Environmental Impact Assessment Report

Volume 3

Chapter 11 Marine Mammals

codling
wind park

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Abbreviations

Abbreviation	Term in Full
ABP	An Bord Pleanála
AC	Alternating Current
ADD	Acoustic Deterrent Device
CEMP	Construction Environmental Management Plan
CWP	Codling Wind Park
CWPE	Codling Wind Park Extension
CWPL	Codling Wind Park Limited
DAS	Digital Aerial Survey
dB	Decibel
EDR	Effective Deterrence Range
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
EMF	Electromagnetic Field
EPA	Environmental Protection Agency
ESB	Electricity Supply Board
EU	European Union
EVMP	Ecological Vessel Management Plan
GW	Gigawatt
IACs	Inter-array Cables
INNS	Invasive Non-native Species
MAC	Maritime Area Consent
MAP	Maritime Area Planning
MBES	Multi-Beam Echo Sounder
MMMP	Marine Mammal Mitigation Protocol
MMO	Marine Mammal Observer
MPA	Marine Protected Area
MSFD	Marine Strategy Framework Directive
MU	Management Unit
NMPF	National Marine Planning Framework
OECC	Offshore Export Cable Corridor
O&M	Operations and Maintenance

Abbreviation	Term in Full
OSS	Offshore Substation Structure
OWF	Offshore Wind Farm
Pa	Pascal
PAM	Passive Acoustic Monitoring
PTS	Permanent Threshold Shift
SAC	Special Area of Conservation
SBI	Sub-Bottom Imager
SBP	Sub Bottom Profiler
SEL	Sound Exposure Level
SPL	Sound Pressure Level
SSS	Side Scan Sonar
TTS	Temporary Threshold Shifts
UHRS	Ultra-High Resolution Seismic
USBL	Ultra-Short Baseline
UXO	Unexploded Ordnance
WTG	Wind Turbine Generator
ZoI	Zone of Influence

Definitions

Glossary	Meaning
alternating current (AC)	A flow of electrical current which reaches maximum in one direction, decreases to zero, then reverses itself and reaches maximum in the opposite direction. The cycle is repeated continuously and the number of cycles per second is equal to the frequency. The Irish electrical system is an AC network that uses a frequency of 50 Hz.
the Applicant	The developer, Codling Wind Park Limited (CWPL).
array site	The red line boundary area within which the wind turbine generators (WTGs), inter-array cables (IACs) and the offshore substation structures (OSSs) are proposed.
Codling Wind Park (CWP) Project	The proposed development as a whole is referred to as the Codling Wind Park (CWP) Project, comprising of the offshore infrastructure, the onshore infrastructure and any associated temporary works.
Codling Wind Park Limited (CWPL)	A joint venture between Fred. Olsen Seawind (FOS) and Électricité de France (EDF) Renewables, established to develop the CWP Project.
Environmental Impact Assessment (EIA)	A systematic means of assessing the likely significant effects of a proposed project, undertaken in accordance with the EIA Directive and the relevant Irish legislation.
Environmental Impact Assessment Report (EIAR)	The report prepared by the Applicant to describe the findings of the EIA for the CWP Project.
ESB Networks (ESBN)	Owner of the electricity distribution system in the Republic of Ireland, responsible for carrying out maintenance, repairs and construction on the grid.
ESBN network cables *(previously the ESB grid connection)*	Three onshore export cable circuits connecting the onshore substation to the proposed ESBN Poolbeg substation, which will then transfer the electricity onwards to the national grid.
export cables	The cables, both onshore and offshore, that connect the offshore substations with the onshore substation.
generating station	Comprising the wind turbine generators (WTGs) inter array cables (IACs) and the interconnector cables.
high water mark (HWM)	The line of high water of ordinary or medium tides of the sea or tidal river or estuary.
inter-array cables (IACs)	The subsea electricity cables between each WTG between and the OSSs.
interconnector cables	The subsea electricity cables between OSSs
landfall	The point at which the offshore export cables are brought onshore and connected to the onshore export cables via the transition joint bays (TJB). For the CWP Project The landfall works include the installation of the offshore export cables within Dublin Bay out to approximately 4 km offshore, where water depths that are too shallow for conventional cable lay vessels to operate.

Glossary	Meaning
limit of deviation (LoD)	Locational flexibility of permanent and temporary infrastructure is described as a LoD from a specific point or alignment.
Maritime Area Consent (MAC)	A Maritime Area Consent (MAC) provides State authorisation for a prospective developer to undertake a maritime usage and occupy a specified part of the maritime area. A MAC is required to be in place before planning consent can be sought.
Maritime Area Planning (MAP) Act 2021	An Act to regulate the maritime area, to achieve such regulation by means of a National Marine Planning Framework, maritime area consents for the occupation of the maritime area for the purposes of maritime usages that will be undertaken for undefined or relatively long periods of time (including any such usages which also require development permission under the Planning and Development Act 2000) and licences for the occupation of the maritime area for maritime usages that are minor or that will be undertaken for relatively short periods of time
offshore development area	The total footprint of the offshore infrastructure and associated temporary works including the array site and the OECC.
offshore export cables	The cables which transport electricity generated by the wind turbine generators (WTGs) from the offshore substation structures (OSSs) to the TJBs at the landfall.
offshore export cable corridor (OECC)	The area between the array site and the landfall, within which the offshore export cables will be installed along with cable protection and other temporary infrastructure for construction.
offshore infrastructure	The permanent offshore infrastructure, comprising of the WTGs, IACs, OSSs, interconnector cables, offshore export cables and other associated infrastructure such as cable and scour protection.
offshore substation structure (OSS)	A fixed structure located within the array site, containing electrical equipment to aggregate the power from the wind turbine generators and convert it into a more suitable form for export to shore.
operations and maintenance (O&M) activities	Activities (e.g., monitoring, inspections, reactive repairs, planned maintenance) undertaken during the O&M phase of the CWP Project.
O&M phase	This is the period of time during which the CWP project will be operated and maintained.
parameters	Set of parameters by which the CWP Project is defined and which are used to form the basis of assessments.
Phase 1 Project	Under the special transition provisions in the Maritime Area Planning Act 2021, as amended (the MAP Act), the Minister for the Department of Environment, Climate and Communications (DECC) has responsibility for assessing and granting a Maritime Area Consent (MAC) for a first phase of offshore wind projects in Ireland. The Phase 1 Projects include Oriel Wind Park, Arklow Bank II, Dublin Array, North Irish Sea Array, Codling Wind Park and Skerd Rocks. A MAC has since been granted by DECC for each of the Phase 1 Projects.
planning application boundary	The area subject to the application for development consent, including all permanent and temporary works for the CWP Project.

Glossary	Meaning
wind turbine generator	All the components of a wind turbine, including the tower, nacelle and rotor.
zone of Influence (ZoI)	Spatial extent of potential impacts resulting from the project.

11 MARINE MAMMALS

11.1 Introduction

1. Codling Wind Park Limited (hereafter 'the Applicant') is proposing to develop the Codling Wind Park (CWP) Project, which is located in the Irish sea approximately 13–22 kilometre (km) off the east coast of Ireland, at County Wicklow.

2. This chapter forms part of the Environmental Impact Assessment Report (EIAR) for the CWP Project. The purpose of the EIAR is to provide the decision-maker, stakeholders and all interested parties with the environmental information required to develop an informed view of any likely significant effects resulting from the CWP Project, as required by the European Union (EU) Directive 2011/92/EU (as amended by Directive 2014/52/EU) (the EIA Directive).

3. This EIAR chapter describes the potential impacts of the CWP Project's Offshore Infrastructure on marine mammals during the construction, operation and maintenance and decommissioning phases.

4. In summary, this EIAR chapter:

   - Details the EIA scoping and consultation process undertaken and sets out the scope of the impact assessment for marine mammals;
   - Identifies the key legislation and guidance relevant to marine mammals, with reference to the latest updates in guidance and approaches;
   - Confirms the study area for the assessment and presents the impact assessment methodology for marine mammals;
   - Describes and characterises the baseline environment for marine mammals established from desk studies, project survey data and consultation;
   - Defines the project design parameters for the impact assessment and describes any embedded mitigation measures relevant to the marine mammals assessment;
   - Presents the assessment of potential impacts on marine mammals and identifies any assumptions and limitations encountered in compiling the impact assessment;
   - Provides the requisite information for a Noise Assessment Statement as required under Underwater Noise Policy 1 of the National Marine Planning Framework; and
   - Details any additional mitigation and / or monitoring necessary to prevent, minimise, reduce or offset potentially significant effects identified in the impact assessment.

5. The assessment should be read in conjunction with **Appendix 11.1 Cumulative Effects Assessment**, which considers other plans, projects and activities that may act cumulatively with the CWP Project and provides an assessment of the potential cumulative impacts on marine mammals.

6. A summary of the CEA for marine mammals is presented in **Section 11.11**.

7. Additional information to support the assessment includes:

   - **Appendix 11.1 Cumulative Effects Assessment;**
   - **Appendix 11.2 Representative Scenario and LoD Assessment;**
   - **Appendix 11.3 Baseline Technical Report;**
   - **Annex 1 to Appendix 11.3 Marine Mammal Density Surface;**
   - **Appendix 9.4 UWN Assessment; and**
   - **Appendix 11.4 Phase 1 Irish Offshore Wind Farms – Cumulative iPCoD modelling.**
   - **Marine Mammal Mitigation Protocol (MMMP)**

11.2 Consultation

8. Consultation with statutory and non-statutory organisations is a key part of the EIA process. Consultation with regards to marine mammals has been undertaken to inform the approach to and scope of the assessment.

9. The key elements of this consultation to date have included EIA scoping, consultation events and ongoing topic specific meetings with key stakeholders. The feedback received throughout this process has been considered in preparing the EIAR. EIA consultation is described further in **Chapter 5 EIA Methodology,** the **Planning Documents** and in the **Public and Stakeholder Consultation Report**, which has been submitted as part of the development consent application.

10. **Table 11-1** provides a summary of the key issues raised during the consultation process relevant to marine mammals and details how these issues have been considered in the production of this EIAR chapter.

Table 11-1 Consultation responses relevant to marine mammals

Consultee	Comment	How issues have been addressed
Scoping responses		
National Parks and Wildlife Service 15 April 2021	NPWS were satisfied with data sources, site specific survey work and the cumulative assessment project list presented in the CWP Project Scoping Report. Any additional projects which become public knowledge before submission of the EIAR have been requested to be included.	For site specific data sources all available information has been used in the assessment. The CEA long-list was updated 6 months prior to Application submission.
National Parks and Wildlife Service 14 May 2021	Morris and Duck 2017/18 thermal imaging survey provides the most recent summer data for grey and harbour seals.	Reference to *inter alia* Morris and Duck reports are presented in **Section 11.4.2**. NPWS are satisfied with the density information and reference populations proposed in the Scoping Report and used within this assessment (**Section 11.10**).
	NPWS strongly recommended giving additional consideration to the potential impacts which were proposed to be scoped out in the Scoping Report. If there is a potential impact from the works on a protected species, then it should be scoped in.	All potential impacts that were identified to be 'scoped out' within the Scoping Report have been scoped into this assessment (**Section 11.10**).
	Consideration should be given to all Special Area of Conservation (SAC) sites for Annex II marine mammal species.	SACs considered in the NIS are detailed in the NIS screening report.

Consultee	Comment	How issues have been addressed
Marine Institute 06 May 2021	Recommend scoping in the presence of Electromagnetic Fields (EMFs).	Existing evidence suggests that the levels of EMFs emitted by offshore renewable energy export cables are at a level low enough that there is no potential for direct significant impacts on marine mammals (Copping and Hemery, 2020) and as such, direct impacts of EMF on marine mammals have not been considered in this chapter. However, indirect impacts of EMF have been scoped into this assessment, due to the potential for EMF to impact on the prey species of and thus, foraging success of marine mammals (**Section 11.10**).
Topic specific meetings		
National Parks and Wildlife Service 15 June 2020	Project introduction meeting – ornithology / mammal surveys, 2014 DAHG guidance, use of the 2007 vs. the 2019 Southall et al. criteria (use 2007 but open to use of both).	The assessment is based on best available and most updated scientific evidence therefore the Southall et al., 2019 criteria has been used.
National Parks and Wildlife Service 07 February 2022	Approach to assessing the effects of pile driving document was accepted based on the best practice approach proposed and no improvements or additions were put forward by NPWS. Justification should be given as to why the new Southall et al. (2019) thresholds are going to be used rather than 2007 thresholds.	Justification for the use of new Southall et al. (2019) thresholds has been included within this assessment (**Section 11.10**).
Wind Energy Ireland with Irish Whale and Dolphin Group	Discussion on IWDG's policy document published in 2020 'IWDG Policy on Offshore Windfarm Development.	No action required.
Irish Whale and Dolphin Group 17 October 2023	Meeting held with CWP Project, technical advisers and IWDG to discuss approaches to assessment and mitigation.	Approaches to assessment discussed and agreed have been presented within this document.

11.3 Legislation, policy and guidance

11.3.1 Legislation

11. The legislation that is applicable to the assessment of marine mammals is summarised below. Further detail is provided in **Chapter 2 Policy and Legislative Context**.

- EIA Directive 2011/92/EU, as amended by Directive 2014/52/EU and transposed into Irish law in the Planning and Development Act, 2000–2020 and the Planning and Development Regulations 2001–2020 as amended by S.I. No. 296 of 2018;
- Water Framework Directive (WFD) (2000/60/EC);
- Marine Strategy Framework Directive (MSFD) (2008/56/EC);
- Marine Planning Policy Statement (November 2019);
- Maritime Spatial Planning (MSP) Directive (2014/89/EU);
- The Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention);
- Convention on the Conservation of Migratory Species of Wild Animals (1983);
- Convention on Conservation of European Wildlife and Natural Habitats (1979);
- Convention for the Protection of the Marine Environment of the North-East Atlantic (1992);
- Agreement on the Conservation of Small Cetaceans of the Baltic, North-East Atlantic, Irish and North Seas 1994 (ASCOBANS);
- Council Directive 92/43/EEC on the Conservation of Natural Habitats and Wild Flora and Fauna 1992 (Habitats Directive) – Annexes II, IV and V;
- Wildlife Act (1976) and amendments (2000, 2005, 2010,2012 and 2023) for protected species; and
- Protected wild animal status for basking shark (Section 23 of the Wildlife Act 1976 (Protection of Wild Animals) Regulations 2022).

11.3.2 Policy

12. The overarching planning policy relevant to the CWP Project is described in EIAR **Chapter 2 Policy and Legislative Context**.

13. The assessment of the CWP Project against relevant planning policy is provided in the Planning Report. This includes planning policy relevant to marine mammals.

11.3.3 Guidance

14. The principal guidance and best practice documents used to inform the assessment of potential impacts on marine mammals is summarised below:

- Guidelines on the information to be contained in Environmental Impact Assessment Reports (EPA, 2022);
- Guidance to manage the risk to marine mammals from man-made sound sources in Irish waters (Department of Arts, Heritage and the Gaeltacht (DAHG), 2014);
- The protection of marine European Protected Species (EPS) from injury and disturbance: Guidance for the marine area in England and Wales and the UK offshore marine area (2010). Joint Nature Conservation Committee (JNCC), Natural England and Countryside Council for Wales. This document has been used to supplement the DAHG (2014) guidance in the absence of Irish guidance which interprets what constitutes disturbance;

- Guidance on the Strict Protection of Certain Animal and Plant Species under the Habitats Directive in Ireland (NPWS, 2021);
- Guidance for assessing the significance of noise disturbance against Conservation Objectives of harbour porpoise SACs (England, Wales and Northern Ireland). JNCC Report No. 654 (JNCC, 2020);
- Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Coastal and Marine (CIEEM, 2019);
- EU Commission's Guidance document on the strict protection of animal species of Community interest under the Habitats Directive (EU, 2021);
- Conservation Plan for Cetaceans in Irish Waters (DAHG, 2009);
- IWDG Policy on Offshore Windfarm Development (IWDG, 2020);
- Policy on the effects of noise pollution on cetaceans (IWDG, 2015);
- Code of Practice for the Protection of Marine Mammals during Acoustic Seafloor Surveys in Irish Waters (NPWS, 2007);
- JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys (JNCC, 2017);
- Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise (JNCC 2010b);
- JNCC guidelines for minimising the risk of injury to marine mammals from using explosives (JNCC 2010a);
- DRAFT guidelines for minimising the risk of injury to marine mammals from unexploded ordnance clearance in the marine environment (JNCC, 2023);
- Department of Communications, Marine and Natural Resources released a Marine Notice (No 15
- of 2005) for the correct procedures when encountering whales and dolphins in Irish coastal waters
- (DCMNR, 2005);
- Irish Whale and Dolphin Group Code of Conduct for all watercraft encountering whales and dolphins (IWDG, 2005);
- Irish Whale and Dolphin Group Cetacean Welfare Policy (IWDG, 2014);
- Marine mammal noise exposure criteria: Initial scientific recommendations (Southall et al., 2007);
- Marine mammal noise exposure criteria: Updated scientific recommendations for residual hearing effects (Southall et al., 2019);
- Technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (version 2.0) (National Oceanic and Atmospheric Administration (NOAA), 2016);
- Assessment and Monitoring of Ocean Noise in Irish Waters. STRIVE Report Series No. 120; (EPA 2011);
- Guidance on survey and Monitoring in Relation to Marine Renewables Deployments in Scotland. Volume 2. Cetaceans and Basking Sharks (SNH and Marine Scotland, 2011);
- Guidance on Marine Baseline Ecological Assessments and Monitoring Activities for Offshore Renewable Energy Projects Part 1 (DCCAE,2018);
- Guidance on Marine Baseline Ecological Assessments and Monitoring Activities for Offshore Renewable Energy Projects Part 2 (DCCAE,2018); and
- Guidance on EIS and NIS Preparation for Offshore Renewable Energy Projects (DCCAE, 2017).

11.4 Impact assessment methodology

15. **Chapter 5 EIA Methodology** provides a summary of the general impact assessment methodology applied to the CWP Project, which includes the approach to the assessment of transboundary and inter-related effects. The approach to the assessment of cumulative impacts is provided in **Chapter 5, Appendix 5.3 CEA Methodology.**

16. The following sections confirm the methodology used to assess the potential impacts on marine mammals.

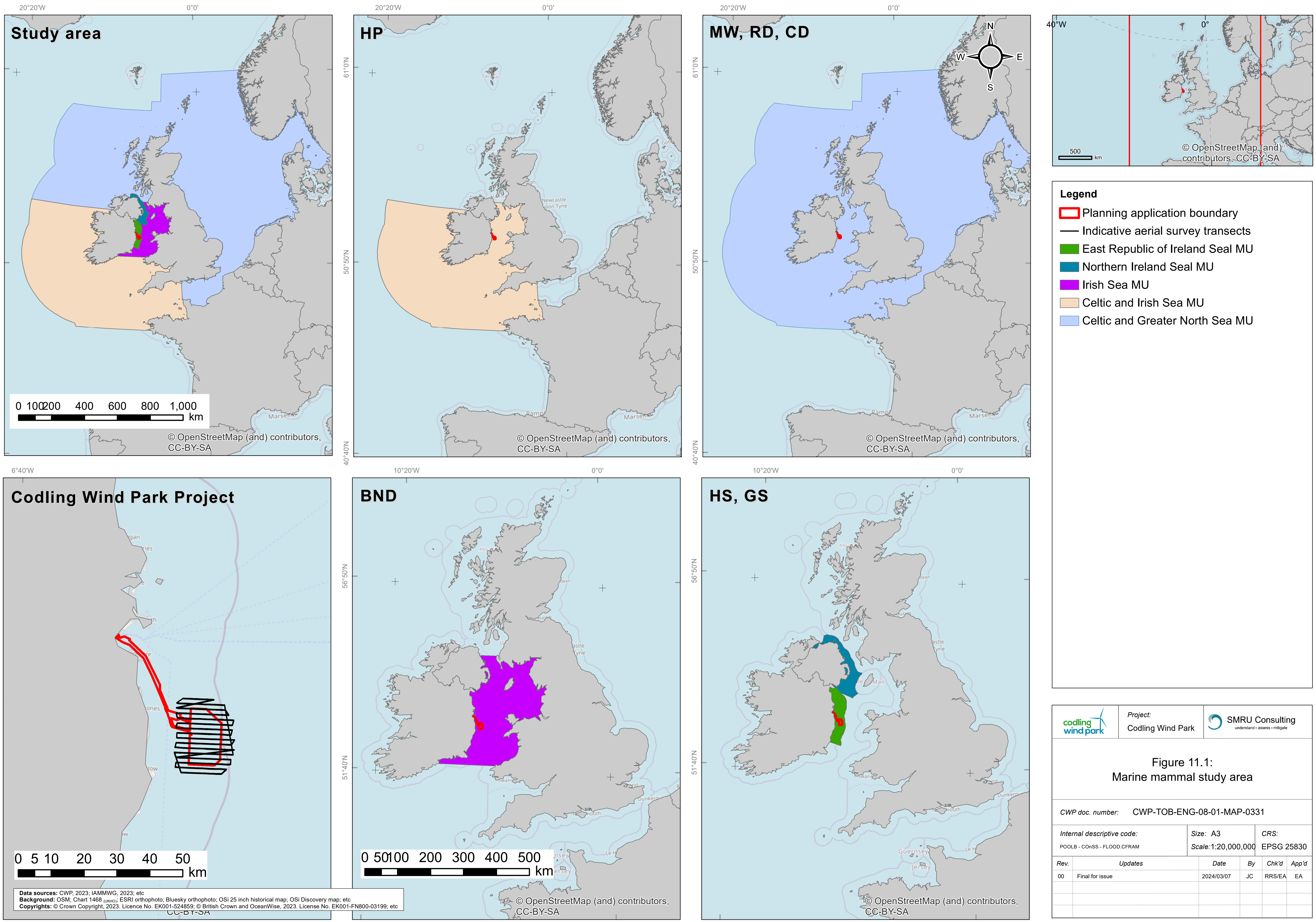
11.4.1 Study area

17. The marine mammal study area varies depending on the species, considering species specific ecology and behaviour. For all species, the study area covers the CWP Project offshore development area, as this represents the area in which construction and operation of the development will take place, with the Marine Safety Demarcation Area being used only for short term navigation activities such as deployment of buoyage. The study area is extended from the offshore development area over an appropriate area considering the scale of movement and population structure for each species. For each species, the area considered in the assessment is defined by the appropriate species Management Unit (MU). Cetacean MUs were defined by the Inter-Agency Marine Mammal Working Group (IAMMWG (2015)) as *'a geographical area in which the animals of a particular species are found to which management of human activities is applied. A MU may be smaller than what is believed to be a 'population' or an 'ecological unit' to reflect spatial differences in human activities and their management'*. Therefore, the MU scale is advised as the most appropriate scale against which to assess and manage human activities.

