Project Four: Environmental Statement (ES), PINS Document Reference: A2.4, APFP Regulation: 5(2)(a), Volume A2, Chapter 4: Marine Mammals
Hornsea Project Three	Hornsea Project Three Offshore Wind Farm, Environmental Statement: Volume 2, Chapter 4 – Marine Mammals, PINS Document Reference: A6.2.4, APFP Regulation 5(2)(a), Date: May 2018
Inch Cape	Inch Cape (Revised Design) - EIA Report Volume 1A, Chapter 10: Marine Mammals
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Morecambe	Morecambe Offshore Windfarm: Generation Assets, Environmental Statement Volume 5, Chapter 11: Marine Mammals, PINS Document Reference: 5.1.11, Rev 01
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Neart Na Gaoithe	NNG Offshore Wind, Chapter 8: Marine Mammals, Pelagic Environmental Consultancy Ltd. March 2018
Norfolk Vanguard East	Norfolk Vanguard Offshore Wind Farm, Chapter 12: Marine Mammals, Environmental Statement, Volume 1, Document Reference: 6.1.12, RHDHV Reference: PB4476-005-012
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North Falls	North Falls Offshore Windfarm, 2024, Environmental Statement Chapter 12: Marine Mammals, Doc No. 3.1.14, Volume 3.1

Project	Reference
North Irish Sea Array	North Irish Sea Array (NISA). 2024. Environmental Impact Assessment Report, Volume 3: Offshore Chapters, Chapter 14: Marine Mammals
Oriel	Oriel Wind Farm Project Environmental Impact Assessment Report Chapter 10: Marine Mammals and Megafauna, Volume 2B. Doc No. A1 C01. March 2024
Orkney Interconnector	Orkney - Caithness 220 kV Link Marine Environmental Appraisal Volume 1: Main Report, Environ, May 2013.
Orkney-Caithness	Orkney - Caithness 220 kV Link Marine Environmental Appraisal Volume 1: Main Report, Environ, May 2013
Outer Dowsing	Outer Dowsing Offshore Wind, Environmental Statement Chapter 11: Marine Mammals, Volume 1, Document Reference: 6.1.11, Rev 1.0, March 2024
Pentland Floating	Pentland floating offshore wind farm, Volume 2: Offshore EIAR, Chapter 11: Marine Mammals and Other Megafauna, Doc No. GBPNTD-ENV-XOD-RP-00006. July 2022
Rampion 2	Rampion 2 Wind Farm, Category 6: Environmental Statement Volume 2, Chapter 11: Marine mammals. Date: August 2023, Revision A, Document Reference: 6.2.11
Rosebank FPSO	Rosebank Environmental Statement Doc No. ES/2022/001, August 2022
Salamander	Salamander Offshore Wind Farm, Offshore EIA Report Volume ER.A.3, Chapter 11: Marine Mammals, Document Number 08435483, April 2024
Sheringham Shoal Extension	Sheringham Shoal and Dudgeon Offshore Wind Farm Extension Projects Environmental Statement, Volume 1 Chapter 10 - Marine Mammal Ecology, August 2022, Document Reference: 6.1.10, APFP Regulation: 5(2)(a), Doc. No. C282-RH-Z-GA-00030 6.1.10
Sofia	Sofia Offshore Wind Farm, Environmental Appraisal of Increased Hammer Energy, March 2018
West of Orkney	West of Orkney Windfarm, Offshore EIA Report Volume 1, Chapter 12 - Marine Mammals and Megafauna, Document Number L-100632-S05-A - ESIA-012, September 2023
White Cross	White Cross Offshore Windfarm, Environmental Statement Chapter 12: Marine Mammal and Marine Turtle Ecology, Document Number FLO-WHI-REP-0002-12, March 2023

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Annex A: Marine Mammals Policy

Legislation, Policy and Guidance

Policy/ Legislation	Key provisions	Section where provision is addressed
Legislation		
Wildlife Acts 1976 to 2021[53]	All cetaceans and seals are protected under the Wildlife Act (1976) and subsequent amendments. Under the act and its amendments, it is an offence to hunt, injure or willfully interfere with, disturb or destroy the resting or breeding place of a protected species (except under license or permit). The act applies out to the 12 nm limit of Irish territorial waters.	Assessment of the potential to injure and disturb marine mammals is provided in the impact assessment section (e.g. Impact 6: Behavioural displacement and disturbance from foundation piling activity).
Guidelines and technical standards		
Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters, DAHG (2014)	Recommend specific maritime activities that should be considered in relation to introduced sound and the prevention of injury or disturbance to marine mammals: • Dredging • Drilling • Pile driving • Geophysical acoustic surveys • Blasting	PTS and Disturbance assessments are provided for: • Geophysical surveys (**Impact 1: Auditory injury as a result of geophysical surveys** and **Impact 2: Behavioural disturbance from geophysical surveys**) • Pile driving (Impact 6: Behavioural displacement and disturbance from foundation piling activity) • UXO (Impact 3: PTS-onset from UXO and Impact 4: Behavioural disturbance from UXO) Drilling and blasting are not included in this impact assessment.
IWDG (2020) Policy on Offshore Wind Farm Development – marine mammals	For acoustic trauma injury levels should be considered at the lowest predicted level of TTS and mitigation strategies should be designed to prevent TTS.	Auditory injury (PTS) and behavioural disturbance are assessed (see Impact 6: Behavioural displacement and disturbance from foundation piling activity). TTS-onset is not assessed – reasoning described in TTS (construction, operation and decommissioning).