18. The study area for marine mammals has been defined at two spatial scales: 1) the MU scale and 2) the marine mammal survey area which provides an indication of the local densities of each species within the CWP Project array site / project boundary through the use of aerial surveys. Site specific surveys were only conducted within the array sites, as Guidance on Marine Baseline Ecological Assessments and Monitoring Activities state that there is no requirement for such surveys within the Offshore Export Cable Corridor (OECC).

19. The CWP Project is located within the following MUs 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 regions of Republic of Ireland (RoI) and Northern Ireland MU; and
- Harbour seal: East regions of RoI and Northern Ireland MU.



codling wind park

Project: Codling Wind Park

SMRU Consulting
understand • assess • mitigate

Figure 11.1:
Marine mammal study area

CWP doc. number: CWP-TOB-ENG-08-01-MAP-0331

Internal descriptive code: POOLB - COnSS - FLOOD.CFRAM	*Size:* A3 *Scale:* 1:20,000,000	*CRS:* EPSG 25830

Rev.	*Updates*	*Date*	*By*	*Chk'd*	*App'd*
00	Final for issue	2024/03/07	JC	RRS/EA	EA

11.4.2 Data and information sources

Site specific surveys

Aerial and boat-based surveys

20. In order to provide site specific and up to date information on which to base the impact assessment, site specific surveys were conducted. This included visual boat-based surveys undertaken between April 2013 and March 2014 (13 months), and October 2018 and January 2020 (16 months) by Natural Power. In addition to this, 24 months of Digital Aerial Surveys (DAS) were undertaken between May 2020 and April 2022 by HiDef Aerial Surveying Limited. The site specific surveys included the CWP Project array site and a 4 km buffer. (**Figure 11-1**). For the derivation of density estimates within the proposed CWP Project offshore development area, only observational data from both boat-based and aerial surveys which were classified as on-effort (i.e., sightings made by a marine mammal observer) were used (Natural Power, 2023) (**Table 11-2**).

21. Boat-based surveys were conducted at CWP Project between April 2013 and April 2014, and October 2018 – August 2020. During boat-based surveys, visual surveying was undertaken along pre-determined track lines, using distance sampling methodology [1] (Natural Power, 2023). Further information on the methodology used during visual boat-based surveys is outlined in **Appendix 11.3 Baseline Technical Report**.

22. In total, 24 aerial surveys were conducted between May 2020 – April 2022. Marine mammal encounter rates have been calculated per survey (number of individuals per km^2 survey effort) where possible. In addition, apportioning was used to assign any unidentified sightings to a particular species (see **Appendix 11.3 Baseline Technical Report** for more information).

23. Although a total of four boat-based and one aerial-based survey were missed due to weather and / or Brexit related issues (**Table 11-2**), this did not impact on the quality of the data collected. As such, the data collected as part of the surveys are considered robust to inform the impact assessment; survey data remain valid and an appropriate characterisation of the receiving environment at the point of application.

Table 11-2 Monthly site specific aerial and boat-based surveys

Date	# Months	Method	Data use	Contractor	Notes
April 2013 – 2014	13	Boat-based visual	Production of density estimates	Natural Power	N/A
October 2018 – January 2020	12	Boat-based visual	Production of density estimates	Natural Power	Four surveys were missed due to adverse weather conditions (November and December 2018; July and November 2019)

[1] In a distance-sampling survey, an observer travels along a pre-determined line-transect and records the observed distance to all detected individuals of a species of interest. This method is used to calculate the abundance and / or density of individuals with a pre-defined survey area.

Date	# Months	Method	Data use	Contractor	Notes
May 2020 – April 2022	24	Digital aerial	Production of density estimates	HiDef	One survey in January 2021 missed due to Brexit related issues*

** Planes which were registered in the United Kingdom did not have the required permission to fly over Irish airspace when Brexit came into effect in January 2021, resulting in a missed survey month.*

Landfall surveys

24. Site specific landfall surveys were undertaken at the intertidal area of the CWP Project site and were carried out between October 2019 and September 2021. Although marine mammals were not the target group for these surveys (see **Chapter 10 Ornithology)**, a total of 11 grey seals, two harbour seals and five harbour porpoises were recorded. Density estimates were not derived from this data.

Desk study

25. In addition to the site specific surveys, a comprehensive desk-based review was undertaken to inform the baseline for marine mammals. Key data sources used to inform the assessment are set out in **Table 11-3.**

Table 11-3 Data sources

Data Source	Type of Data	Temporal and Spatial Coverage
IWDG Irish Sea cetacean surveys (Berrow et al., 2011)	Visual and acoustic survey	2 surveys in August 2011. Inshore surveys in 2 blocks: Block A (northern Irish Sea) and Block B (southern Irish Sea). The CWP Project has some overlap with both Block A and B.
IWDG Irish coastal water surveys for harbour porpoise (Berrow et al., 2008)	Vessel based visual line transect surveys and T-POD acoustic monitoring	6 survey days between July–September 2008. 5 sites (North County Dublin, Dublin Bay, Cork coast, Roaringwater Bay SAC and Galway Bay).
IWDG SAC Surveys (Berrow and O'Brien, 2013, O'Brien and Berrow, 2016, Berrow et al., 2021)	Visual and acoustic line transect surveys	1 survey in 2013. 4 surveys in 2016. 6 surveys in 2021. Rockabill to Dalkey Island SAC.
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.

Data Source	Type of Data	Temporal and Spatial Coverage
ObSERVE (Stratum 5) (Rogan et al., 2018)	Visual aerial surveys	4 surveys: summer 2015, winter 2015, summer 2016 and winter 2016. Offshore waters around Ireland, within and beyond Ireland's continental shelf.
SCANS III and IV (Hammond et al., 2017, Hammond et al., 2021, Lacey et al., 2022, Gilles et al., 2023)	Aerial and vessel visual surveys	All European Atlantic waters. CWP Project located in block E (western Irish Sea) for SCANS III surveys. This block was renamed to block CS-D for SCANS IV.
Distribution and abundance of cetaceans Wales and its adjacent waters (Evans and Waggitt, 2023)	Maps of sighting rates and indicative density surface maps from aerial and vessel survey data	1990–2020. Wales and adjacent seas.
MERP maps (Waggitt et al., 2020) (Waggitt et al., 2019)	Collation of data from JCP (aerial and vessel)	1980 and 2018. European Atlantic waters.
Atlas of the distribution and relative abundance of marine mammals in Irish offshore waters (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 EEZ.
Habitat-based distribution maps and seal at-sea density (Carter et al., 2020)	Seal habitat-use derived from telemetry data	2005–2019. UK and Ireland.
Seal Counts 2005 and 2009–2012 (Ó Cadhla et al., 2007, Ó Cadhla et al., 2013)	Aerial survey	Five broad areas of the Irish coastline, including the East (site D) which encompassed the coastlines of the following counties: Louth, Meath, Dublin, Wicklow and Wexford. The CWP Project is located in site D.
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 and 2010). Raven Point: 19 x grey seals 2013 and 2014. Great Blasket Island: 8 x grey seals 2009.
NPWS surveys for harbour and grey seals (Lyons, 2004)	Seal census count data derived from multiple methodologies	1978–2003. Entire coastline of Ireland.
NISA OWF (ARUP, 2021)	Visual boat-based surveys and DAS	29 aerial surveys between May 2020 – October 2022. NISA array area plus a 4 km buffer.

Data Source	Type of Data	Temporal and Spatial Coverage
Dublin Array (SLR et al., 2020)	Visual boat-based surveys	19 surveys between June 2019 – January 2020, May 2020 – September 2020 and December 2020 – April 2021. Survey area was a total of 266 km^2 (consisting of the array area plus 4 km buffer).
Arklow Bay Wind Park (RPS, 2020)	Visual boat-based surveys and DAS	Monthly vessel surveys: July 1996 to March 1997, and June 2000 to 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.

11.4.3 Impact assessment

26. The significance of potential effects has been evaluated using a systematic approach, based upon identification of the importance / value of receptors and their sensitivity to the project activity, together with the predicted magnitude of the impact. This section describes the criteria applied in this chapter to assign values of the sensitivity of receptors (**Table 11-4**) and the magnitude of impacts (**Table 11-5**). Both sensitivity and magnitude are assessed on a four-level scale to align with the EPA's guidance: High, Medium, Low and Very Low / Negligible.

27. Information about the project and the project activities for all stages of the project 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.

Sensitivity of receptor

28. For each effect, the assessment identifies receptors sensitive to that effect and implements a systematic approach to understanding the impact pathways and the level of impacts on given receptors.

29. The sensitivity of marine mammal receptors is 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 is shown in **Table 11-4**. It should be noted that 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 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 11-4 Criteria for determination of receptor sensitivity

Sensitivity	Criteria
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 are 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).
Very Low	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

30. The scale or magnitude of potential impacts (both beneficial and adverse) 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 11-5**.

Table 11-5 Criteria for determining magnitude of impact

Magnitude	Criteria
High	Duration: The effect is expected to result in behavioural changes that last for years. Frequency: The effect occurs over several years. 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.

Magnitude	Criteria
Medium	Duration: The effect is expected to result in behavioural changes that last up to a year. Frequency: The effect occurs over a few years. 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	Duration: The effect is expected to result in behavioural changes that last days at the most. Frequency: The effect occurs over a year. 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	Duration: The effect is expected to result in behavioural changes that last a day at the most. Frequency: The effect occurs over less than a year. Probability: The effect is 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.

Significance of effect

31. As set out in **Chapter 5 EIA Methodology**, an Impact Assessment Matrix (IAM) is used to determine the significance of an effect. In basic terms, the potential significance of an effect is a function of the sensitivity of the receptor and the magnitude of the impact, as shown in **Table 11-6.**

32. The matrix provides a framework for the consistent and transparent assessment of predicted effects across all technical chapters; however, it is important to note that individual assessments are based on relevant guidance and the application of expert judgement.

33. The matrix provides levels of effect significance ranging from Negligible to Major. For the purposes of this assessment, potential effects identified to be of moderate significance or above are considered to be significant in EIA terms and additional mitigation will be required. Effects identified as less than moderate significance are generally considered to be not significant in EIA terms.

Table 11-6 Impact assessment matrix for determination of significance of effect

Sensitivity	Magnitude			
	Negligible	**Low**	**Medium**	**High**
Very Low	Negligible (Not significant)	Negligible (Not significant)	Minor (Not significant)	Minor (Not significant)
Low	Negligible (Not significant)	Minor (Not significant)	Minor (Not significant)	**Moderate (Significant)**
Medium	Minor (Not significant)	Minor (Not significant)	**Moderate (Significant)**	**Major (Significant)**
High	Minor (Not significant)	**Moderate (Significant)**	**Major (Significant)**	**Major (Significant)**

Assessment methodology – auditory injury

34. The following sections describe the methodologies adopted in assessing the potential impacts associated with the CWP Project. The impact assessment is then presented in **Section 11.10**.

Auditory injury (PTS)

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

36. Exposure to loud sounds can lead to a reduction in hearing sensitivity (a shift in hearing threshold). This threshold shift results from physical injury to the auditory system and may be temporary (TTS) or permanent (PTS). The point at which threshold shifts occur in marine mammals is species specific (i.e., functional hearing group dependent, see **Table 11-7**). The ranges at which TTS onset occurs however 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. Therefore, TTS cannot adequately be assessed using the current TTS onset thresholds. Current TTS onset thresholds are inappropriate to determine a biologically significant level of TTS and thus, PTS only is used in the impact assessment for auditory injury from piling.

37. The PTS-onset thresholds used in this assessment to calculate PTS-onset impact ranges are those presented in Southall et al. (2019), which are detailed in **Table 11-7**. 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), with the latter thresholds being frequency-weighted to marine mammal functional hearing groups.

Table 11-7 PTS-onset thresholds for impulsive noise Southall et al. (2019)

Functional hearing group	Species relevant to this assessment	Cumulative PTS (SELcum dB re 1 µPa2s weighted)	Instantaneous PTS (SPLpeak dB re 1 µPa unweighted)
Very High Frequency (VHF) Cetacean	**Harbour porpoise**	**155**	**202**
High Frequency (HF) Cetacean	**Bottlenose dolphin, common dolphin and Risso's dolphin**	**185**	**230**
Low Frequency (LF) Cetacean	**Minke whale**	**183**	**219**
Phocid carnivores (seals) in water (PCW)	**Grey and harbour seal**	**185**	**218**

38. In calculating the received noise level that animals are likely to receive during the whole piling sequence, constant animal swimming speeds were used. Marine mammal swimming speeds have previously been recommended by Scottish Natural Heritage (2016). They recommend that 1.4 m/s is used for harbour porpoise, based on an average descent and ascent speed from tagged porpoise (Westgate et al., 1995) which is likely slower than a typical fleeing speed. For example, Kastelein et al. (2018) found that swimming speeds of ~7 km/h (1.94 m/s) are sustainable for harbour porpoise (throughout a 30 min test period); therefore, the modelling is considered conservative as it used fleeing speeds lower than this. Scottish Natural Heritage (2016) also recommend a fleeing speed of 2.1 m/s for minke whales based on Williams (2009); however, this reference states that the routine speeds for mysticete whales is 2.1–2.6 m/s and is therefore slower than expected and conservative in the assessment. Scottish Natural Heritage (2016) recommend a swimming speed of 1.8 m/s for grey seals, based on Thompson (2015) which estimated that typical swimming speeds were in the range of 1.8–2.0 m/s. Swim speeds for bottlenose, common and Risso's dolphin, and harbour seal have not been derived. In the absence of these values, a swim speed of 1.5 m/s is used. These swim speeds are considered the most appropriate for use within the impact assessment in the absence of Irish specific guidance.

39. The calculated PTS-onset impact ranges therefore represent the minimum safe starting distances from the piling location for fleeing animals to avoid a dose higher than the threshold. Southall et al. (2019) propose the SPL_{peak} (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 that is associated with high peak sound pressures is not frequency dependent (i.e., restricted to the audible frequency range of a species).

40. The physiological damage that sound energy can cause is mainly restricted to energy occurring in the frequency range of a species' hearing range. 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) (**Plate 11-1**).

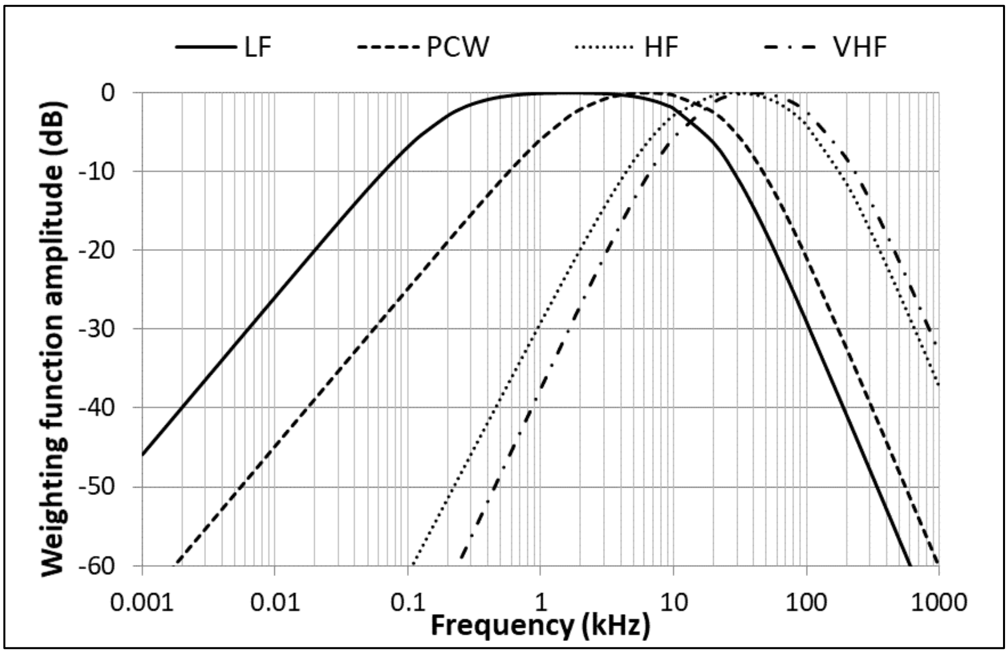


Plate 11-1 Auditory weighting functions for low frequency (LF), high frequency (HF) and very high frequency (VHF) cetaceans as well as phocid carnivores (seals) in water (PCW) taken from Southall et al. (2019)

Auditory injury (PTS) – pre-construction surveys

41. The potential for auditory injury (PTS) from pre-construction surveys was assessed by firstly reviewing the overlap between typical survey equipment operating characteristics and marine mammal functional hearing capability. The assessment was then led by advice from DECC (2011) and JNCC et al*.* (2010) on assessment of these surveys types and detail in the published literature.

Auditory injury (PTS) – pile driving

42. Impact piling will be the loudest noise source during the construction phase of the CWP Project. 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 recent threshold presented by Southall et al*.* (2019).

43. Based on agreed density estimates for each species presented in **Appendix 11.3 Baseline Technical Report**, 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.

44. 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.

Auditory injury (PTS) – UXO clearance

45. Current practice is that Southall et al*.* (2019) should be used for assessing the impacts from UXO detonation on marine mammals. However, the suitability of these criteria for UXO 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.

46. Full details of the underwater noise modelling and the resulting PTS-onset impact areas and ranges are detailed in **Appendix 9.4 UWN Assessment**. A selection of charge weights have been considered based on what has been found at sites in North Sea waters and, in each case, it has been assumed that the maximum explosive charge in each device is present and undergoes a full explosive detonation (a 'high-order' event).

47. For high-order clearance, the maximum assumed charge weight is 698 kg (TNT equivalent). In addition to this a range of smaller charge weights have been estimated as 25, 55, 120, 240 and 525 kg. In each case, an additional donor weight of 0.5 kg has been included to initiate detonation. Additionally, a low-order clearance scenario has been modelled, assuming a donor charge of 0.25 kg. 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).

48. 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.

Auditory injury (PTS) – other construction activities and geophysical surveys

49. 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 geophysical surveys (i.e., the use of Multi-Beam Echo Sounder, Sub-bottom Profilers etc.), dredging, cable laying, rock placement and trenching, as well as sheet piling for the cofferdam and noise generated by the presence of construction vessels.

50. A high level assessment of the noise impacts from other construction (i.e., excluding impact piling and UXO clearance) is presented in **Appendix 9.4 UWN Assessment**. This includes an assessment of the potential PTS and / or TTS-onset impact ranges for:

- Geophysical surveys: geophysical survey equipment including but not limited to multi-beam echosounders, sub-bottom profilers, side scan sonar, etc.;
- 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, array cables and interconnector cable installation. Suction dredging has been assumed as a worst-case;
- 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 (disturbance): Vessel noise from large and medium sized vessels.

51. Prior to an evaluation in relation to each item of equipment, the overlap between typical survey equipment operating characteristics and marine mammal functional hearing capability is considered. Where there is no overlap between hearing capability and functional hearing, there is no potential for disturbance effects to occur; however, the potential for injury will still need to be considered if animals could be exposed to sound pressure of sufficient magnitude to cause hearing damage or other harm.

Assessment methodology – disturbance

Assessment of disturbance – pre-construction surveys

52. The potential for auditory injury (PTS) from pre-construction surveys was assessed by firstly reviewing the overlap between typical survey equipment operating characteristics and marine mammal functional hearing capability. Where there is overlap, and thus the potential for disturbance effects, the assessment was informed by expert opinion on the potential extend of the impact, given the fact that there are currently no empirical data available on the behavioural responses of marine mammals to any of these sources.

Assessment of disturbance – pile driving

53. The assessment of disturbance from pile-driven foundations was based on the current best practice methodology, 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.

54. Compared with the effective deterrence range (EDR) and fixed noise threshold approaches, the application of a dose-response function allows for more realistic assumptions about animal response varying with dose, which is supported by a growing number of studies. A dose-response function was 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).

55. Using a species-specific dose-response function rather than a fixed behavioural threshold to assess disturbance is currently considered to be the best practice methodology and 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 (2019) 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'*.

56. Noise contours at 5 dB intervals were generated by noise modelling and were overlain on species density surfaces to predict the number of animals potentially disturbed. This allowed for the quantification of the number of animals that will potentially respond.

Dose-response function – Harbour porpoise

57. 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. (2017) (**Plate 11-2**). The Graham et al. (2017) dose-response function was developed using data on harbour porpoise collected during the first six weeks of piling during Phase 1 of the Beatrice Offshore

Wind Farm monitoring program. Changes in porpoise occurrence (detection positive hours per day) were estimated using 47 CPODs[2] 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.

58. Porpoise were considered to have exhibited a behavioural response to piling when the proportional decrease in occurrence was greater than 0.5. 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., 2017).

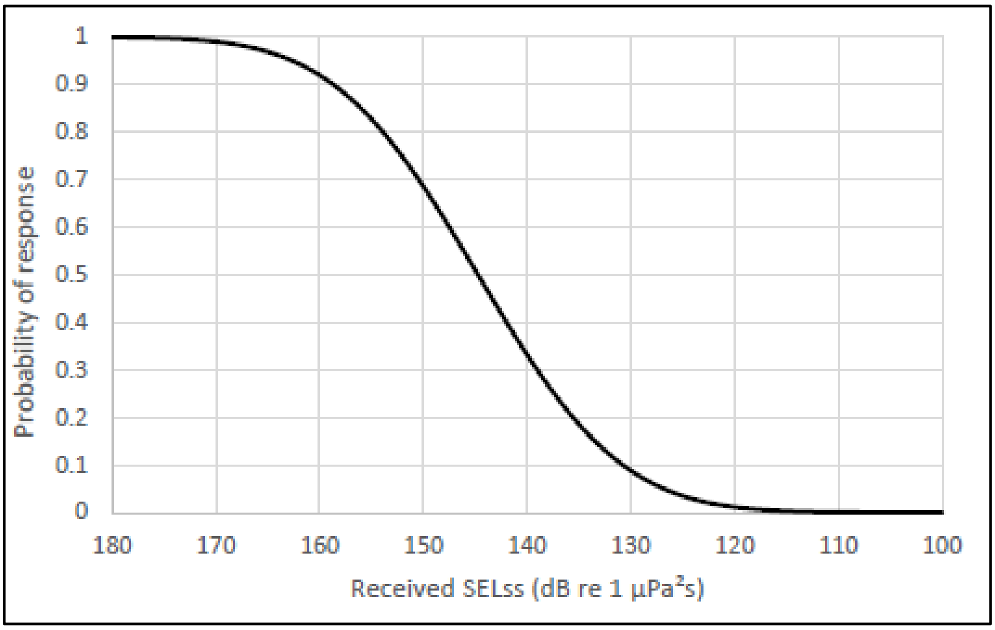


Plate 11-2 Relationship between the proportion of porpoise responding and the received single strike SEL (SELss) (Graham et al., 2017)

59. Since the initial development of the dose-response function in 2017, additional data from the remaining pile driving events at Beatrice Offshore Windfarm have been processed, and are presented in Graham et al. (2019). The passive acoustic monitoring 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 (**Plate 11-3**) (Graham et al., 2019). 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.

60. 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. (2017) 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.

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[2] 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

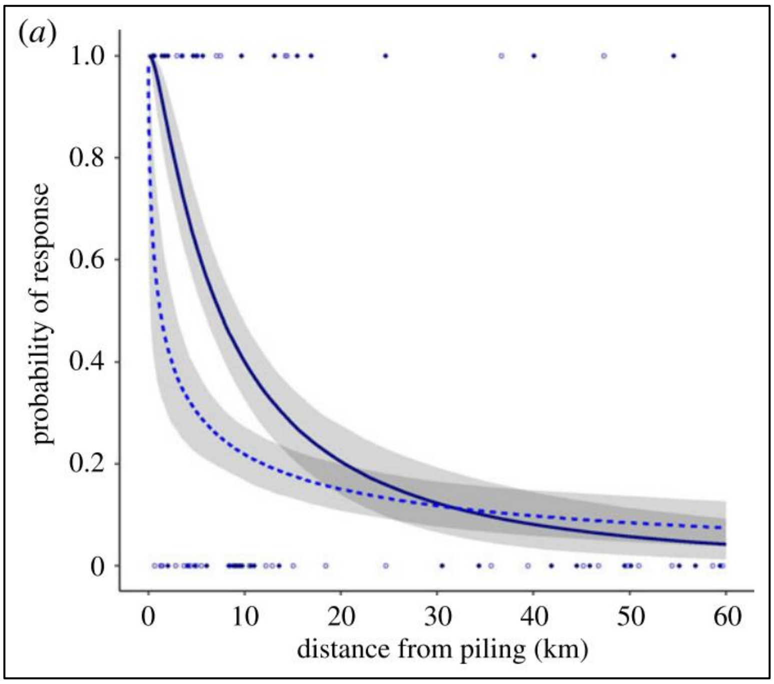


Plate 11-3 The probability of a harbour porpoise response (24 h) in relation to the partial contribution of distance from piling for the first location piled (solid navy line) and the final location piled (dashed blue line). Obtained from Graham et al. (2019).

Dose-response function – other species

61. In the absence of species specific data on dolphin species 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 curve to other cetacean species is highly over precautionary.

62. 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, Sarnocińska et al., 2020, Thompson et al., 2020, Benhemma-Le Gall et al., 2021a).

63. 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). 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).

64. The assessment for all cetacean species presented in this chapter 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.

Level B harassment

65. 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[3] will occur when an animal is exposed to received levels above 160 dB re 1 μPa (rms) for non-explosive impulsive (e.g., 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).

66. 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.

Dose-response function – seals

67. For seals, the dose-response function adopted was based on the data presented in Whyte et al. (2020) (**Plate 11-4**). The Whyte et al. (2020) 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 windfarm. The original study used telemetry data from 25 harbour seals tagged in the Wash between 2003 and 2006, in addition to a further 24 harbour seals tagged in 2012, to assess how seal usage changed in relation to the pile driving activities at the Lincs Offshore Wind farm in 2011–2012.

[3] Level B harassment refers to acts that have the potential to disturb (but not injure) a marine mammal or marine mammal stock in the wild by disrupting behavioural patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering.

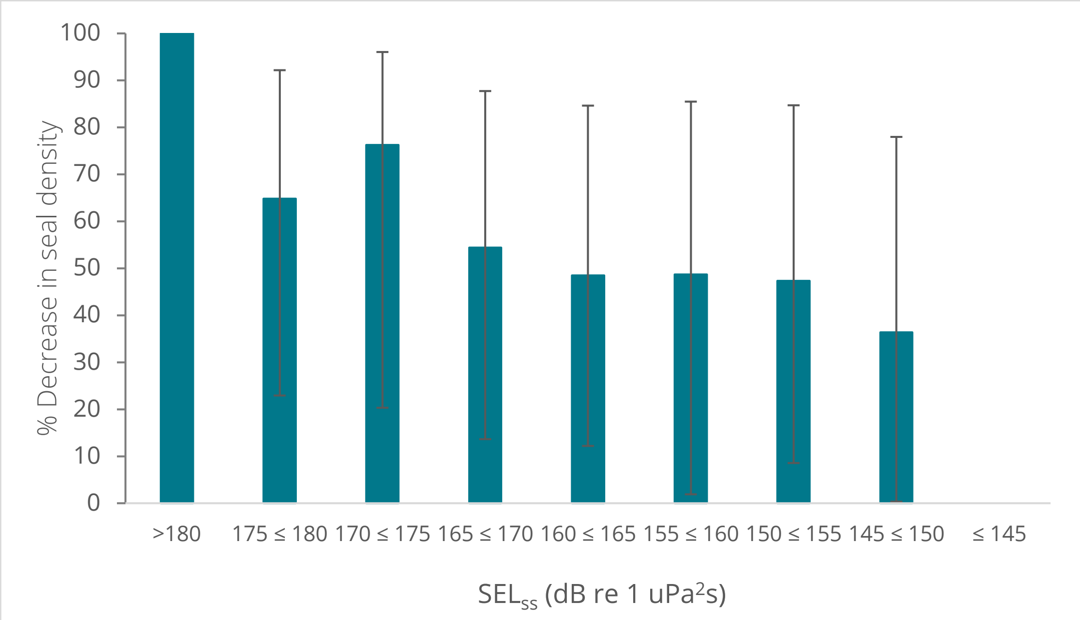


Plate 11-4 Predicted decrease in seal density as a function of estimated sound exposure level, error bars show 95% CI (Whyte et al., 2020)

68. In the Whyte et al. (2020) dose-response function it has been assumed that all seals are displaced at sound exposure levels above 180 dB re 1 µPa²s. 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 1 µPa²s 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.

69. 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. 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). Recent 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.

Disturbance from UXO clearance

70. 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’, 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.

71. It is important for the impact assessment to acknowledge that our understanding of the effect of disturbance from UXO detonation is very 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.

72. Since there is no dose-response function available that appropriately reflects 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

73. There is guidance available on the EDR that should be applied to assess the significance of noise disturbance against Conservation Objectives of harbour porpoise SACs in England, Wales and Northern Ireland (JNCC 2020). 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, and will be used in the absence of Irish guidance.

74. 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 OWF 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 26 km 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).

75. 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).

76. 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 alongside the 26 km EDR approach.

EDR – 5 km for low order UXO clearance

77. 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 in the absence of Irish guidance.

TTS as a proxy for disturbance

78. 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, Neart na Goithe and Awel y Mor OWFs). 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 behavioral 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 behavioral 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 behavioral effect per se, but we use this auditory effect as a de facto behavioral 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 behavior.'* (Southall et al*.*, 2007).

79. '*Due to the transient nature of a single pulse, the most severe behavioral reactions will usually be temporary responses, such as startle, rather than prolonged effects, such as modified habitat utilization. A transient behavioral 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 behavioral 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 behavioral 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).

80. 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).

Assessment of other impact pathways

81. **Other construction activities:** There is currently no guidance on the thresholds to be used to assess disturbance of marine mammals from other construction activity. Moreover, there are currently no empirical data available on the behavioural responses of marine mammals to some geophysical survey equipment sources such as sub-bottom profilers, sub-bottom imagers and ultra-short base line systems. Therefore, these impact assessments provide 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 to 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 CWP Project, with dredging potentially being required for export cable, array cable and interconnector cable installations.

82. **Vessel collision and disturbance:** The assessment is qualitative, and relates the likelihood of impact given the expected level of CWP Project specific vessel activity in relation to existing baseline activity in the area. Evidence from published literature is used to inform the likelihood to impact based on the limited studies that have been conducted to date.

83. **Indirect impacts to prey:** a qualitative assessment is provided, based on the predicted impacts to marine mammal prey species, as assessed in **Chapter 9 Fish, Shellfish and Turtle Ecology**.

84. **Operational noise:** a qualitative assessment is provided, based on evidence in the published literature on marine mammal presence and behaviour within existing operational fixed foundation wind farms.

85. **Decommissioning:** a limited assessment is provided given the uncertainty in decommissioning activities at this time. The effects of these activities on marine mammals are considered to be similar to, or less than those occurring during construction.

Population modelling

86. The iPCoD 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 piling activities. 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.

87. 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.

88. 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 6 hours on the day of disturbance, and that no feeding (or nursing) would occur during the 6 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.

89. The piling schedule used in the iPCoD modelling assumes 78 piling days between April and October 2027 inclusive (**Plate 11-5**). It is noted that 2027 is presented as the proposed year of construction at the time of writing; however, it is acknowledged that the CWP Project programme, and other projects within the planning systems of Ireland and the UK, may change and activities may occur in a different year. Despite the uncertainty in the construction schedule at the time of writing, this assessment is considered appropriate for the purposes of EIA as it considers the relevant and likely effects, and introduces appropriate mitigation measures which remain effective for the project alone immaterial of changes in the programme. **Table 11-8** lists the parameters specified in the iPCoD modelling for each species.

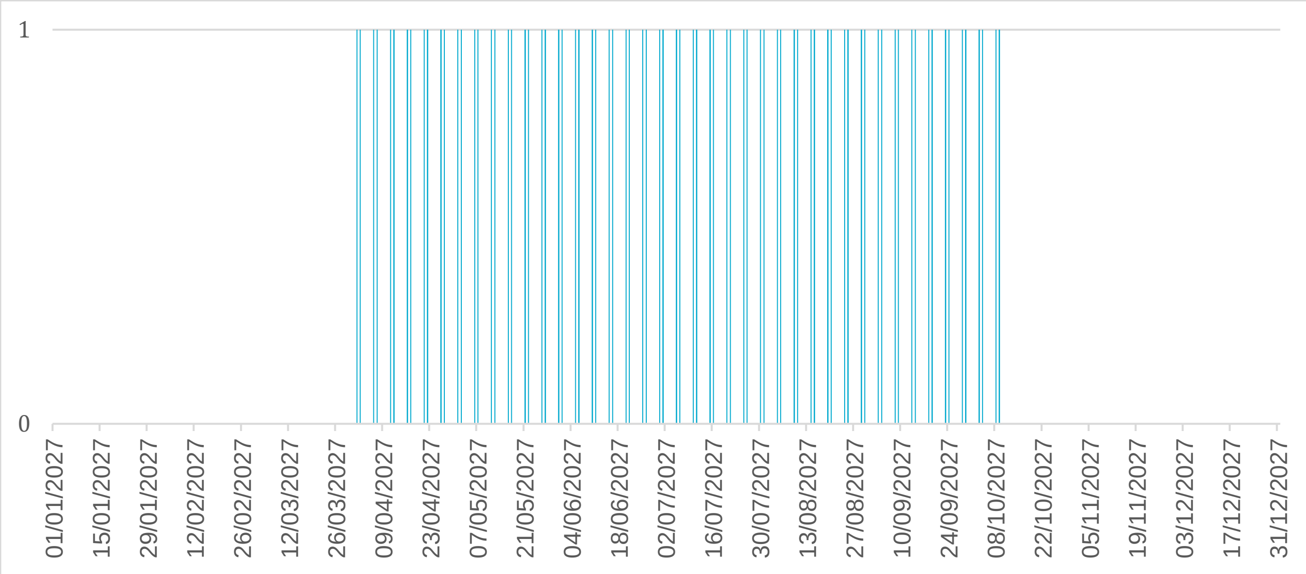


Plate 11-5 Piling schedule used in the iPCoD modelling

Table 11-8 Parameters used in the iPCoD population modelling

	Harbour porpoise	Bottlenose dolphin	Harbour seal	Grey seal
"**pmean**" – Population Size	62,517	469, 1,069 or 8,326	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	1	1	1
"**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	c(1)	c(1)	c(1)	c(1)

	Harbour porpoise	Bottlenose dolphin	Harbour seal	Grey seal
effects of piling on each vulnerable component of the population				
"**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**" – will disturbed animals avoid all piling operations when experiencing residual disturbance? TRUE = yes, 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. TRUE = animals only vulnerable on first day, 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

11.5 Assumptions and limitations

90. 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 presented in **Section 11.17 Annex 1 – Assumptions and limitations.**

11.6 Existing environment

91. The following sections provide a summary description of the baseline conditions for marine mammals. A full detailed baseline characterisation is provided in **Appendix 11.3 Baseline Technical Report.**

11.6.1 Harbour porpoise

92. The harbour porpoise is the most widely distributed and most common cetacean species in the waters of Britain and Ireland (NPWS, 2019). Harbour porpoise are assessed as having a Favourable conservation status in Irish waters (NPWS, 2019), Harbour porpoise within the Celtic and Irish Seas MU have an estimated abundance of 62,517 (95% CI : 48,324–80,877, CV : 0.13) (IAMMWG, 2023). This is based on data collected during SCANS III and the ObSERVE surveys (Rogan et al., 2018, Hammond et al., 2021). Data from the sources analysed indicates the potential for harbour porpoise presence all year round, although several studies (e.g., Berrow et al., 2008, Rogan et al., 2018), including site specific boat and aerial surveys found density and abundance to be highest during the summer months. There are several SACs for harbour porpoise in the MU, including the Rockabill to Dalkey Island SAC. In the summer of 2021 (Sep–Aug), 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).

93. During site specific surveys, harbour porpoise was the most commonly sighted cetacean. Density estimations for harbour porpoise were derived by modelling both boat-based survey and aerial survey data (Natural Power, 2023). The density surface average using both boat and DAS data was 0.1225 porpoises per km^2 across the survey area. 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 as they only provide information on the density of each species within the CWP Project array site and not across the whole MU), the SCANS IV uniform density estimate, the SCANS III density surface estimate and the Evans and Waggitt (2023) density surface.

94. In the British Isles, it is estimated that the breeding season typically occurs between June and September, with births predominantly in June (Lockyer, 1995). They are considered a slowly reproducing species as they give birth only once a year and therefore are dependent on a successful breeding season (Kesselring et al., 2017). Dynamic energy budget modelling has shown that female porpoise are expected to be most vulnerable to disturbance (reduction in food intake) between the time the calf is born until it is able to acquire at least some food independently (June–Sept inclusive) (Harwood et al., 2020). The population will, therefore, be more vulnerable to disturbance during this breeding and early lactation season. Based on the site specific survey data, harbour porpoise were most common within the CWP Project during the months of March and August, with the lowest number of sightings occurring in February. Several other surveys conducted (e.g., Berrow et al., 2008, Rogan et al., 2018) also found harbour porpoise density and abundance to be higher during the summer months.

11.6.2 Bottlenose dolphin

95. Bottlenose dolphins were sighted off all Irish coasts, with evidence that an offshore ecotype of bottlenose dolphins exists in Irish waters (Mirimin et al., 2011). Bottlenose dolphins 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). No bottlenose dolphins were recorded during any of the aerial or boat-based CWP Project site specific baseline surveys and therefore, no site specific density estimates could be derived. A range of density estimates have been taken forward to the quantitative impact assessment to reflect the uncertainty in bottlenose dolphin density in the CWP Project offshore development area. These include the SCANS IV uniform density estimate, the SCANS III density surface and the Evans and Waggitt (2023) density surface.

96. The density surfaces obtained from the SCANS III data show the predicted bottlenose dolphin distribution across the MU is not uniform, with higher densities found in the southwest of the MU (Lacey et al., 2022). Densities of bottlenose dolphin in the vicinity of the CWP Project are relatively low with values below 0.05 bottlenose dolphin/km^2 in the array site and OECC. While the SCANS III bottlenose dolphin density surface provides some information on bottlenose dolphin distribution within the Irish Sea (higher in the coastal waters of east Ireland), the density surface is incompatible with the Irish Sea MU population size estimate of 293 bottlenose dolphins (IAMMWG, 2023). If the grid cells within the Irish Sea MU are summed, then the number of bottlenose dolphins present in the Irish Sea MU according to the Lacey et al. (2022) density surface is 1,069 bottlenose dolphins. This is over three times higher than the MU abundance estimate advised by IAMMWG (2023). Where the Lacey et al. (2022) density surface is to be used in a quantitative impact assessment to predict the number of bottlenose dolphins impacted, then the Irish Sea MU population has to be assumed to be 1,069 bottlenose dolphins, otherwise this could result in more dolphins predicted to be impacted than there are in the MU population if it is assumed to be 293.

97. The CWP Project is located within SCANS IV survey block CS-D (which covered the western Irish Sea). Bottlenose dolphins were sighted throughout SCANS IV survey block CS-D, resulting in a block wide abundance estimate of 8,199 (95% CI: 3,595–15,158) and a uniform density across the survey block of 0.2352 dolphins/km^2 (CV 0.353) (Gilles et al., 2023). It is important to highlight here the significant differences between the SCANS III and SCANS IV results for the abundance of bottlenose dolphins in the Irish Sea, as SCANS IV estimates there to be 8,326 bottlenose dolphins in the Irish Sea. The current recommended population estimate for the Irish Sea MU is therefore completely incompatible with the SCANS IV block CS-D density estimate. Therefore, it is not possible to use the SCANS IV density estimate in a quantitative impact assessment unless the Irish Sea MU abundance estimate is assumed to be 8,326 instead of 293.

98. In Evans and Waggitt (2023), bottlenose dolphins were modelled throughout the Irish Sea and Bristol Channel, with consistent distribution patterns across seasons. The modelled outputs indicate that the main areas of high density are inclusive of Cardigan Bay and west Anglesey, with some densities in a concentrated area on the southwest coast of England. The densities predicted for the east coast of the Republic of Ireland were comparatively very low. Using the maximum density per cell across all months, the estimated density in the CWP Project array site is at most 0.01 dolphins/km^2. As noted for the SCANS surveys, the Evans and Waggitt (2023) maximum density surface is not compatible with the Irish Sea MU population size estimate of 293 bottlenose dolphins (IAMMWG, 2023). If the grid cells within the Irish Sea MU are summed, then the number of bottlenose dolphins present in the Irish Sea MU according to the Evans and Waggitt (2023) maximum density surface is 496 bottlenose dolphins. This is over 1.5 times higher than the MU abundance estimate advised by IAMMWG (2023). If the Evans and Waggitt (2023) maximum density surface is to be used in a quantitative impact assessment to predict the number of bottlenose dolphins impacted, then the Irish Sea MU population has to be assumed to be 496 bottlenose dolphins, otherwise this could result in more dolphins predicted to be impacted than there are in the MU population if it is assumed to be 293.The different estimates taken forward for the quantitative impact assessment are summarised in **Table 11-9.**

99. Whilst other studies have shown that bottlenose dolphins have been sighted all year round in Irish waters (Berrow et al., 2012), data from ObSERVE showed no real difference in the density of bottlenose dolphins between summer and winter in strata 5 (Rogan et al., 2018). In addition, Evans and Waggitt (2023) demonstrated consistent distribution patterns and density estimations of bottlenose dolphins in the Irish Sea across all seasons. These data seem to confirm a year-round presence of bottlenose dolphins in the Irish Sea.

11.6.3 Common dolphin

100. 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 (NPWS, 2019). The species has been assessed as having an overall Favourable conservation status in Irish waters (NPWS, 2019). The IAMMWG recommend that a single Celtic and Greater North Seas MU is appropriate for common dolphins (IAMMWG, 2023). The abundance estimate for the MU is 102,656 (CV: 0.29, 95% CI: 58,932–178,822) based on data collected during SCANS III and the ObSERVE surveys (Rogan et al., 2018, Hammond et al., 2021).

101. Density estimations for common dolphin were derived by modelling both boat-based survey and aerial survey data (Natural Power, 2023). During 2013–2014 boat-based surveys, no common dolphins were sighted, whilst during the 2018–2020 boat-based surveys, six common dolphins were recorded, giving a density estimate of 0.0026 dolphins/km^2. By comparison, during the 2020–2022 aerial surveys, 82 common dolphins were recorded giving a density estimate of 0.2810 dolphins/km^2.