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[53] Wildlife Acts 1976 to 2021 is a collective citation for the Wildlife Act 1976 and subsequent amendment acts (2000, 2010, 2012), the Heritage Act 2018 and Planning, Heritage and Broadcasting (Amendment) Act 2021.

Policy/ Legislation	Key provisions	Section where provision is addressed
	The impact of noise pollution on adjacent SACs, MPAs or cetacean hotspots and resultant behavioural disruption, habitat degradation and changes in use of these areas by cetaceans should also be considered.	Impacts on SACs is addressed in the RIAA. Behavioural disruption (disturbance) is addressed in the construction impacts section (e.g. Impact 6: Behavioural displacement and disturbance from foundation piling activity).
	Passive Acoustic Monitoring (PAM) should be adopted into standard mitigation protocols to allow detection of cetaceans in poor visibility during the hours of darkness and for detecting animals underwater where source levels are often highest. Where PAM is deemed to be insufficiently adequate to mitigate against impacts to marine mammals then thermal imaging with adequate detection capability and range should be employed for night-time operations. Acoustic Deterrent Devices (ADDs) should be used to reduce the threat of auditory injury, where they are known to be effective for the species present.	Included, where relevant, in the MMMP (see **Section 5.12**).
	Where possible UXOs should be removed for disposal ashore, where not possible and ordnance is to be detonated, deflagration is recommended with noise abatement to reduce noise impact. Standard mitigation practices should be applied for removal, in case of accidental detonation and for in-situ detonation with MMOs and PAM operators.	Assessment of UXO clearance (MDO – high-order detonation) is presented in **Impact 3: PTS-onset from UXO** and **Impact 4: Behavioural disturbance from UXO.** Mitigation to be addressed in the MMMP (see **Section 5.12)**
	Noise mitigation measures such as coffer dams, bubble curtains and other Noise Abatement Systems (NAS) should be implemented where appropriate to reduce noise emitted into the environment, taking into account the depth, current, seabed and environmental conditions of the site.	The Applicant commits to the implementation of at-source mitigation methods (e.g. bubble curtains) to minimize the underwater noise impacts. All underwater noise modelling for pile driving conducted in this assessment assumes noise mitigation is implemented.

Policy/ Legislation	Key provisions	Section where provision is addressed
	Soft starts or ramp-ups, while unproven in efficacy, should be used where possible, with stepped increases of approximately 6 dB in pressure level. Soft starts should be of an appropriate length based on the number of steps and a duration (number of minutes) per step should be determined and reduce noise in the environment.	Assessment of PTS-onset using the SEL_{cum} threshold includes a modelled soft-start to the pile driving (see **Section 5.11** and **Volume 4, Appendix 4.3.5-7: Underwater noise assessment**).
Southall *et al*. (2019) Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects	The most recent guidance on PTS and TTS-onset thresholds in marine mammal hearing groups from continuous and impulsive noise sources. This supersedes the previous guidance from Southall et al (2007).	The quantitative assessment of PTS-onset from UXO clearance (Impact 3: PTS-onset from UXO clearance), piling (Impact 5: Auditory injury as a result of foundation piling activity) and other construction activities (**Impact 7: Other construction activities**) uses the Southall *et al.* (2019) PTS-onset thresholds. The quantitative assessment of disturbance from UXOs uses TTS-onset as a proxy for disturbance based upon the Southall *et al.* (2019) TTS-onset thresholds (**Impact 4: Behavioural disturbance from UXO clearance**).
JNCC et al. (2020) Guidance for assessing the significance of noise disturbance against Conservation Objectives of harbour porpoise SACs	Recommended 26 km EDR for high-order UXO clearance.	The quantitative assessment of disturbance from UXOs uses the 26 km EDR as recommended (**Impact 4: Behavioural disturbance from UXO clearance**).
JNCC (2023) DRAFT guidelines for minimising the risk of injury to marine mammals from unexploded ordnance clearance in the marine environment	Guidelines provided for defining the mitigation zone, and mitigation methods to be considered for UXO clearance (pre-detonation MMO search, and potential use of PAM, ADDs and noise abatement if required).	Included in the outline MMMP (see **Section 5.12**).

Policy/ Legislation	Key provisions	Section where provision is addressed
JNCC (2010) Statutory Nature Conservation Agency Protocol for Minimising the Risk of Injury to Marine Mammals from Piling Noise	Guidelines provided for defining the mitigation zone and mitigation methods to be considered for pile driving activities (pre-piling MMO search, and potential use of PAM, ADDs and noise abatement if required).	Included in the outline MMMP (see **Section 5.12**). The Applicant commits to the implementation of at-source mitigation methods (e.g. bubble curtains) to minimize the underwater noise impacts. All underwater noise modelling for pile driving conducted in this assessment assumes noise mitigation is implemented (Impact 5: Auditory injury as a result of foundation piling activity and **Impact 6: Behavioural displacement and disturbance from foundation piling activity**).

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