102. It is important to consider not only the site specific survey data, but also density estimates for much wider areas that are more suited to potential larger scale disturbance impacts. Therefore, a range of

density estimates have been taken forward to the quantitative impact assessment. These include the CWP Project site specific survey estimate, SCANS IV uniform density estimate, the SCANS III density surface and the Evans and Waggitt (2023) density surface. While a range of density estimates will be taken forward for the quantitative impact assessment, it is acknowledged that the CWP Project site specific survey density estimate is an order of magnitude greater than the more recent SCANS-IV density for block CS-D. This will lead to large discrepancies in the predicted number of individuals impacted as a result of pile driving activities. Other site specific surveys for renewable energy projects in the Celtic and Irish Seas have also demonstrated the same trends. For example, the results of site specific surveys at Erebus (Floating) Offshore Wind Farm resulted in density estimates for common dolphins of 1.61 dolphins/km^2 (Darias-O'Hara and Sinclair, 2021, Blue Gem Wind, 2022) which is much greater than the SCANS IV density estimate for the relevant block (0.8410 dolphins/km^2, CS-C). While there is no evidence to suggest the higher densities of common dolphins persists beyond the site specific survey area at the CWP Project, this density estimate will be used when assessing the potential for disturbance from pile driving to acknowledge that common dolphin density in the Irish Sea may be higher than was predicted in the SCANS surveys. This is considered to be a highly precautionary approach.

103. Common dolphins have been reported in Irish waters year-round with the higher densities of these animals from late spring to autumn (specifically July–September (Evans and Waggitt, 2023)), and this species becoming largely absent during the winter (Wall et al., 2013), contradicting the site specific survey data. An increased density in the late spring to autumn would coincide with common dolphin breeding periods, where calves are typically born during the summer months, typically from May to August (Robinson et al., 2010).

11.6.4 Risso's dolphin

104. Risso's dolphin occurrence is described as '*wide and frequent… throughout Irish waters'*, sighted in both the continental shelf and slope as well as the margins of deeper ocean basins (NPWS, 2019). The species has been assessed as having a Favourable overall conservation status in Irish waters (NPWS, 2019). Risso's dolphins were reported around the entire Irish coast, with highest relative abundances reported to be off the southwest and southeast coasts (Wall et al., 2013). These individuals were sighted in Irish waters from April–November, with a peak in sightings during the summer months. The IAMMWG recommend a single Celtic and Greater North Seas MU for Risso's dolphin where the estimate of abundance is 12,262 (CV: 0.46, 95% CI: 5,227–28,764) (IAMMWG, 2023) based on data collected during SCANS III and the ObSERVE surveys (Rogan et al., 2018, Hammond et al., 2021).

105. No Risso's dolphins were recorded during any of the aerial CWP Project site specific baseline surveys, although two sightings of Risso's dolphin were observed in the 2013–2014 boat-based surveys (May and July 2013). The density surface estimate was calculated as 0.0008 dolphins/km^2. In Evans and Waggitt (2023), Risso's dolphin were modelled throughout the Irish Sea and Bristol Channel, with seasonally varying distribution patterns. The third quarter, July–September, had peak densities. The modelled outputs below indicate that the main areas of higher density are inclusive of the Irish Sea from July–September, particularly the southeast coast of the Republic of Ireland and the deeper waters in the central Irish Sea. Using the maximum density per cell across all months, the estimated density in the CWP Project is up to 0.025 dolphins/km^2.

106. It is important to consider not only the site specific survey data, but also density estimates for much wider areas that are more suited to potential larger scale disturbance impacts. Therefore, a range of density estimates have been taken forward to the quantitative impact assessment. These include the CWP Project site specific survey estimate (not suitable for wider scale disturbance impacts), SCANS IV uniform density estimate, the SCANS III density surface and the Evans and Waggitt (2023) density surface.

107. The knowledge of the reproduction and breeding of Risso's dolphins is still limited, although studies in other regions have indicated it is typically during the summer and autumn months (Chen et al., 2011).

11.6.5 Minke whale

108. Minke whales are observed throughout Irelands coastal and offshore waters, and both the continental slope and shelf. The species has been assessed as having an overall Favourable conservation status in Irish waters (NPWS, 2019). The IAMMWG recommend that a single Celtic and Greater North Seas MU is appropriate for minke whales, for which the abundance estimate is 20,118 minke whales (CV: 0.18, 95% CI: 14,061–28,786) (IAMMWG, 2023) based on data collected during SCANS III and the ObSERVE surveys (Rogan et al., 2018, Hammond et al., 2021).

109. Site specific (CWP Project array site) density estimations for minke whales were derived by modelling the boat-based survey data only as no sightings of minke whale were made during aerial surveys (Natural Power, 2023). During 2013–2014 boat-based surveys, two minke whales were sighted giving a density estimate of 0.0017 whales/km^2. During the 2018–2020 boat-based surveys, three minke whales were recorded giving a density estimate of 0.0020 whales/km^2. Based on these five observations, the density estimate calculated and used in this impact assessment is 0.0019 whales/km^2.

110. It is important to consider not only the site specific survey data, but also density estimates for much wider areas that are more suited to potential larger scale disturbance impacts. Therefore, a range of density estimates have been taken forward to the quantitative impact assessment. These include the CWP Project site specific survey estimate (not suitable for wider scale disturbance impacts), SCANS IV uniform density estimate, the SCANS III density surface and the Evans and Waggitt (2023) density surface.

111. Minke whales are known to exhibit a high degree of seasonal variation in their presence in the Irish Sea, with sightings occurring more frequently during the summer months (Rogan et al., 2018). Minke whales are known to perform seasonal migrations between high latitude feeding grounds in the summer and low latitude area for breeding and calving in the winter months (Risch et al., 2014a) and their increased presence in the summer months supports this migration pattern. Wall et al. (2013) reported some seasonal variation in the presence of minke whales, with highest relative abundances of this species recorded in the western Irish Sea in Spring. This peak in relative abundance was concluded to be due to foraging, with concentrations of pelagic schooling fish present in the area.

11.6.6 Grey seal

112. Grey seals occur throughout Irish waters, and those in Ireland are considered to be part of a meta-population that also inhabits adjacent jurisdictions (NPWS, 2019). They have a Favourable conservation status with an increasing trend in Irish waters (NPWS, 2019). The CWP Project is located within the East region of the RoI. Given the wide scale movement of grey seals, the relevant reference population against which to assess the impacts of the CWP Project is a combination of the east regions of RoI and the Northern Ireland MU. Morris and Duck (2019) reported on the number and distribution of hauled-out grey seals in RoI. A total of 418 grey seals were counted in the East region and 556 in the southeast region. The most recent 2021 August haul-out counts for grey seals in the Northern Ireland MU is 549 individuals (SCOS, 2023). The total August counts for the east region (418), southeast 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).

113. Aerial and boat-based survey data were not used to obtain information on seals and thus, no density estimates from site specific surveys have been derived for grey seals. There have been several studies on grey seal abundance and distribution at haul-outs around Ireland; however, there is a lack of at-sea density estimates due to a lack of telemetry data in Irish waters. Given that there is no alternative, it is recommended that the at-sea density estimates obtained from the habitat preference maps (i.e., Carter et al. (2020)) are taken forward for impact assessment for the CWP Project. Using the data from Carter et al. (2020), grey seal at-sea density estimates are relatively low in the project area (average 0.1536 seals/km^2 for both the array site and OECC).

114. Grey seal pups are typically born between August and December. Following pupping, the pups will suckle for 17 to 23 days and once weaned, will remain in the breeding colony for a further two to three weeks. Once the adult females have finished lactation, mating will then occur, before heading back out to sea (SCOS, 2023). Grey seals also undertake an annual moult between December and April (SCOS, 2023). During the breeding season and whilst moulting, grey seals spend longer periods of times hauled out on land, resulting in a higher density of seals on land and typically forage within 100 km of haul out sites (SCOS, 2023). They may, therefore, be more vulnerable to activity being conducted close to haul out sites during these months. Outside of the breeding season, seals will exhibit a much wider spatial variation.

11.6.7 Harbour seal

115. Harbour seals occur throughout Irish waters in estuarine, coastal and fully marine areas. They have been assessed as having a Favourable conservation status in Irish waters (NPWS, 2019). Morris and Duck (2019) reported on the number and distribution of hauled-out harbour seals in RoI. A total of 131 seals were counted in the East region and 34 in the southeast region. The most recent 2021 August counts for harbour seals in the Northern Ireland MU is 818 individuals, which was 23% lower than the 2018 count (SCOS, 2023). The total August counts for the East region (131), southeast 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).

116. Aerial and boat-based survey data were not used to obtain information on seals and thus, no density estimates from site specific surveys have been derived for harbour seals. There have been several studies on harbour seal abundance and distribution at haul-outs around Ireland; however, there is a lack of at-sea density estimates due to a lack of telemetry data in Irish waters. Given that there is no alternative, it is recommended that the at-sea density estimates obtained from the habitat preference maps (i.e., Carter et al. (2020)) are taken forward for impact assessment for the CWP Project. Using the data from Carter et al. (2020), harbour seal at-sea density estimates are relatively low in the project area (average 0.0075 seals/km^2 for both the array site and OECC).

117. Harbour seal pupping occurs during the summer months, primarily in June and July (Arso Civil et al., 2018, SCOS, 2023). Moulting most frequently occurs during August (SCOS, 2023) following pupping, although seals in active moult have been observed in southwest Ireland from June to November (Cronin et al., 2013). During the breeding season and whilst moulting, grey seals spend longer periods of times hauled out on land (SCOS, 2023), resulting in a higher density of seals on land. They may, therefore, be more vulnerable to activity being conducted close to haul out sites during these months. Outside of the breeding season, seals will exhibit a wider spatial variation.

11.6.8 Climate change and natural trends

118. The baseline 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.

119. 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 that 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, foodweb 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 arounds the UK and Ireland, the review does not cover the specifics for each of the species discussed in this baseline report and thus there remains some uncertainty around the potential impacts of climate change on species of marine mammals.

11.6.9 Summary

120. Although it is challenging to predict the future trajectories of marine mammal populations, the data available suggests that, apart from harbour porpoise, all other marine mammal populations included in this assessment are relatively stable (longer-term monitoring would be required to determine whether the harbour seal population is in decline within the Northern Ireland MU). Nonetheless, the most recent species conservation assessments included in this baseline characterisation classified all marine mammal species as having a Favourable overall conservation status, with grey seals noted as having an increasing trend (NPWS, 2019).

121. The table below presents the MUs and density estimates selected as the most appropriate to be used in the quantitative assessment for each marine mammal species, with consideration of the spatial scale of potential impacts. It should be noted that for bottlenose dolphins, differing MU population estimates will be used in the impact assessment (to assess for the proportion (%) of the MU impacted) depending on the density estimate used, as there is some incompatibility between the density estimates and the current Irish Sea MU population size (IAMMWG, 2023) (see **Table 11-9** and associated footnotes).

Table 11-9 Table of MUs and density estimates for each species to be used in the quantitative impact assessment

Species	MU	Density (#/km^2)
Harbour porpoise	Celtic and Irish Seas MU 62,517 porpoise (IAMMWG, 2023)	0.1225 (CWP Project site specific surveys) *Not suitable for wide scale disturbance impacts that extend beyond the survey area*
		Grid cell specific densities (SCANS III density surface, Lacey et al., 2022)
		0.2803 (SCANS IV block CS-D, Gilles et al., 2023)
		Grid cell specific densities (Irish Sea density surface, Evans and Waggitt, 2023)

Species	MU	Density (#/km²)
Bottlenose dolphin	Irish Sea MU 1,069 dolphins[4]	Grid cell specific densities (SCANS III density surface, Lacey et al., 2022)
	Irish Sea MU 496 dolphins[5]	Grid cell specific densities (Irish Sea density surface, Evans and Waggitt, 2023)
	Irish Sea MU 8,236 dolphins[6]	0.2352 (SCANS IV block CS-D, Gilles et al., 2023)
Common dolphin	Celtic and Greater North Seas MU 102,656 dolphins (IAMMWG, 2023)	0.2810 (CWP Project site specific DAS) *Used in the presentation for wide scale disturbance impacts that extend beyond the survey area (i.e.: pile driving disturbance) but the results are likely to be highly precautionary*
		Grid cell specific densities (SCANS III density surface, Lacey et al., 2022)
		Grid cell specific densities (Irish Sea density surface, Evans and Waggitt, 2023)
		0.0272 (SCANS IV block CS-D, Gilles et al., 2023)
Minke whale	Celtic and Greater North Seas MU 20,118 whales (IAMMWG, 2023)	0.0019 (CWP Project site specific surveys) *Not suitable for wide scale disturbance impacts that extend beyond the survey area*
		Grid cell specific densities (SCANS III density surface, Lacey et al., 2022)
		Grid cell specific densities (Irish Sea density surface, Evans and Waggitt, 2023)
		0.0137 (SCANS IV block CS-D, Gilles *et al.,* 2023)
Risso's dolphin	Celtic and Greater North Seas MU 12,262 dolphins (IAMMWG, 2023)	0.0008 (CWP Project site specific surveys) *Not suitable for wide scale disturbance impacts that extend beyond the survey area*
		Grid cell specific densities (Irish Sea density surface, Evans and Waggitt, 2023)
		0.0022 (SCANS IV block CS-D, Gilles et al., 2023)
Harbour seal	East RoI and Northern Ireland MU 1,365 seals	Grid cell specific densities (Habitat preference map, Carter et al., 2020, 2022) Average density across cells within the array site and Offshore OECC = 0.0075 seals/km²

[4] 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). Therefore, it is not possible to use this density surface in a quantitative impact assessment unless the Irish Sea MU abundance estimate is assumed to be 1,069 instead of 293.

[5] When summing the grid cells within the Irish Sea, the Irish Sea density surface from Evans and 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).Therefore, it is not possible to use this density surface in a quantitative impact assessment unless the Irish Sea MU abundance estimate is assumed to be 496 instead of 293.

[6] 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	Density (#/km²)
Grey seal	East RoI and Northern Ireland MU 6,056 seals	Grid cell specific densities (Habitat preference map, Carter et al., 2020, 2022) Average density across cells within the array site and OECC = 0.1536 seals/km²

11.7 Scope of the assessment

122. An EIA Scoping Report for the Offshore Infrastructure was published on the 6 January 2021. The Scoping Report was uploaded to the CWP Project website and shared with regulators, prescribed bodies and other relevant consultees, inviting them to provide relevant information and to comment on the proposed approach being adopted by the Applicant in relation to the offshore elements of the EIA.

123. Based on responses to the Scoping Report, further consultation and refinement of the CWP Project design, potential impacts to marine mammals scoped into the assessment are listed below in **Table 11-10**.

Table 11-10 Potential impacts scoped into the assessment

Impact No.	Description of impact	Notes
Construction		
Impact 1	Auditory injury (PTS) from pre-construction surveys	Proposed to be scoped out in the EIA Scoping Report, but now included in the assessment.
Impact 2	Disturbance from pre-construction surveys	Proposed to be scoped out in the EIA Scoping Report, but now included in the assessment.
Impact 3	Auditory injury (PTS) from UXO clearance	Quantitative assessment provided.
Impact 4	Disturbance from UXO clearance	Quantitative assessment provided.
Impact 5	Auditory injury (PTS) from piling – WTGs and OSSs	Quantitative assessment provided.
Impact 6	Disturbance from piling – WTGs and OSSs	Quantitative assessment provided.
Impact 7	Auditory injury (PTS) from piling – onshore substation	Quantitative assessment provided.
Impact 8	Disturbance from piling – onshore substation	Quantitative assessment provided.
Impact 9	Auditory injury (PTS) from other construction activities	Quantitative assessment provided.
Impact 10	Disturbance from other construction activities	Qualitative assessment provided.
Impact 11	Vessel collision	Proposed to be scoped out in the EIA Scoping Report, but now included in the assessment.

Impact No.	Description of impact	Notes
Impact 12	Disturbance from vessels	Proposed to be scoped out in the EIA Scoping Report, but now included in the assessment.
Impact 13	Indirect impacts to prey	Proposed to be scoped out in the EIA Scoping Report, but now included in the assessment.
Operation and Maintenance		
Impact 1	Auditory injury (PTS) from operational noise	Proposed to be scoped out in the EIA Scoping Report, but now included in the assessment.
Impact 2	Disturbance from operational noise	Proposed to be scoped out in the EIA Scoping Report, but now included in the assessment.
Impact 3	Vessel collision	Proposed to be scoped out in the EIA Scoping Report, but now included in the assessment.
Impact 4	Disturbance from vessels	Proposed to be scoped out in the EIA Scoping Report, but now included in the assessment.
Impact 5	Indirect impacts to prey	Proposed to be scoped out in the EIA Scoping Report, but now included in the assessment.
Decommissioning		
Impact 1	Auditory injury (PTS) and disturbance from decommissioning activities	Qualitative assessment provided.
Impact 2	Vessel collision	Proposed to be scoped out in the EIA Scoping Report, but now included in the assessment.
Impact 3	Indirect impacts to prey	Proposed to be scoped out in the EIA Scoping Report, but now included in the assessment.

11.7.1 Impacts scoped out

124. **Table 11-11** outlines the impacts scoped out of the assessment for marine mammals.

Table 11-11 Impacts scoped out of the assessment

Impact	Phase	Justification
Accidental pollution Events / contamination	All	CWP Project's Construction Environmental Management Plan (CEMP) will adhere to current guidelines and follow industry best practice regarding prevention of pollution at sea.

Impact	Phase	Justification
Presence of electromagnetic fields (EMF)	O&M	Existing evidence suggests that the levels of EMFs emitted by offshore renewable energy export cables are at a level low enough that there is no potential for direct significant impacts on marine mammals (Copping and Hemery, 2020). 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). Given that marine mammals are known to closely associate with offshore wind farm structures (Scheidat et al., 2011, Russell et al., 2014), it is predicted that the magnitude and vulnerability score for direct EMF impacts would be negligible, and the likelihood of a significant effect can therefore be ruled out beyond reasonable scientific doubt.
Barrier to movement / loss of habitat	Construction	All evidence collated to date shows that while individuals may be displaced in the short-term during construction activities, they return to the area of impact after the cessation of activities (e.g., Russell et al., 2016a, Brandt et al., 2018, Benhemma-Le Gall et al., 2020). Therefore, while disturbance leading to temporary displacement may occur, this is expected to be spatially and temporally small scale and thus it is not expected that construction activities will result in a permanent barrier to the movement of marine mammals in the area, and the likelihood of a significant effect can therefore be ruled out beyond reasonable scientific doubt.
Barrier to movement / loss of habitat	O&M	A number of studies have reported the presence of marine mammals within wind farm footprints. For example, at the Horns Rev and Nysted offshore wind farms 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) indicating the presence of the windfarm was not adversely affecting harbour porpoise presence. Other studies at Dutch and Danish OWFs (Lindeboom et al., 2011) also suggest that harbour porpoise may be attracted to increased foraging opportunities 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 WTGs, strongly suggestive of these structures being used for foraging. Previous reviews have also concluded that operational wind farm noise will have negligible barrier effects (Madsen et al., 2006, Teilmann et al., 2006a, Teilmann et al., 2006b, CEFAS, 2010, Brasseur et al., 2012). Thus, it is not expected that O&M activities will result in a permanent barrier to the movement of marine mammals in the area, and the likelihood of a significant effect can therefore be ruled out beyond reasonable scientific doubt.

11.8 Assessment parameters

11.8.1 Background

125. Complex, large-scale infrastructure projects with a terrestrial and marine interface such as the CWP Project, are consented and constructed over extended timeframes. The ability to adapt to changing supply chain, policy or environmental conditions and to make use of the best available information to feed into project design, promotes environmentally sound and sustainable development. This ultimately reduces project development costs and therefore electricity costs for consumers and reduces CO_2 emissions.

126. In this regard the approach to the design development of the CWP Project has sought to introduce flexibility where required, among other things, to enable the best available technology to be constructed and to respond to dynamic maritime conditions, whilst at the same time to specify project boundaries, project components and project parameters wherever possible, whilst having regard to known environmental constraints.

127. **Chapter 4 Project Description** describes the design approach that has been taken for each component of the CWP Project. Wherever possible the location and detailed parameters of the CWP Project components are identified and described in full within the EIAR. However, for the reasons outlined above, certain design decisions and installation methods will be confirmed post-consent, requiring a degree of flexibility in the planning consent.

128. Where necessary, flexibility is sought in terms of:

- Up to two options for certain permanent infrastructure details and layouts such as the WTG layouts;
- Dimensional flexibility; described as a limited parameter range i.e., upper and lower values for a given detail such as cable length; and
- Locational flexibility of permanent infrastructure; described as Limit of Deviation (LoD) from a specific point or alignment.

129. The CWP Project had to procure an opinion from An Bord Pleanála to confirm that it was appropriate that this application be made and determined before certain details of the development were confirmed. An Bord Pleanála issued that opinion on 25 March 2024 (as amended in May 2024) and it confirms that the CWP Project could make an application for permission before the details of certain permanent infrastructure described in **Section 4.3** of **Chapter 4 Project Description** is confirmed.

130. In addition, the application for permission relies on the standard flexibility for the final choice of installation methods and O&M activities.

131. Notwithstanding the flexibility in design and methods, the EIAR identifies, describes and assesses all of the likely significant impacts of the CWP Project on the environment.

11.8.2 Options and dimensional flexibility

132. Where the application for permission seeks options or dimensional flexibility for infrastructure or installation methods, the impacts on the environment are assessed using a representative scenario approach. A ‘representative scenario’ is a combination of options and dimensional flexibility that has been selected by the author of this EIAR chapter to represent all of the likely significant effects of the project on the environment. Sometimes, the author will have to consider several representative scenarios to ensure all impacts are identified, described and assessed.

133. For marine mammals this analysis is presented in **Appendix 11.2** which identifies one or more representative scenario for each impact with supporting text to demonstrate that no other scenarios would give rise to new or materially different effects; taking into consideration the potential impact of other scenarios on the magnitude of the impact or the sensitivity of the receptor(s) that is being considered.

134. **Table 11-12** and **Table 11-13** below, present a summarised version of **Appendix 11.2** and describe the representative scenarios on which the construction and O&M phase marine mammal assessment has been based. Where options exist, for each receptor and potential impact, the table identifies the representative scenario and provides a justification for this.

11.8.3 Limit of deviation

135. Where the application for permission seeks locational flexibility for infrastructure, the impacts on the environment are assessed using a LoD. The LoD is the furthest distance that a specified element of the CWP Project can be constructed.

136. This chapter assesses the specific preferred location for permanent infrastructure. However, **Appendix 11.2** provides further analysis to determine if the proposed LoD for permanent infrastructure may give rise to any new or materially different effects; taking into consideration the potential impact of the proposed LoD on the magnitude of the impact.

137. For marine mammals, this analysis is summarised in **Table 11-13**.

138. Where the potential for LoD to cause a new or materially different effect is identified, then this is noted in **Table 11-13** and is considered in more detail within **Section 11.10** of this chapter.

Table 11-12 Design parameters relevant to assessment of marine mammals

Impact	Representative scenario details	Value	Notes / Assumptions
Construction			
Impact 1: Auditory injury (PTS) from pre-construction surveys **Impact 2:** Disturbance from pre-construction surveys	Installation methods and effects		
	Array Site and OECC Cable Lay Geophysical Survey • Multi-Beam Echo Sounder (MBES); • Sub-Bottom Imager (SBI); • Side Scan Sonar (SSS); • Sub Bottom Profiler (SBP) – pinger; • Ultra-High resolution seismic (UHRS) – sparker; • Ultra-Short Base Line (USBL) system; and • Magnetometer.	NA	No variation between WTG Option A or B.
Impact 3: Auditory injury (PTS) from UXO clearance **Impact 4:** Disturbance from UXO clearance	Installation methods and effects		
	# UXO	10	No variation between WTG Option A or B.
	Maximum charge weight (Net Explosive Quantity (NEQ))	525 kg	
Impact 5: Auditory injury (PTS) from pile driving – WTGs and OSSs **Impact 6:** Disturbance from piling – WTGs and OSSs	Installation methods and effects		
	WTGs	WTG Option A	WTG Layout Option A is the representative scenario due to the greater number of WTGs and foundations.
	Maximum # monopile foundations	75	
	Method of installation	Impact pile driving	
	Maximum hammer energy	4,400 kJ	

	Number of piles installed per day	2	**Temporal Representative Scenario:** Installation of 1 monopile per day (highest number of piling days) **Spatial Representative Scenario:** Installation of 2 monopiles per day in the NW zone (largest cumulative PTS impact ranges)
	Piling days (assuming 1 pile per day)	75	
	Piling days (assuming 2 piles per day)	38	
	Maximum hours piling per pile	3.17	
	Maximum hours piling per day (assuming 2 monopiles)	6.3	
	Concurrent piling	None	
	Piling period	April–October 2027 inclusive	
	OSS		**Temporal Representative Scenario:** Installation of 1 monopile per day (highest number of piling days) **Spatial Representative Scenario:** Installation of 2 monopiles per day in the NW zone (largest cumulative PTS impact ranges)
	Maximum # monopile foundations	3	
	Maximum monopile diameter	9.5 m	
	Method of installation	Impact pile driving	
	Maximum hammer energy	4,400 kJ	
	Number of piles installed per day	2	
	Piling days (assuming 1 pile per day)	3	
	Piling days (assuming 2 piles per day)	2	
	Maximum hours piling per pile	3.17	
	Maximum hours piling per day (assuming 2 monopiles)	6.3	
	Concurrent piling	None	
	Piling period	April–October 2027 inclusive	

Impact 7: Auditory injury (PTS) from piling – onshore substation revetment **Impact 8:** Disturbance from piling – onshore substation	Installation methods and effects		
	Cofferdam installation	NA	
	Method of installation	Impact pile driving	
	Maximum hammer energy	440 kJ	
	Maximum hours piling per pile	8	
	Concurrent piling	Yes	
	Maximum duration	20 weeks	
Impact 9: Auditory injury (PTS) from other construction-related activities **Impact 10:** Disturbance from other construction-related activities	Installation methods and effects		
	• Boulder clearance (plough or sub-sea grab); • Pre-lay grapnel run; • IAC and interconnector cable installation; • Offshore export cable installation; • Sandwave clearance (dredger or mass flow excavation); and • IAC burial (jetting, trenching or ploughing).	NA	
Impact 11: Vessel collision **Impact 12:** Vessel disturbance	Installation methods and effects		
	WTG foundations (round trips)	WTG Option A	Maximum number of vessels on site and maximum number of annual round trips
	• Seabed preparation vessels (including surveys, UXO investigation and boulder clearance).	4 (20)	
	• WTG and OSS monopile installation vessels (includes installation vessel, feeder vessel and anchor handlers).	6 (43)	
	• Transition Piece (TP) installation vessels.	7 (43)	

• Scour protection installation vessels (including filter layer and seabed preparation).	7 (107)
WTGs and OSSs	
WTG installation vessels (includes installation vessel, feeder vessel and anchor handlers)	4 (50)
OSS Topside installation vessels	4 (20)
Cable installation vessels	
Seabed preparation vessels (including Trailing Suction Hopper Dredger (TSHD) for sandwave clearance and disposal off site, Pre Lay Grapnel Run (PLGR), Out Of Service (OOS) removal, boulder clearance, pre-crossing protection and survey vessel)	7 (548)
Array cable and interconnector installation vessels (includes support, cable protection and anchor handling vessels)	6 (39)
Export cable installation vessels (including at landfall) (includes support, cable protection and anchor handling vessels)	5 (43)
Nearshore export cable installation vessels (including at landfall) (includes barges, tugs and small work boats)	17 (118)
Commissioning vessels	
Commissioning vessels	2 (48)
Support vessels	
General support vessels (including guard vessel, project Service Operation Vessel (SOV) and work boats)	4 (506)
Crew transfer vessels (CTV)	2 (824)

	Total construction vessels		
	Maximum total construction vessels (round trips)	75 (2,409)	
	Indicative peak vessels on site simultaneously	38	
Impact 13: Indirect effects – changes in prey	Installation methods and effects		
	See **Chapter 9 Fish, Shellfish and Turtle Ecology**	NA	
Operations and maintenance			
	• Jack Up Vessel (JUV): Peak Vessel Numbers 2 (Annual Round Trips 3); • Service Operation Vessel (SOV): 1 (26); • CTV: 6 (1,152); • Cable maintenance vessel: 2 (1); and • Auxiliary vessel (includes survey vessels, ROVs, AUVs, tug operations, cargo vessels, passenger vessels and scour replacement vessels): 3 (27).	NA	
Increased underwater noise from operation	Permanent infrastructure		
	Rotor diameter	250 m / 276 m	
Indirect effects – changes in prey	Permanent infrastructure		
	See **Chapter 9 Fish, Shellfish and Turtle Ecology**	NA	
Decommissioning			
	It is recognised that legislation and industry best practice change over time. However, for the purposes of the EIA, at the end of the operational lifetime of the CWP Project, it is assumed that all offshore infrastructure will be removed where practical to do so. In this regard, for the purposes of a representative scenario for decommissioning impacts, the following assumptions have been made: • The WTGs and OSS topsides will be completely removed.		

	• Following WTG and OSS topside decommissioning and removal, the monopile foundations will be cut below the seabed level, to a depth that will ensure the remaining foundation is unlikely to become exposed. This is likely to be approximately one metre below seabed, although the exact depth will depend upon the seabed conditions and site characteristics at the time of decommissioning. • All cables and associated cable protection in the offshore environment will be wholly removed. It is likely that equipment similar to that which is used to install the cables may be used to reverse the burial process and expose them. Therefore, the area of seabed impacted during the removal of the cables is anticipated to be the same as the area impacted during the installation of the cables. • Generally, decommissioning is anticipated to be a reverse of the construction and installation process for the CWP Project and the assumptions around the number of vessels on site and vessel round trips is therefore the same as described for the construction phase of the offshore components. Given the above it is anticipated that for the purposes of a representative scenario, the impacts will be no greater than those identified for the construction phase.

Table 11-13 Limit of deviation relevant to assessment of marine mammals

Project component	Limit of deviation	Conclusion from Appendix 11.2
WTGs / OSSs	100 m from the centre point of each WTG and OSS location is proposed to allow for small adjustments to be made to the structure locations.	No potential for new or materially different effects
IACs / interconnector cables	100 m either side of the preferred alignment of each IAC and interconnector cable 200 m from the centre point of each WTG location	No potential for new or materially different effects
Offshore export cables	250 m buffer either side of the preferred alignment of each export cable within the array site. The offshore export cable corridor (OECC) outside of the array site.	No potential for new or materially different effects
Location of onshore substation revetment perimeter structure	Defined LoD boundary	No potential for new or materially different effects

11.8.4 Pile driving assessment parameters

139. Underwater noise modelling of pile driven WTG foundations has been undertaken by Subacoustech Environmental Limited using the INSPIRE model. Full details of the underwater noise modelling methods can be found in **Appendix 9.4 UWN Assessment**.

WTG

140. Four WTG model locations were selected within the array site to represent the range of ground conditions across the site as well as the varying water depth. The ground conditions vary from harder substrate in the southwest to softer sediment in the northwest, while water depths vary from 13.3 m (NW) to 26 m (SE) across the array site. The modelled locations are therefore appropriately representative of the noise produced at any location within the array area, and any conclusions informed by the modelling may be taken with confidence. The four WTG modelling locations are detailed in **Table 11-14** and shown in **Figure 11-2**.

141. The CWP Project has, through iterative design, imposed design restrictions on percussive piling in order to minimise impacts from underwater noise. The design restrictions relate to three spatially discrete regions of the array, three spatially specific piling scenarios have therefore been assessed:

- **Scenario 1:** Most restrictive – 9.5 m monopile, maximum 4,000 kJ hammer energy, 1 pile per 24 hours, 3.17 hours piling, 5,594 hammer strikes;
- **Scenario 2:** Less restrictive – 9.5 m monopile, maximum 4,000 kJ hammer energy, 1 pile per 24 hours, 3.17 hours piling, 4,734 hammer strikes; and
- **Scenario 3:** Least restrictive – 9.5 m monopile, maximum 4,000 kJ hammer energy, 2 piles per 24 hours, 6.33 hours piling, 9,468 hammer strikes.

142. The three WTG piling parameters including soft-start and ramp-up details for each piling scenario are provided in **Table 11-15**. Note, the exact same piling parameters are assumed for the installation of the OSS.

Table 11-14 WTG pile driving noise modelling locations

Modelling location	Piling scenario	Latitude	Longitude	Water depth (m)
South East (SE)	1	53.013	-5.719	26.0
South West (SW)	2	53.002	-5.841	16.8
North East (NE)	2	53.107	-5.719	15.6
North West (NW)	3	53.142	-5.841	13.6

Table 11-15 Piling parameters for WTGs

Energy (kJ)	440	440	1,100	2,200	3,300	4,400	Total
Scenario 1: Most restrictive (SE location)							**1 pile per day**
# strikes per pile	200	1,248	1,151	1,143	899	953	**5,594**
Duration (s)	1,200	2,160	1,980	1,980	1,800	2,280	**3.17 hours**
Strike rate (blows/min)	10	35	35	35	30	25	**-**
Scenario 2: Less restrictive (NE and SW locations)							**1 pile per day**
# strikes per pile	200	277	279	277	240	3,461	**4,734**
Duration (s)	1,200	480	480	480	480	8,280	**3.17 hours**
Strike rate (blows/min)	10	35	35	35	30	25	**-**
Scenario 3: Least restrictive (NW location)							**2 piles per day**
# strikes per pile	200	277	279	277	240	3,461	**9,468**
Duration (s)	1,200	480	480	480	480	8,280	**6.33 hours**
Strike rate (blows/min)	10	35	35	35	30	25	**-**

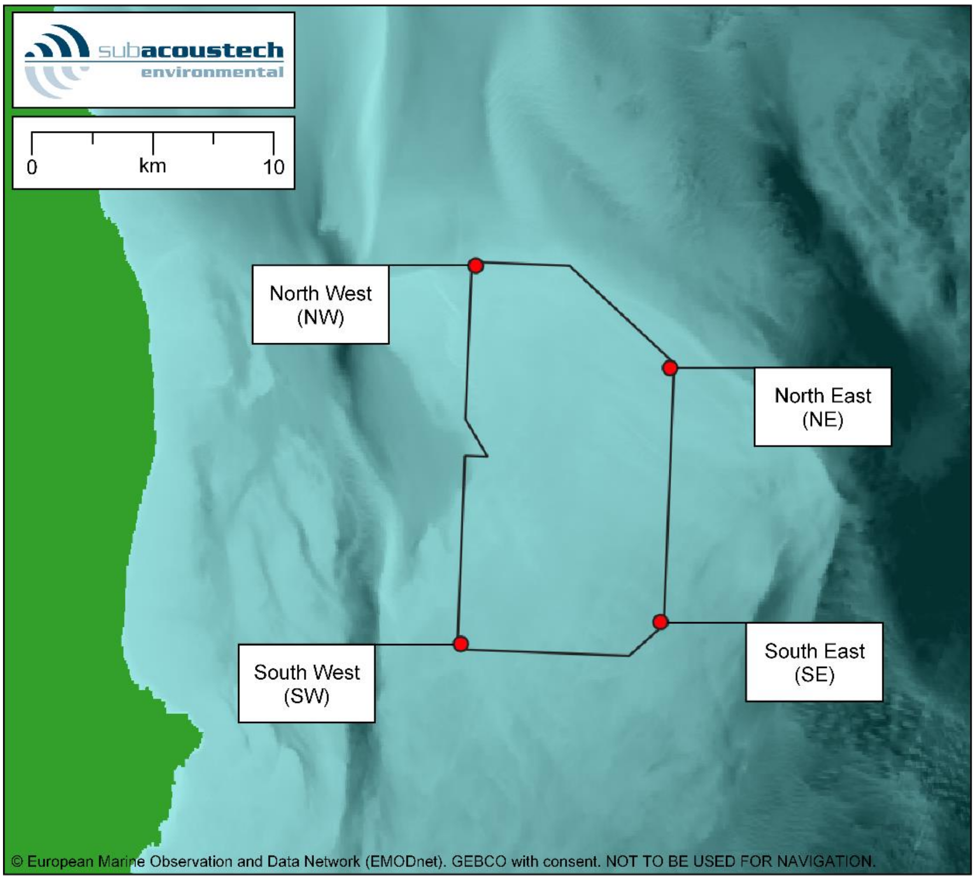


Figure 11-2 Underwater noise modelling locations for WTGs (Figure from **Appendix 9.4**)

Onshore substation (River Liffey)

143. Activities at the onshore substation may require the installation of a combi-wall and reclamation for the ESB building at landfall on the banks of the River Liffey, Dublin. These activities will occur in the River Liffey, and thus will generate underwater noise that requires consideration in the marine mammal assessment. While the combi-wall may be installed using vibro-piling, impact piling using 2.5 m diameter tubular piles has been assessed here. The modelling location is detailed in **Table 11-16** and shown in **Figure 11-3** and the piling parameters are provided in **Table 11-17**.

Table 11-16 Onshore substation pile driving noise modelling locations

Modelling location	Latitude	Longitude
Landfall	53.34207222	-6.195163889

Table 11-17 Piling parameters for the onshore substation

	1 piling rig	2 piling rigs
Energy (kJ)	440	440
# strikes	48,000	96,000
Duration	8 hours	8 hours

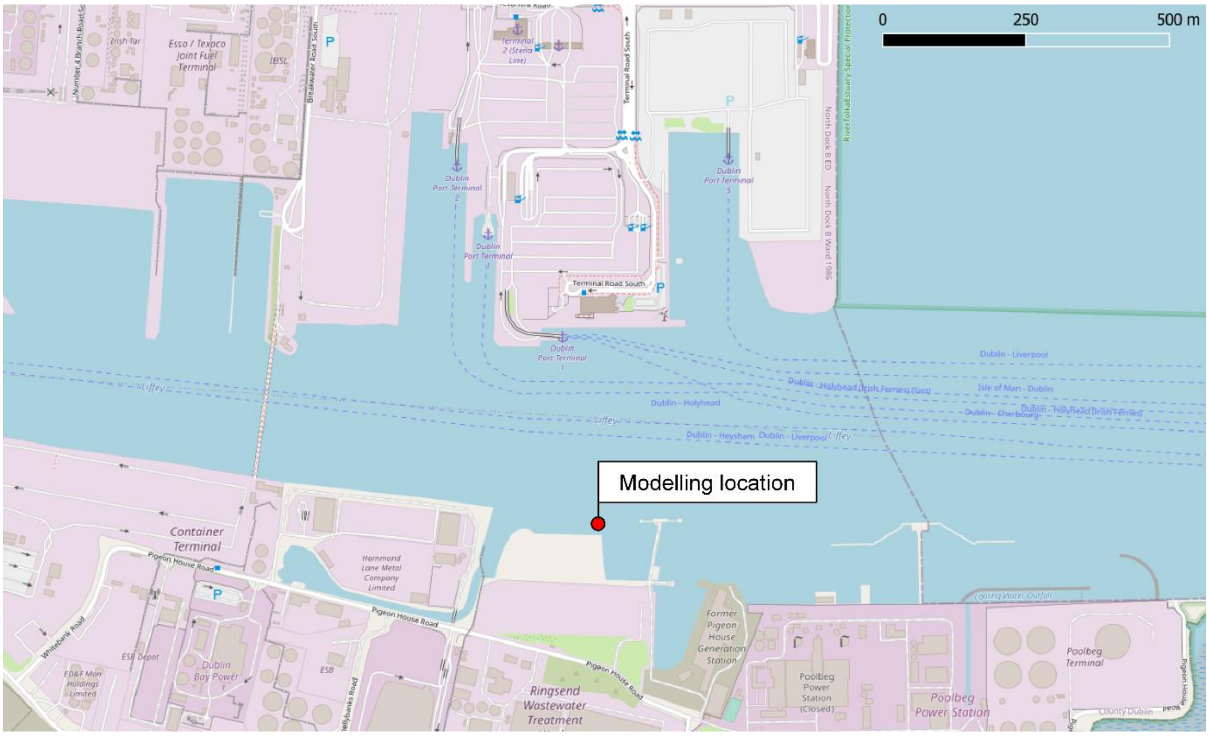


Figure 11-3 Underwater modelling location used to assess the potential underwater noise impacts from the installation of the combi-wall that will be installed in relation to the onshore substation (Figure from Appendix 9.5)

11.9 Primary mitigation measures

144. Throughout the evolution development of the CWP Project, measures have been adopted as part of the evolution of the project design and approach to construction, to avoid or otherwise reduce adverse impacts on the environment. These mitigation measures are referred to as ‘primary mitigation’. They are an inherent part of the CWP Project and are effectively ‘built in’ to the impact assessment.

145. Primary mitigation measures relevant to the assessment of marine mammals are set out in **Table 11-18.** Where additional mitigation measures are proposed, these are detailed in the impact assessment (**Section 11.10**). Additional mitigation includes measures that are not incorporated into the design of the CWP Project and require further activity to secure the required outcome of avoiding or reducing impact significance.

Table 11-18 Primary mitigation measures

Project element	Primary mitigation measure
Increased underwater noise – WTG piling	Zonation of the WTG pile driving parameters to minimise potential impacts. In the southeast zone (represented by SE model location), only Piling Scenario 1 (most restrictive) will be conducted. In the central zone (represented by SW and NE modelling locations), only piling using Piling Scenario 2 (less restrictive) will be conducted. Piling Scenario 3 will only be conducted in the northwest zone (represented by NW modelling location).
Pollution	A **Construction Environmental Management Plan** (CEMP) has been prepared to provide a management framework, to ensure appropriate controls are in place to manage environmental risks associated with the construction of the CWP Project. It outlines environmental procedures that require consideration throughout the construction process, in accordance with legislative requirements and industry best practice. In summary, the CEMP includes details of: • The Environmental Management Framework for the CWP Project including environmental roles and responsibilities (i.e., ecological clerk of works) and contractor requirements (i.e., method statements for specific construction activities); • Mitigation measures and commitments made within the EIAR, Natura Impact Statement (NIS) and supporting documentation for the CWP Project; • Measures proposed to ensure effective handling of chemicals, oils and fuels including compliance with the MARPOL convention; • A Marine Pollution Prevention and Contingency Plan to address the procedures to be followed in the event of a marine pollution incident originating from the operations of the CWP Project; • An Emergency Response Plan adhered to in the event of discovering unexploded ordnance; • Offshore biosecurity and invasive species management detailing how the risk of introduction and spread of invasive non-native species will be minimised; and • Offshore waste management and disposal arrangements. The CEMP will be implemented by the Applicant and its appointed contractor(s) and will be secured through conditions of the development consent. It will be a live document which will be updated and submitted to the relevant authority, prior to the start of construction.

Project element	Primary mitigation measure
Increased underwater noise – geophysical surveys Increased underwater noise – UXO clearance	A **Marine Mammal Mitigation Protocol** (MMMP) has been prepared to outline the mitigation requirements for minimising the impacts on marine mammals during the construction of the CWP Project. The **MMMP** will be implemented by the Applicant and its appointed contractor(s) and will be secured through conditions of the development consent. It will be a live document which will be updated and submitted to the relevant authority, prior to the start of construction. **Primary mitigation measures in the Geophysical Survey MMMP** (section 7 of the **MMMP**): • Pre-survey visual watch by an MMO (and PAM if required). **Primary mitigation measures in the UXO MMMP** (section 10 of the **MMMP**): • Pre-detonation visual watch by an MMO; and • Pre-detonation PAM (if required to supplement to visual observations).
Increased underwater noise – piling	A **Marine Mammal Mitigation Protocol** (MMMP) has been prepared to outline the mitigation requirements for minimising the impacts on marine mammals during the construction of the CWP Project. The MMMP will be implemented by the Applicant and its appointed contractor(s) and will be secured through conditions of the development consent. It will be a live document which will be updated and submitted to the relevant authority, prior to the start of construction. **Primary mitigation measures in the WTG/OSS Piling MMMP** (section 8 of the **MMMP**) **and the Onshore Substation Piling MMMP** (section 9 of the **MMMP**): • Pre-piling visual watch by an MMO; and • Pre-piling PAM (if required to supplement to visual observations).
Increased underwater noise – decommissioning	A **Marine Mammal Mitigation Protocol** (MMMP) has been prepared to outline the mitigation requirements for minimising the impacts on marine mammals during the decommissioning of the CWP Project. The Decommissioning **MMMP** (section 11 of the **MMMP**) will be implemented by the Applicant and its appointed contractor(s) and will be secured through conditions of the development consent. It will be a live document which will be updated and submitted to the relevant authority, prior to the start of decommissioning. As a minimum, it is expected that an MMO watch and a PAM watch (to supplement the MMO) will likely be required for any underwater noise generating activity that has predicted the potential for auditory injury to marine mammals.
Vessel collisions and vessel disturbance	An **Ecological Vessel Management Plan** (EVMP) has been prepared to determine vessel routing to and from construction sites and ports and to include a code of conduct for vessel operators. The EVMP includes details of: • The types and specifications of vessels for the CWP Project; • How vessels will be monitored and coordinated; and • The use of defined transit routes to site from key construction and operation ports, where practicable to do so. The EVMP will be implemented by the Applicant and its appointed contractor(s) and will be secured through conditions of the development consent. It will be a live document which will be updated and submitted to the relevant authority, prior to the start of construction.
Decommissioning	A **Rehabilitation Schedule** is provided as part of the planning application. This has been prepared in accordance with the MAP Act (as amended by the Maritime and Valuation (Amendment) Act 2022) to provide preliminary information on the

Project element	Primary mitigation measure
	approaches to decommissioning the offshore and onshore components of the CWP Project. A final Rehabilitation Schedule will require approval from the statutory consultees prior to the undertaking of decommissioning works. This will reflect discussions held with stakeholders and regulators to determine the exact methodology for decommissioning, taking into account available methods, best practice and likely environmental effects.

11.10 Impact assessment

11.10.1 Construction phase

Impact 1: Auditory injury (PTS) from pre-construction surveys

146. Pre-construction geophysical equipment could include any or all of the following:

- **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;
- **Sub-Bottom Imager (SBI):** provides a real-time 3D view of the sub-seabed via multiple 5 m wide data swaths that penetrates 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[7]. 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;
- **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) – pinger:** The pinger 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[8]. 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[9];
- **Ultra-High resolution seismic (UHRS) – sparker:** 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;
- **Ultra-Short Base Line (USBL) system:** 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

[7] https://krakenrobotics.com/our-services/sub-bottom-imager/
[8] https://www.aspectsurveys.com/survey-services/geophysical/sub-bottom-profiling/
[9] https://www.ixblue.com/maritime/subsea-imagery/sub-bottom-profilers/

which is detected by the transponder, followed by a reply of an acoustic pulse from the transponder. Range and bearing information allow an accurate estimate of the location of the deployed equipment; and

- **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. The magnetometer is a passive system and, therefore, does not emit any noise.

147. 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 11-19**. 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 vocalisations.

Table 11-19 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	7 Hz–35 kHz	200 Hz–19 kHz	-
High-frequency (HF) cetaceans	Bottlenose dolphin Common dolphin Risso's dolphin	150 Hz–160 kHz	8.8–110 kHz	58 kHz
Very high-frequency (VHF) cetacean	Harbour porpoise	275 Hz–160 kHz	12–140 kHz	105 kHz
Phocid carnivores in water (PCW)	Harbour seal Grey seal	50 Hz–86 kHz	1.9–30 kHz	13 kHz

†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).

148. Prior to an evaluation in relation to each item of equipment, the overlap between typical survey equipment operating characteristics and marine mammal functional hearing capability is considered in **Table 11-20**. **Table 11-20** 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; however, the potential for injury will still need to be considered if animals could be exposed to sound pressure of sufficient magnitude to cause hearing damage or other harm.

Table 11-20 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 1 µPa)	Expected Sound Frequency	LF	HF	VHF	PCW
MBES	210–240 dB re 1 µPa (SPL_{peak}) for multiple beams* (Lurton and Deruiter, 2011) 197 dB re 1 µPa (SPL_{peak}) for a single beam at an operational frequency of 200 kHz (Risch et al., 2017)	200–400 kHz (Hartley Anderson Ltd, 2020)	Above all hearing ranges			
SSS	210 dB re 1 µPa (SPL_{peak}) (Crocker and Fratantonio, 2016, Crocker et al., 2019)	300 and 900 kHz (Crocker and Fratantonio, 2016, Crocker et al., 2019)	Above all hearing ranges			
USBL	187–206 dB re 1 µPa (SPL_{RMS}) (Jiménez-Arranz et al., 2020)	19–34 kHz (Jiménez-Arranz et al., 2020)	Yes	Yes	Yes	Yes
SBI[10]	192 dB re 1 µPa (SPL_{peak})	4.5–12.5 kHz band width	Yes	Yes	Yes	Yes
SBP pinger	210–220 dB re 1 µPa (SPL_{peak}) (Hartley Anderson Ltd, 2020)	Frequency selectable. Typically 2–15k Hz with a peak frequency of 3.5 kHz (Hartley Anderson Ltd, 2020)	Yes	Yes	Yes	Yes
UHRS sparker	215–225 dB re 1 µPa (SPL_{peak}) (Hartley Anderson Ltd, 2020)	100 Hz–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 of impact

149. **MBES and SSS:** JNCC (2017) advise that mitigation to avoid injury from use of MBES is not necessary in shallow (<200 m) waters where the MBES used are of high frequencies (as they are planned to be here). EPS Guidance (JNCC et al., 2010) 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 or behavioural disturbance under the 160 dB re 1 µPa (rms) threshold adopted in the United States (Ruppel et al., 2022). Therefore, the risk of injury from MBES and SSS is concluded to be of **Negligible** magnitude.

150. **USBL:** Transmission loss from geometric spreading and frequency-dependent absorption will be such that SPLs within the main beam of the USBL can be expected to drop to below 200 dB re 1 µPa within a few metres of the source, although they are often operated at a source level of <200 dB re 1 µPa. Sound levels outside of this beam will be considerably lower. Therefore, even where a USBL system

[10] https://pangeosubsea.com/wp-content/uploads/2017/10/RPT-07641-1-Technical-Description-SBI-Data-Processing.pdf

was operating at the higher end of the SPL range considered, the risk of injury is predicted to be negligible. As there is a negligible risk of PTS onset to any marine mammals from the use of USBL equipment, the magnitude of impact is assessed as **Negligible**.

151. **SBI:** The source levels of SBI equipment are below the PTS-onset thresholds for harbour porpoise, minke whale, dolphins and seals (see **Table 11-20**). As such, there is no risk of PTS onset to any marine mammal species from the use of SBI and the magnitude of impact is assessed as **Negligible.**

152. **SBP and URHS:** For dolphins, the source levels of SBP and URHS equipment are below the PTS-onset thresholds (see **Table 11-7**). 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.**

153. **SBP and URHS:** For harbour porpoise, each of the predicted SBP and URHS source levels exceed the PTS-onset threshold and as such, the use of this equipment has the potential to cause PTS. However, results for both SBPs and URHS sparkers have indicated that PTS onset is likely to arise between 17–23 m from the use of this equipment at source levels of 267 dB re 1 µPa (SPL_{peak}) (BEIS, 2020). This source level is considerably louder than those likely to be used within the CWP Project and as such, impacts which could adapt behaviour so that individual survival and reproduction rates may be affected are unlikely. Moreover, URHS (sparkers) are less directional than other SBP and seafloor mapping sources and generate lower frequency noise. However, the greatest energy levels emitted by these sources are still directed vertically down, and the source levels are substantially lower than those generated by airgun arrays for deep geophysical survey; consequently, the potential for injury and horizontal propagation of sound is limited. It is also suggested that SBPs and seafloor mapping sources (including sparkers) used in high-resolution geophysical surveys have a very low potential for injury or significant disturbance of sensitive marine fauna (BEIS, 2019). While the likelihood of an animal experiencing PTS-onset from SBP and URHS is very low, PTS is a permanent effect on the hearing sensitivity of the animal, and thus the magnitude is considered **Medium**.

154. **SBP and URHS:** For seals and minke whales, 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 project it is difficult to determine whether that will be the case. As such, if these equipment operate 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 the sparker SBPs have shown slightly greater propagation from sources generating low frequencies (<10 kHz), whilst some of the highest frequency sources (>50 kHz) 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 220 dB re 1 µPa (SPL_{peak}) (Shell, 2017), and ~10 m for seals (Department for Business Energy and Industrial Strategy, 2019). While the likelihood of an animal experiencing PTS-onset from SBP and URHS is very low, PTS is a permanent effect on the hearing sensitivity of the animal, and thus the magnitude is considered **Medium**.

Receptor sensitivity

155. **USBL:** The source levels of USBL equipment are below the PTS-onset thresholds for minke whale, dolphins and seals. Therefore, it is concluded that there would be no risk of PTS onset to any of these species from the use of USBL equipment and their sensitivity is assessed as **Very Low**.

156. **USBL:** Although the upper limit of the estimated sound pressure level from USBL exceeds the PTS-onset thresholds for harbour porpoise, harbour porpoise hearing is most sensitive at high frequencies between approximately 100 kHz and 140 kHz (Kastelein et al., 2002, Southall et al., 2007), with maximum sensitivity occurring at 125 kHz across multiple tested individuals (Kastelein et al., 2017a). As such, the frequency at which USBL operates is below those to which harbour porpoise are most

sensitive to auditory impacts. Harbour porpoise sensitivity to USBL is therefore assessed as **Very Low.**

157. **MBES and SSS:** While the indicative source levels for MBES and SSS exceed the unweighted injury threshold for harbour porpoise and seals, peak energy is far above that of greatest hearing sensitivity and the frequency of the source is sufficiently high that sound pressure levels would be rapidly attenuated to below thresholds for PTS-onset for harbour porpoise within a few meters of the source. As such, the sensitivity of all marine mammals to PTS-onset from use of MBES and SSS equipment is assessed as **Very Low**.

158. **SBI:** The source levels of SBI equipment are below the PTS-onset thresholds for minke whale, dolphins and seals. Therefore, it is concluded that there would be no risk of PTS onset to any of these species from the use of SBI equipment and the sensitivity their sensitivity is assessed as **Very Low**.

159. **SBP, URHS:** While the indicative source levels for SBP and URHS exceed the unweighted injury threshold for harbour porpoise and seals, harbour porpoise and seal hearing sensitivity is greatest between 12–140 kHz (porpoise peak sensitivity: 105 kHz) and 1.9–30 kHz (seal peak sensitivity: 13 kHz) respectively. As the operational frequencies of SBP (2–15 kHz (peak: 3.5kHz)) and URHS (100 Hz–5 kHz) will typically operate below that at which harbour porpoise and seals are most sensitivity to auditory impact, the sensitivity of porpoise and seals to PTS-onset from use of SBP and URHS equipment is assessed as **Low**.

160. The source levels of SBP and URHS equipment are below the PTS-onset thresholds for dolphins. Therefore, it is concluded that there would be no risk of PTS onset to any of these species from the use of SBP and URHS equipment and their sensitivity is assessed as **Very Low**.

161. The source levels of SBP and URHS equipment exceed the PTS-onset thresholds for minke whale, and their operable frequencies overlap with minke whale hearing ranges (200 Hz–19 kHz). As there is no indication of the peak hearing sensitivity of minke whales, it would be conservative to assume that minke whales are sensitive to the use of this equipment. As such, their sensitivity is assessed as **Low.**

Significance of the effect

Prior to application of primary mitigation measures

162. As the sensitivity of all marine mammals to PTS onset from USBL, MBES and SSS equipment has been assessed as **Very Low**, and the magnitude of impact has been assessed as **Negligible**, the significance of the effect is assessed as **Negligible (Not significant).**

163. As the sensitivity of all marine mammals to PTS onset from SBI equipment has been assessed as **Very Low**, and the magnitude of impact has been assessed as **Negligible**, the significance of the effect is assessed as **Negligible (Not significant).**

164. As the sensitivity of dolphin species have been assessed as **Very Low**, and the magnitude of impact from the use of SBP and URHS equipment has been assessed as **Negligible.** As such, the significance of the effect is assessed as **Negligible (Not significant)** for all dolphin species**.**

165. For harbour porpoise, seals and minke whale, the sensitivity has been assessed as **Low**, and the magnitude of impact from the use of SBP and URHS equipment has been assessed as **Medium**. As such, the significance of the effect is assessed as **Minor (Not significant)** for these species.

166. Primary mitigation of geophysical survey equipment sources (SBP and URHS) with a greater than negligible magnitude of impact will be covered by 'Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters' (DAHG, 2014), which outlines measures to reduce the potential impacts to negligible levels. This includes the need for:

- A qualified and experienced marine mammal observer (MMO) to be appointed to monitor for marine mammals and to log all relevant events using standardised data forms; and
- A mitigation zone of 500 m radial distance from the sound source intended for use, i.e., within the Monitored Zone[11].

167. Following the primary mitigation (implementation of DAHG (2014) guidance through the geophysical survey **MMMP** (section 7 of the **MMMP**)), the residual impact of auditory injury from pre-construction surveys will be **Negligible (Not significant).**

Additional mitigation

168. None required. It is expected that the use of an MMO and a 500 m mitigation / monitored zone as advised in the DAHG (2014) guidance and presented in the geophysical survey **MMMP** (section 7 of the **MMMP**) will reduce the risk of auditory injury to negligible levels.

Residual effect

169. Following the primary mitigation (implementation of DAHG (2014) guidance through the geophysical survey **MMMP** (section 7 of the **MMMP**)), the significance of the residual effect of auditory injury from pre-construction surveys will be **Negligible (Not significant).**

Impact 2: Disturbance from pre-construction surveys

Magnitude of impact

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

171. **USBL, SBP, URHS and SBI:** There are currently no empirical data available on the behavioural responses of marine mammals to any of these sources. Therefore, a disturbance range and number of animals potentially disturbed cannot be quantified here. However, the noise emitted from these sources will be rapidly attenuated with distance from source such that noise levels at which behavioural disturbance would be anticipated to occur will be of small spatial extent. In particular, it is noted that those sources with higher source levels (SBP, URHS), along with the SBI, are highly directional, with noise levels outside of the main beam considerably lower and therefore with limited horizontal propagation of noise levels. While the range and number of animals potentially disturbed is not quantified here, it is expected that any disturbance impact range will be very small, highly localised and highly directional. Therefore, the number of animals expected to experience disturbance will be low, representing temporary behavioural effects in a small proportion of the population that is very unlikely to result in changes to the population trajectory. The magnitude of impact is assessed as **Low**.

[11] Unless information specific to the location and/or plan/project is otherwise available to inform the mitigation process (e.g., specific sound propagation and/or attenuation data) and a distance modification has been agreed with the Regulatory Authority.

Receptor sensitivity

172. **MBES or SSS**: As indicated in **Table 11-20** there is no potential for disturbance effects to occur through use of MBES or SSS, as the sound levels emitted are above 200 kHz 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 **Very Low**.

173. **USBL, SBP, URHS and SBI:** As indicated in **Table 11-20**, the expected sound frequency for the USBL, SBP, URHS and SBI falls within the function hearing range for all relevant marine mammal species and, therefore, has the potential to result in disturbance effects. 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 1 µPa at 1 m) than USBL, SBP, URHS and SBI (see **Table 11-20**)) does not lead to long-term displacement of harbour porpoises. Therefore, the magnitude of impact is assessed as **Low** for all marine mammals, as disturbance will only cause short-term and / or intermittent and temporary behavioural effects in a limited spatial extent around the source, and therefore only affect a small proportion of the population.

174. Considering the characteristics of the noise emitted, the risk of disturbance from USBL is considered to be less than that of sub-bottom profilers (SBPs). 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. However, it is unlikely that this would be considered as disturbance in the terms of the Regulations.'* Similar responses also be expected for the use of URHS and SBI. When considering the nature of the USBL source alone, 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). For example, support and supply vessels of 50–100 m length (which encompasses the indicative survey vessels of 70–80 m length) 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). When using thrusters for dynamic positioning (DP) to hold station during sampling activities, increased sound generation in the order of *c*. 10 dB over levels when in transit may be expected (Rutenko and Ushchipovskii, 2015). Therefore, the noise generated by the survey vessel while holding station on DP is likely to be approaching a similar amplitude to that of the USBL system, albeit with dominant energy at lower frequencies. The sensitivity of marine mammals to disturbance for USBL, SBP, URHS and SBI equipment is therefore assessed as **Low**.

Significance of the effect

Prior to application of primary mitigation measures

175. As the sensitivity of all marine mammals to disturbance from MBES and SSS equipment has been assessed as **Very Low**, and the magnitude of impact has been assessed as **Negligible**, the significance of the effect is assessed as **Negligible (Not significant).**

176. As the sensitivity of all marine mammals to disturbance from USBL, SBP, URHS and SBI equipment has been assessed as **Low**, and the magnitude of impact has been assessed as **Low**, the significance of the effect is assessed as **Minor (Not significant).**

Primary mitigation

177. To mitigate the risks of disturbance, and to keep impacts of disturbance to marine mammals from geophysical surveys not significant, the measures outlined in the 'Guidance to Manage the Risk to

Marine Mammals from Man-made Sound Sources in Irish Waters' will be followed (Department of Arts Heritage and the Gaeltacht, 2014). This includes the need for:

- A qualified and experienced marine mammal observer (MMO) to be appointed to monitor for marine mammals and to log all relevant events using standardised data forms; and,
- A mitigation zone of 500 m radial distance from the sound source intended for use, i.e., within the Monitored Zone.

Additional mitigation

178. None required as the impact is not significant.

Residual effect

179. The significance of the residual effect of disturbance from pre-construction surveys remains as **Negligible** to **Minor (Not significant).**

Impact 3: Auditory injury (PTS) from UXO clearance

180. If UXO are identified across the array site or OECC, a risk assessment will be undertaken and items of UXO will be either avoided by equipment micro-siting, moved, or detonated in situ. Recent advancements in the commercial availability of methods for UXO clearance mean that high-order detonation may be largely or completely avoided. The methods of UXO clearance considered for CWP Project may include:

- Removal / relocation;
- Low-order detonation (deflagration); and
- High-order detonation.

181. It is not possible to determine how many items of UXO will require clearance. In order to define the design envelope for consideration of UXO within the EIA, a review of recent information has been undertaken. Current advice from the UK Statutory Nature Conservation Bodies is that the Southall et al. (2019) criteria should be used for assessing the impacts from UXO detonation on marine mammals, and this advice has been followed for this assessment. However, it is noted that the suitability of these criteria for UXO 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.

182. Regardless, the maximum charge weight for the potential UXO devices that could be present within the site boundary has been estimated as 525 kg (TNT equivalent). The potential auditory injury (PTS) impact ranges have been modelled for the high-order clearance of a 525 kg UXO alongside a range of smaller devices, at charge weights of 25, 55, 120 and 240. In each case, an additional donor weight of 0.5 kg has been included to initiate detonation. Additionally, a low-order clearance scenario has been modelled, assuming a donor charge of 0.25 kg.

183. The unweighted UXO clearance source levels are presented in **Table 11-21**.

Table 11-21 Summary of the unweighted SPL_{peak} and SEL_{ss} source levels used for UXO clearance modelling

Charge weight (TNT equivalent)	Unweighted SPLpeak source level	Unweighted SELss source level
Low order (0.25 kg)	269.8 dB re 1 μPa @ 1 m	215.2 dB re 1 μPa^2s @ 1 m
25 kg + donor	284.9 dB re 1 μPa @ 1 m	228.0 dB re 1 μPa^2s @ 1 m
55 kg + donor	287.5 dB re 1 μPa @ 1 m	230.1 dB re 1 μPa^2s @ 1 m
120 kg + donor	290.0 dB re 1 μPa @ 1 m	232.2 dB re 1 μPa^2s @ 1 m
240 kg + donor	292.3 dB re 1 μPa @ 1 m	234.2 dB re 1 μPa^2s @ 1 m
525 kg + donor	294.8 dB re 1 μPa @ 1 m	236.4 dB re 1 μPa^2s @ 1 m

Magnitude of impact

184. UXO detonation is defined as a single pulse and thus both the weighted SEL criteria and the unweighted SPL_{peak} criteria from Southall et al*.* (2019) have been given in **Table 11-22**. As a result, animal fleeing assumptions do not apply to the values presented.

Table 11-22 Summary of the auditory injury (PTS-onset) impact ranges for UXO detonation using the impulsive, weighted SEL_{ss} and unweighted SPL_{peak} noise criteria from Southall et al*.*, (2019) for marine mammals

Southall et al. **(2019)**	**PTS (weighted SEL_{ss})**				**PTS (unweighted SPL_{peak})**			
	LF 183 dB	**HF 185 dB**	**VHF 155 dB**	**PCW 185 dB**	**LF 219 dB**	**HF 230 dB**	**VHF 202 dB**	**PCW 218 dB**
Low order (0.25 kg)	230 m	<50 m	80 m	40 m	170 m	60 m	990 m	190 m
25 kg + donor	2.2 km	<50 m	570 m	390 m	820 m	260 m	4.6 km	910 m
55 kg + donor	3.2 km	<50 m	740 m	570 m	1.0 km	340 m	6.0 km	1.1 km
120 kg + donor	4.7 km	<50 m	950 m	830 m	1.3 km	450 m	7.8 km	1.5 km
240 kg + donor	6.5 km	<50 m	1.1 km	1.1 km	1.7 km	560 m	9.8 km	1.9 km
525 kg + donor	9.5 km	50 m	1.4 km	1.6 km	2.2 km	730 m	12 km	2.5 km

185. Estimated auditory injury (PTS-onset) impact ranges increases with the size of the charge for all marine mammal groups. With the exception of LF cetaceans, PTS-onset impact ranges are larger for the unweighted SPL_{peak} criterion than the weighted SEL criterion. At all charge weights, HF cetaceans have the smallest predicted impact range of up to 730 m (SPL_{peak}). Seal species (PCW) and LF cetaceans are predicted to have maximum PTS-onset impact ranges of 2.5 km and 2.2 km (SPL_{peak}) respectively. VHF cetaceans (harbour porpoise) have the largest PTS-onset impact ranges for each charge, with a maximum of 12 km (SPL_{peak}) for a 525 kg charge plus donor. For LF cetaceans (minke whale and humpback whale), the low-frequency sensitivity of their hearing results in larger impact ranges using the weighted SEL PTS-onset criteria, with a maximum range of 9.5 km for the largest charge weight.

186. The number of marine mammal individuals expected to experience PTS, based on the detonation of UXO at each charge weight are presented in **Table 11-23**.

Table 11-23 Estimated number of marine mammals (and proportion of MU) potentially at risk of PTS from UXO clearance

Species	Harbour porpoise		Bottlenose dolphin	Common dolphin		Risso's dolphin		Minke whale		Grey seal	Harbour seal
Density (#/km^2)	0.1225 CWP surveys	0.2803 SCANS IV	0.2352 SCANS IV	0.2810 CWP surveys	0.0272 SCANS IV	0.0008 CWP surveys	0.0022 SCANS IV	0.0019 CWP surveys	0.0137 SCANS IV	0.1563	0.0075
Weighted SEL											
Low order (0.25 kg)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
25 kg + donor	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
55 kg + donor	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
120 kg + donor	0 (0.00%)	1 (<0.01%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (<0.01%)	0 (0.00%)	0 (0.00%)
240 kg + donor	0 (0.00%)	1 (<0.01%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (0.01%)	1 (0.01%)	0 (0.00%)
525 kg + donor	1 (<0.01%)	1 (<0.01%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (<0.01%)	4 (0.02%)	1 (0.01%)	0 (0.00%)
Unweighted SPL_{peak}											
Low order (0.25 kg)	0 (0.00%)	1 (<0.1%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
25 kg + donor	7 (0.01%)	19 (0.03%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)

Species	Harbour porpoise		Bottlenose dolphin	Common dolphin		Risso's dolphin		Minke whale		Grey seal	Harbour seal
Density (#/km^2)	0.1225 CWP surveys	0.2803 SCANS IV	0.2352 SCANS IV	0.2810 CWP surveys	0.0272 SCANS IV	0.0008 CWP surveys	0.0022 SCANS IV	0.0019 CWP surveys	0.0137 SCANS IV	0.1563	0.0075
55 kg + donor	13 (0.02%)	32 (0.05%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.01%)	0 (0.00%)
120 kg + donor	22 (0.03%)	54 (0.09%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.01%)	0 (0.00%)
240 kg + donor	34 (0.05%)	85 (0.14%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (0.03%)	0 (0.00%)
525 kg + donor	51 (0.08%)	127 (0.20%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (0.05%)	0 (0.00%)

187. Across all marine mammal species, only bottlenose dolphins, common dolphins and Risso's dolphins are predicted to have ≤1 individual to experience auditory injury (PTS-onset) from UXO clearance activities under both SPL_{peak} and SEL scenarios (**Table 11-23**). For harbour porpoise, up to 127 individuals (SPL_{peak}, using SCANS IV Block CS-D uniform density estimate) are predicted to experience auditory injury (PTS-onset) from UXO clearance at the greatest charge weight, which is 0.20% of the Celtic and Irish Sea MU. For minke whale, up to five individuals (SEL, using the SCANS III Block E density estimate) are predicted to experience auditory injury (PTS-onset) from UXO clearance at the largest charge weight, which is 0.02% of the Celtic and Greater North Seas MU. The largest impact for pinnipeds is for grey seals, where three seals (0.05% MU) are predicted to be subject to PTS at the largest charge weight for the unweighted SPL_{peak} noise criteria.

188. While the number of marine mammals and proportion of their respective MUs predicted to experience PTS-onset is low, PTS is a permanent effect, and thus the magnitude of unmitigated impact is **Medium.**

Receptor sensitivity

189. 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, most marine mammals (porpoise, dolphins and seals) have been assessed as having a **Low** sensitivity to auditory injury (PTS-onset) from UXO clearance.

190. Recent acoustic characterisation of UXO clearance noise has shown that there is more energy at lower frequencies (<100 Hz) then 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 (and other low frequency cetaceans such as humpback whale) as having a **Medium** sensitivity to auditory injury (PTS-onset) from UXO clearance.

Significance of the effect

Prior to application of primary mitigation measures

191. As the sensitivity of porpoise, dolphins and seals has been assessed as **Low,** and the magnitude of impact has been assessed as **Medium,** the significance of effect of PTS from UXO detonation is assessed as **Minor (Not significant)**.

192. As the sensitivity of low frequency cetaceans (minke whale) has been assessed as **Medium,** and the magnitude of impact has been assessed as **Medium,** the significance of effect of PTS from UXO detonation is assessed as **Moderate (Significant)**.

Primary mitigation

193. The CWP Project is committed to implementing a UXO **MMMP** (section 10 of the **MMMP**). The primary mitigation methods include: pre-detonation MMO watches and pre-detonation PAM (if required to supplement the MMO) during poor visibility or darkness. Additional mitigation includes the potential for pre-detonation ADDs, the implementation of a soft-start approach and / or the sequencing of detonations, consideration of removal / relocation, and deflagration rather than high-order detonation

and the potential use of at-source noise abatement methods in the event that deflagration fails. The mitigation applied will reduce potential impacts to negligible levels.

Additional mitigation

194. None required as the impact is not significant.

Residual effect

195. The UXO **MMMP** (section 10 of the **MMMP**) will reduce the risk of auditory injury (PTS) to a negligible magnitude. Therefore, the significance of the residual effect of auditory injury from UXO clearance is assessed as **Negligible (Not significant).**

Impact 4: Disturbance from UXO clearance

Magnitude of impact

196. This assessment of disturbance impacts to marine mammals from UXO clearance presents results for each of the following behavioural disturbance thresholds:

- 26 km effective deterrence range (EDR) for high-order detonation;
- 5 km EDR for low-order detonation; and
- TTS-onset thresholds for both high- and low-order detonation.

26 km EDR

197. There is no guidance available from NPWS on the methodology that should be used to assess disturbance from high order detonation UXO clearance. It is advised by some UK SNCBs that an effective deterrence range of 26 km around the source location is used to determine the impact area from UXO clearance with respect to disturbance of harbour porpoise in SACs (JNCC, 2020). In the absence of agreed metrics and Irish guidance, the 26 km EDR has been used here for illustrative purposes and should be viewed with caution as there is no empirical evidence to support this impact range for any species of marine mammal. It is also important to note that high order detonation will only be used by the CWP Project where avoidance or low order detonation (deflagration) is not feasible; the CWP Project will preferentially clear UXO through deflagration.

198. The resulting number of animals, proportion of the reference population and impact magnitude is detailed in **Table 11-24**.

Table 11-24 Estimated number of marine mammals potentially at risk of disturbance during high-order UXO clearance (26 km EDR; assuming an impact area of 2,124 km^2)

Species	Density (#/km^2)	# Impacted	% MU	Magnitude
Harbour porpoise	0.1225 CWP surveys	260	0.42%	Low
	0.2803 SCANS IV	595	0.95%	Low
Bottlenose dolphin	0.2352 SCANS IV	499	7.22%[12]	Medium
Common dolphin	0.2810 CWP surveys	597	0.31%	Low
	0.0272 SCANS IV	58	0.06%	Low
Risso's dolphin	0.0008 CWP surveys	2	0.01%	Low
	0.0022 SCANS IV	5	0.04%	Low
Minke whale	0.0019 CWP surveys	4	0.02%	Low
	0.0137 SCANS IV	29	0.14%	Low
Grey seal	0.1536	326	5.39%	Medium
Harbour seal	0.0075	16	1.16%	Low

199. The 26 km EDR for UXO clearance is based on the high-order detonation of UXOs. However, there is no empirical evidence of marine mammal avoidance from such events. It is expected that the detonation of a UXO would elicit a startle response and potentially very short duration behavioural responses and would therefore not be expected to cause widespread and prolonged displacement (JNCC, 2020). The consequence of the impact is therefore short-term, intermittent over the course of a UXO clearance campaign and with temporary behavioural effects that are very unlikely to alter survival and reproductive rates to the extent that the population trajectory would be altered.

200. The greatest estimated disturbance in terms of percentage MU is to bottlenose dolphins, where up to 499 bottlenose dolphins (7.22% MU) are predicted to be disturbed (**Table 11-24**). For grey seals, up to 326 individuals are expected to be disturbed using a 26 km EDR approach (5.39% MU). For harbour porpoise, up to 595 (0.95% MU) are predicted to be disturbed, and for harbour seals, up to 16 (1.16% MU) are predicted to be disturbed. For the remaining marine mammal species less than 0.5% of the MU are predicted to be impacted. For bottlenose dolphins and grey seals, disturbance impacts associated with high-order UXO clearance assuming a 26 km EDR are assessed as **Medium** magnitude, and for all other marine mammal species the impacts are assessed as **Low** magnitude.

[12] Assuming MU is 8,236 dolphins.

5 km EDR

201. It is important to note that high-order detonation represents the very worst-case scenario for UXO clearance, and it is highly likely that low-order clearance methods (deflagration) will be used instead.

202. Although the 5 km EDR has been used here for illustrative purposes for impacts of low-order deflagration, they should be viewed with caution as there is no empirical evidence to support this impact range for any species of marine mammal.

203. The resulting number of animals, proportion of the reference population and impact magnitude is detailed in **Table 11-25**.

Table 11-25 Estimated number of marine mammals potentially at risk of disturbance during high-order UXO clearance (5 km EDR; assuming an impact area of 78.5 km^2)

Species	Density (#/km^2)	# Impacted	% MU	Magnitude
Harbour porpoise	0.1225 CWP surveys	10	0.02%	Low
	0.2803 SCANS IV	22	0.04%	Low
Bottlenose dolphin	0.2352 SCANS IV	18	0.22%[13]	Low
Common dolphin	0.2810 CWP surveys	22	0.02%	Low
	0.0272 SCANS IV	2	0.00%	Very Low
Risso's dolphin	0.0008 CWP surveys	<1	0.00%	Very Low
	0.0272 SCANS IV	2	0.01%	Low
Minke whale	0.0019 CWP surveys	<1	0.00%	Very Low
	0.0137 SCANS IV	1	0.00%	Very Low
Grey seal	0.1536	12	0.20%	Low
Harbour seal	0.0004	1	0.04%	Very Low

204. The greatest estimated disturbance occurs for bottlenose dolphins and grey seals, where 18 dolphins (0.22% MU) and 12 grey seals (0.20% MU) are predicted to be disturbed. For all other marine mammal species. less than 0.1% of the MU are predicted to be impacted. It is expected that the detonation of a UXO would elicit a startle response and potentially very short duration behavioural responses and would therefore not be expected to cause widespread and prolonged displacement (JNCC, 2020). The consequence of the impact is short-term, intermittent over the course of a UXO clearance campaign, with temporary behavioural effects that are very unlikely to alter survival and reproductive rates to the

[13] Assuming MU is 8,236 dolphins.

extent that the population trajectory would be altered. Therefore, disturbance impacts associated with low-order UXO clearance on all marine mammals are assessed as **Negligible** to **Low** magnitude.

TTS as a proxy for disturbance

205. **Table 11-26** presents the TTS as a proxy for disturbance impact ranges for UXO detonation considering various charge weights and impact criteria. Full details of the underwater noise modelling and the resulting TTS-onset impact areas and ranges are detailed in **Appendix 9.4 UWN Assessment**.

Table 11-26 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)

Southall et al. **(2019)**	**TTS (weighted SEL)**				**TTS (unweighted SPL_{peak})**			
	LF 183 dB	**HF 185 dB**	**VHF 155 dB**	**PCW 185 dB**	**LF 219 dB**	**HF 230 dB**	**VHF 202 dB**	**PCW 218 dB**
Low order (0.25 kg)	3.2 km	<50 m	750 m	570 m	320 m	100 m	1.8 km	360 m
25 kg + donor	29 km	150 m	2.4 km	5.2 km	1.5 km	490 m	8.5 km	1.6 km
55 kg + donor	41 km	210 m	2.8 km	7.5 km	1.9 km	640 m	11 km	2.1 km
120 kg + donor	57 km	300 m	3.2 km	10 km	2.5 km	830 m	14 km	2.8 km
240 kg + donor	76 km	390 m	3.5 km	14 km	3.2 km	1.0 km	18 km	3.5 km
525 kg + donor	100 km	530 m	4.0 km	19 km	4.1 km	1.3 km	23 km	4.6 km

206. Estimated TTS impact ranges increased with the size of the charge for all marine mammal groups (**Table 11-26**). At all charge weight, HF cetaceans (dolphins) have the smallest predicted impact range of <50 m to 530 m for weighted SEL noise criteria and 100 m to 1.3 km for unweighted SPL_{peak} noise criteria. Impact ranges for VHF cetaceans (harbour porpoise) were 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 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 noise criteria, with TTS-onset predicted at 3.2 km to 100 km (smallest to largest charge).

207. The number of marine mammal individuals expected to experience TTS, based on the detonation of UXO at each charge weight are presented in **Table 11-27**.

Table 11-27 Estimated number of marine mammals (and proportion of MU) potentially at risk of disturbance (using TTS as a proxy) from UXO clearance

Species	Harbour porpoise		Bottlenose dolphin	Common dolphin		Risso's dolphin		Minke whale		Grey seal	Harbour seal
Density (#/km²)	0.1225 CWP surveys	0.2803 SCANS IV	0.2352 SCANS IV	0.2810 CWP surveys	0.0272 SCANS IV	0.0008 CWP surveys	0.0022 SCANS IV	0.0019 CWP surveys	0.0137 SCANS IV	0.1563	0.0075
Weighted SEL											
Low order (0.25 kg)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
25 kg + donor	2 (<0.01%)	5 (0.01%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	5 (0.02%)	36 (0.18%)	13 (0.22%)	1 (0.05%)
55 kg + donor	3 (<0.01%)	7 (0.01%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	10 (0.05%)	72 (0.36%)	27 (0.45%)	1 (0.05%)
120 kg + donor	4 (0.01%)	9 (0.01%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	19 (0.10%)	140 (0.70%)	48 (0.80%)	2 (0.17%)
240 kg + donor	4 (0.01%)	11 (0.02%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	34 (0.17%)	249 (1.24%)	95 (1.56%)	5 (0.34%)
525 kg + donor	6 (0.01%)	14 (0.02%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	60 (0.30%)	430 (2.14%)	174 (2.88%)	5 (0.34%)

Species	Harbour porpoise		Bottlenose dolphin	Common dolphin		Risso's dolphin		Minke whale		Grey seal	Harbour seal
Density (#/km^2)	0.1225 CWP surveys	0.2803 SCANS IV	0.2352 SCANS IV	0.2810 CWP surveys	0.0272 SCANS IV	0.0008 CWP surveys	0.0022 SCANS IV	0.0019 CWP surveys	0.0137 SCANS IV	0.1563	0.0075
Unweighted SPL$_{peak}$											
Low order (0.25 kg)	1 (<0.01%)	3 (<0.01%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
25 kg + donor	26 (0.04%)	64 (0.10%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.02%)	0 (0.00%)
55 kg + donor	43 (0.07%)	107 (0.17%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (0.04%)	0 (0.00%)
120 kg + donor	69 (0.11%)	173 (0.28%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	4 (0.06%)	0 (0.00%)
240 kg + donor	115 (0.18%)	285 (0.46%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	6 (0.10%)	0 (0.00%)
525 kg + donor	187 (0.30%)	466 (0.75%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (<0.01%)	10 (0.17%)	0 (0.00%)

208. For bottlenose dolphin, common dolphin and Risso's dolphin, less than 0.01% of the MU are predicted to be subject to TTS across all charge weight under both SEL and SPL_{peak} noise criteria (**Table 11-27**). For harbour porpoise, the greatest TTS impact is at the highest charge weight for unweighted noise criteria (SPL_{peak}), where 466 individuals are anticipated to be subject to TTS using the SCANS IV density estimate, which is 0.75% of the MU. For minke whales 534 individuals (2.66% MU) are predicted to be subject to TTS at the largest charge weight for weighted SEL noise criteria when using the SCANS III density estimate. The largest impact for pinnipeds is for grey seals, where 174 seals (2.88% MU) are predicted to be subject to TTS respectively at the largest charge weight, again, for weighted SEL noise criteria.

209. 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.

210. In the case of minke whale, sound is unlikely to propagate as far as the theoretical predicted ranges for the highest charge weight (**Table 11-26**), and therefore the number of individuals predicted to be impacted (and proportion of MU) presented in **Table 11-27** is likely to be significantly less.

211. It is expected that the detonation of a UXO would elicit a startle response and potentially very short duration behavioural responses and would therefore not be expected to cause widespread and prolonged displacement (JNCC, 2020). Given the percentage of the MUs predicted to be impacted across all marine mammals, and the fact the consequence of the impact is likely to be short-term, intermittent during a UXO clearance campaign, and with temporary behavioural effects that are very unlikely to alter survival and reproductive rates to the extent that the population trajectory would be altered, disturbance effects associated with UXO clearance using TTS-onset as a proxy on all marine mammals are assessed as **Low** magnitude.

Receptor sensitivity

212. 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...'. Whilst detonations will usually be undertaken as part of a campaign and, therefore, there may result in multiple detonations over several days (JNCC, 2020), each detonation will be of a short-term duration. Therefore, 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 assessed.

Significance of the effect

26 km EDR

213. The sensitivity of all marine mammals to disturbance from UXO detonation has been assessed as **Low**. As the magnitude of impact has been assessed as **Medium** for bottlenose dolphins and grey seals, the significance of the impact of disturbance from UXO detonation is assessed as **Minor (Not significant**). As the magnitude of impact has been assessed as **Low** for all other marine mammals, the significance of the effect of disturbance from UXO detonation is assessed as **Minor (Not significant).**

5 km EDR

214. As the sensitivity of all marine mammals to disturbance from UXO detonation has been assessed as **Low**, and the magnitude of impact has been assessed as **Negligible** to **Low,** the significance of the effect of disturbance from UXO detonation is assessed as **Negligible** to **Minor (Not significant).**

TTS as a proxy

215. As the sensitivity of all marine mammals to disturbance from UXO detonation has been assessed as **Low**, and the magnitude of impact has been assessed as **Low,** the significance of the effect of disturbance from UXO detonation is assessed as **Minor (Not significant).**

Primary mitigation

216. The CWP Project is committed to implementing a UXO **MMMP** (section 10 of the **MMMP**). While this is primarily to reduce the risk of auditory injury (PTS) to negligible levels, the UXO **MMMP** will also provide some reduction in disturbance impacts.

Additional mitigation

217. None required as the impact is not significant.

Residual effect

218. The significance of the residual effect of disturbance from UXO clearance is assessed as **Negligible to Minor (Not significant).**

Impact 5: Auditory injury (PTS) from piling – WTGs and OSSs

Harbour porpoise

Magnitude of impact

219. For instantaneous PTS from 1 pile strike at full hammer energy, the maximum PTS-onset range is 620 m at the SE location, impacting <1 harbour porpoise at all locations (**Table 11-28**).

220. The cumulative PTS impact ranges vary significantly by piling location, due to the differences in water depths at each location (**Table 11-29**). The SE location results in higher impact ranges compared to the other three locations as it is located in the deepest water and is adjacent to the deep waters to the east of the CWP Project array site where noise will propagate further.

221. For Scenario 1 (most restrictive, SE), the maximum cumulative PTS-onset range is 4.7 km, which is predicted to impact up to 11 harbour porpoise using the Evans and Waggitt (2023) maximum density surface (0.02% MU).

222. For Scenario 2 (less restrictive, SW and NE), the maximum cumulative PTS-onset range is 3.2 km, which is predicted to impact up to 5 harbour porpoise using the Evans and Waggitt (2023) maximum density surface (0.01% MU).

223. For Scenario 3 (least restrictive, NW), the maximum cumulative PTS-onset range is 2.2 km, which is predicted to impact up to 1 harbour porpoise (<0.01% MU).

224. 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) (**Plate 11-6**). Therefore, the increased level of vessel presence and pre-piling activities can act as a deterrent prior to piling commencing which is not accounted for in the modelling and assumed density / spatial distribution of animals once piling commences. This means that the predicted number of animals experiencing PTS is likely to be overestimated (in addition to the levels of precaution in the modelling).

225. While the number of harbour porpoise and proportion of the MU predicted to experience PTS-onset is low, PTS is a permanent effect, and thus the magnitude of unmitigated impact is **Medium**.

Table 11-28 Harbour porpoise predicted auditory (instantaneous PTS) from WTG piling

Instantaneous PTS (SPL_{peak})		SE	SW	NE	NW
Area (km^2)		1.2	0.65	0.55	0.43
Range (m)		620	460	420	390
Site specific density (0.1225)	# animals	<1	<1	<1	<1
	% MU	<0.01	<0.01	<0.01	<0.01
SCANS III density surface (Lacey et al., 2022)	# animals	<1	<1	<1	<1
	% MU	<0.01	<0.01	<0.01	<0.01
SCANS IV (0.2803 in CS-D) (Gilles et al., 2023)	# animals	<1	<1	<1	<1
	% MU	<0.01	<0.01	<0.01	<0.01
Irish Sea density surface (Evans and Waggitt, 2023)	# animals	<1	<1	<1	<1
	% MU	<0.01	<0.01	<0.01	<0.01

Table 11-29 Harbour porpoise predicted auditory (cumulative PTS) from WTG piling

		Scenario 1	Scenario 2		Scenario 3
Cumulative PTS (SEL_{cum})		**SE**	**SW**	**NE**	**NW**
Area (km^2)		26	11	12	3.4
Range (m)		4,700	2,500	3,200	2,200
Site specific density (0.1225)	# animals	3	1	1	<1
	% MU	0.01	<0.01	<0.01	<0.01
SCANS III density surface (Lacey et al., 2022)	# animals	6	2	3	1
	% MU	0.01	<0.01	<0.01	<0.01
SCANS IV (0.2803 in CS-D) (Gilles et al., 2023)	# animals	7	3	3	1
	% MU	0.01	<0.01	<0.01	<0.01
Irish Sea density surface (Evans and Waggitt, 2023)	# animals	11	4	5	1
	% MU	0.02	0.01	0.01	<0.01

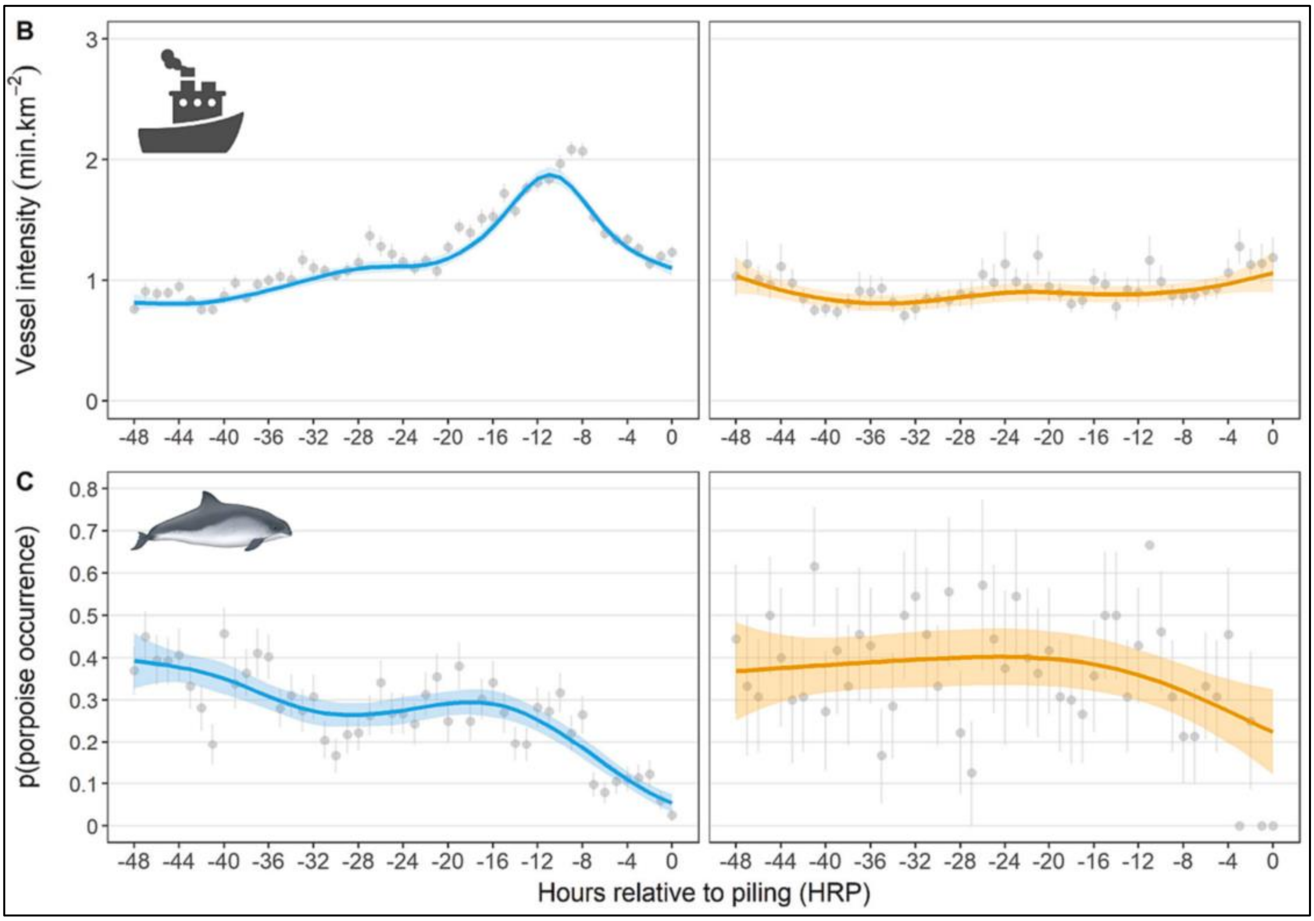


Plate 11-6 Variation in B) vessel intensity (min/km^2) and C) probability of porpoise occurrence throughout the 48 h prior to the start of pile-driving activities at a subset of piling locations at Beatrice (left) and Moray East (right) offshore windfarms. Figure taken from Benhemma-Le Gall et al*.* (2023).

Receptor sensitivity

226. 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[14] discussed the nature, extent and potential consequence of PTS to UK 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.

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

227. 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 6dB, 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.

228. For piling noise, most energy is between ~30–500 Hz, with a peak usually between 100–300 Hz 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., 2017b). 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., 2017b) 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). The expert elicitation concluded that:

> *'… the effects of a 6 dB PTS in the 2–10 kHz 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.'*

229. 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 11-30**. The data provided in **Table 11-30** 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) (**Plate 11-7**).
- 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) (**Plate 11-8**).
- 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) (**Plate 11-9**).

Table 11-30 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

	Percentiles of the elicited probability distribution								
	10%	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**
Calf / Juvenile survival	0	0	0.02	0.09	0.18	0.31	0.49	0.8	1.46

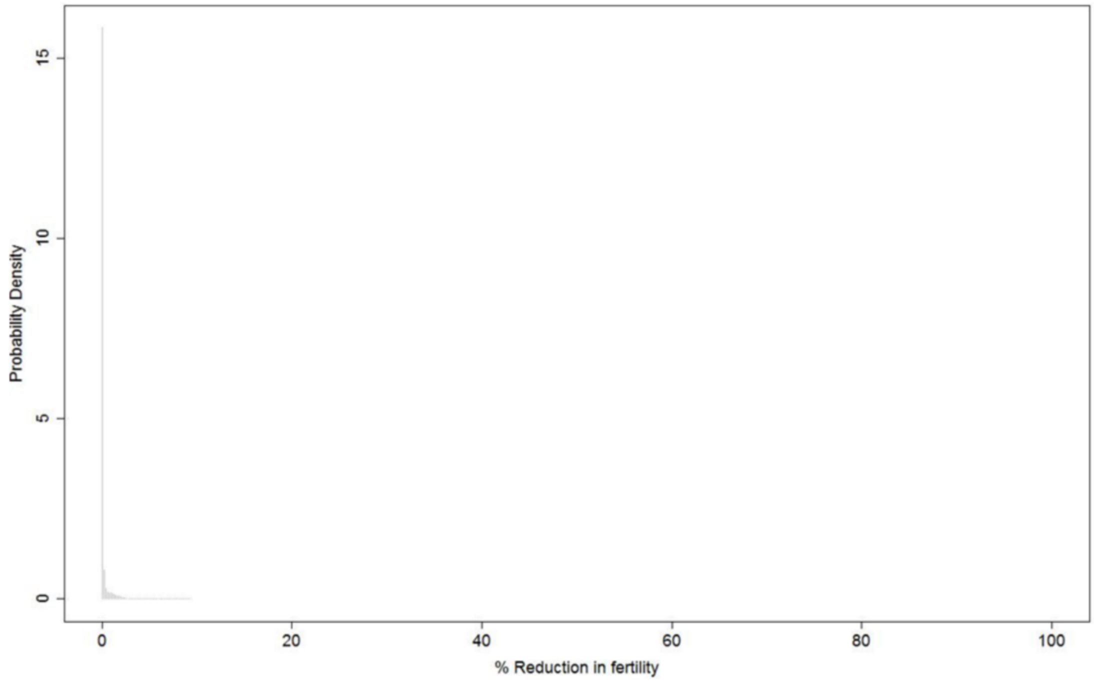


Plate 11-7 Probability distribution showing the consensus distribution for the effects on fertility of a mature female harbour porpoise as a consequence of a maximum 6 dB of PTS within a 2–10 kHz band (Booth and Heinis, 2018)

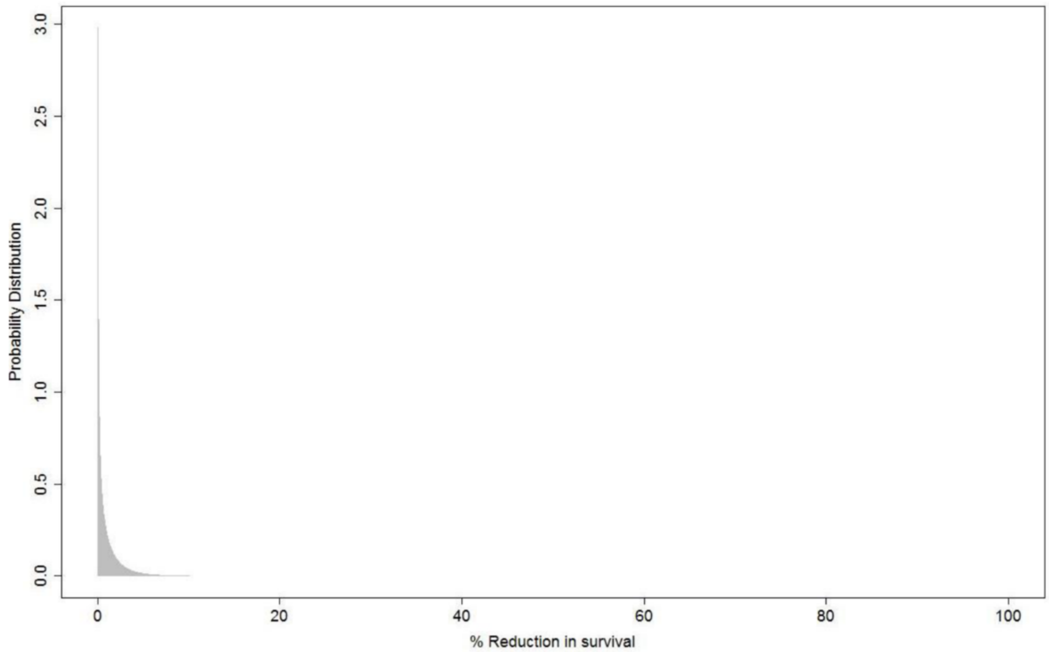


Plate 11-8 Probability distribution showing the consensus distribution for the effects on survival of a mature female harbour porpoise as a consequence of a maximum 6 dB of PTS within a 2–10 kHz band (Booth and Heinis, 2018)

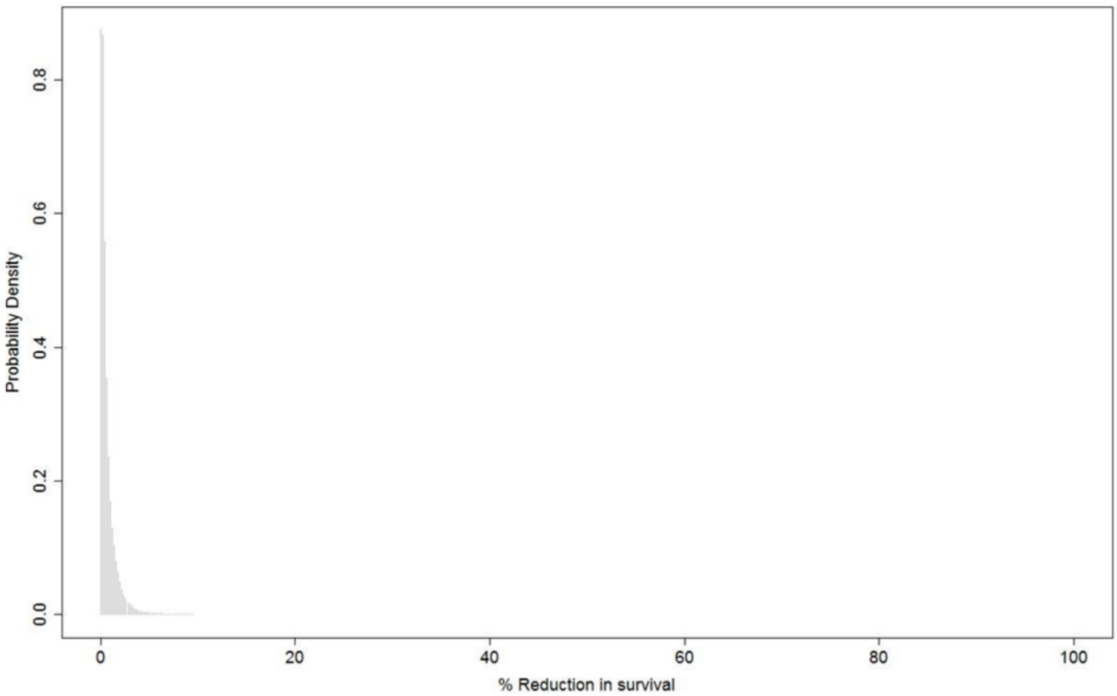


Plate 11-9 Probability distribution showing the consensus distribution for the effects on survival of juvenile or dependent calf harbour porpoise as a consequence of a maximum 6 dB of PTS within a 2–10 kHz band (Booth and Heinis, 2018)

230. Furthermore, data collected during windfarm construction have demonstrated that porpoise detections around the pile driving site decline several hours prior to the start of pile driving. 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, Graham et al., 2019, Benhemma-Le Gall et al., 2021b, Benhemma-Le Gall et al., 2023). Therefore, the presence of construction related vessels prior to the start of piling can act as a local scale deterrent for harbour porpoise and therefore reduce the risk of auditory injury. Assumptions that harbour porpoise are present in the vicinity of the pile driving at the start of the soft start are therefore likely to be overly conservative.

231. 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, harbour porpoise have been assessed as having a **Low** sensitivity to PTS.

Significance of the effect

Prior to application of primary mitigation measures

232. The sensitivity of harbour porpoise to PTS from WTG pile driving has been assessed as **Low** and the magnitude of unmitigated impact has been assessed as **Medium.** Therefore, significance of the effect is assessed as **Minor (Not significant).**

Primary mitigation

233. While the number of harbour porpoise and proportion of the MU predicted to experience PTS-onset is low, it is an offence to injure an EPS in the absence of a derogation licence. Therefore, CWP has committed to implementing a WTG/OSS piling **MMMP** (section 8 of the **MMMP**) to reduce the risk of auditory injury (PTS). This is in line with the guidance to manage the risk to marine mammals from man-made sound sources in Irish waters (NPWS, 2014). Primary mitigation measures outlined in the WTG/OSS piling **MMMP** (section 8 of the **MMMP**) include those that are considered to be 'industry standard' and are supported by the NPWS (2014) guidance:

- Pre-piling visual watch by an MMO; and
- Pre-piling PAM (if required to supplement to visual observations).

234. These measures will ensure the risk of instantaneous PTS to harbour porpoise is negligible.

Additional mitigation

235. The maximum predicted cumulative PTS impact ranges (4.7 km for porpoise) are beyond those that can be mitigated by 'industry standard' measures. As such, additional mitigation measures will be required if cumulative PTS is to be mitigated. The WTG/OSS piling **MMMP** provides an outline of the potential additional mitigation measures that could be implemented to reduce the risk of cumulative PTS to negligible levels, including:

- Use of ADDs to deter marine mammals from the immediate vicinity of the pile;
- Use of at source noise abatement methods; and
- Use of alternative piling methods.

236. The final **MMMP** with selected mitigation measures will be provided post consent once a piling contractor is in place and final detailed installation methods are known.

Residual effect

237. The WTG/OSS piling **MMMP** (section 8 of the **MMMP**) including both primary and additional mitigation measures will reduce the risk of auditory injury (PTS) to a negligible magnitude. Therefore, the residual effect of mitigated piling is assessed as **Negligible (Not significant).**

Dolphins

Magnitude of impact

238. Across all WTG piling scenarios and all four WTG locations, the predicted instantaneous PTS impact range is <50 m and the predicted cumulative PTS impact range is <100 m for all dolphin species (**Table 11-31**). The magnitude of impact is therefore **Negligible**.

Table 11-31 Dolphin species predicted auditory from WTG piling: all scenarios

	SE	SW	NE	NW
Instantaneous PTS (SPL_{peak})				
Area (km^2)	<0.01	<0.01	<0.01	<0.01
Range (m)	<50	<50	<50	<50
Cumulative PTS (SEL_{cum})				
Area (km^2)	<0.1	<0.1	<0.1	<0.1
Range (m)	<100	<100	<100	<100

Receptor sensitivity

239. As for harbour porpoise, the ecological consequences of PTS for bottlenose dolphins are uncertain. At the same expert elicitation workshop detailed above for harbour porpoise, 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). The predicted decline in bottlenose dolphin vital rates from the impact of a 6dB PTS in the 2–10kHz band for different percentiles of the elicited probability distribution are provided in **Table 11-32**. The data provided in **Table 11-33** should be interpreted as:

- 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 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 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).

240. 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 bottlenose dolphin have been assessed as having a **Low** sensitivity to PTS.

241. As they are also high frequency cetaceans, it is anticipated that the sensitivity of common and Risso's dolphins to PTS onset from piling will be the same as that of bottlenose dolphins. Therefore, common and Risso's dolphins have also been assessed as having a **Low** sensitivity to PTS.

Table 11-32 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	1.60	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	3.30	5.19	11.24
Calf survival	0	0.29	0.93	1.77	2.96	4.96	7.81	10.69	14.79

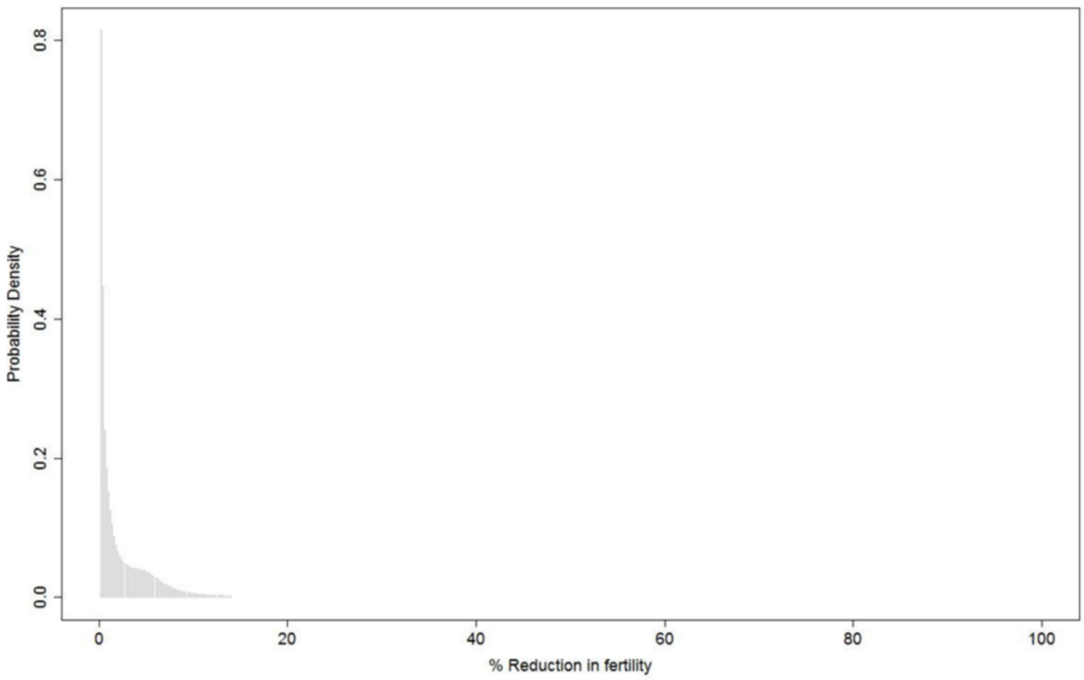


Plate 11-10 Probability distribution showing the consensus distribution for the effects on fertility of mature female bottlenose dolphin as a consequence of a maximum 6 dB of PTS within a 2–10 kHz band (Booth and Heinis, 2018)

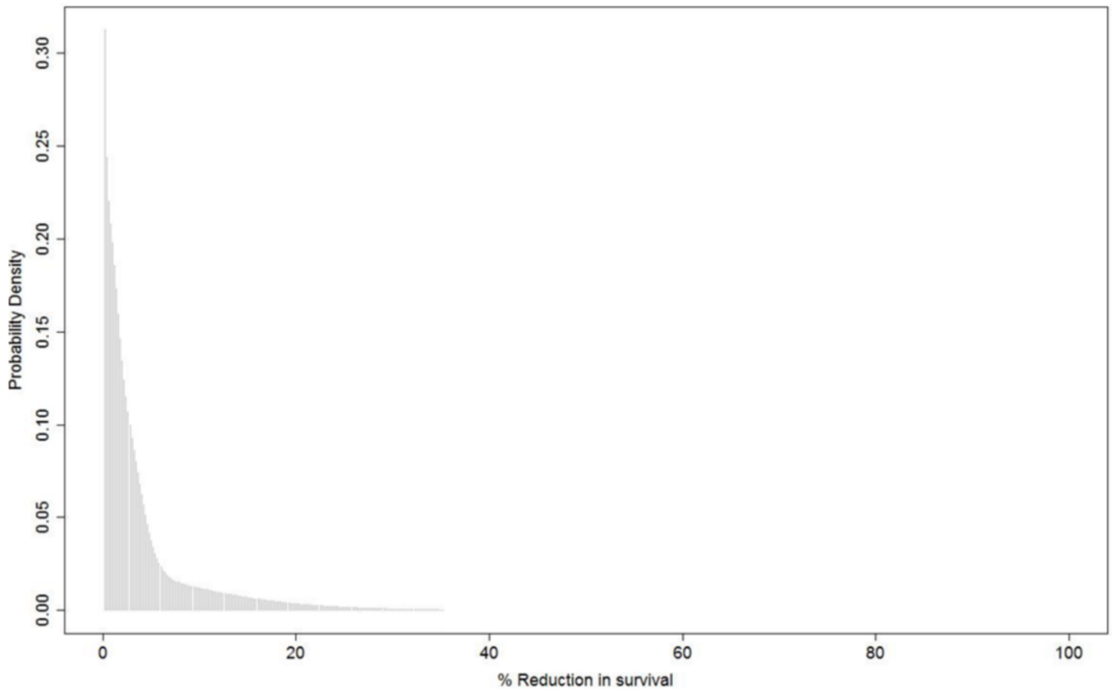


Plate 11-11 Probability distribution showing the consensus distribution for the effects on survival of mature female bottlenose dolphin as a consequence of a maximum 6 dB of PTS within a 2–10 kHz band (Booth and Heinis, 2018)

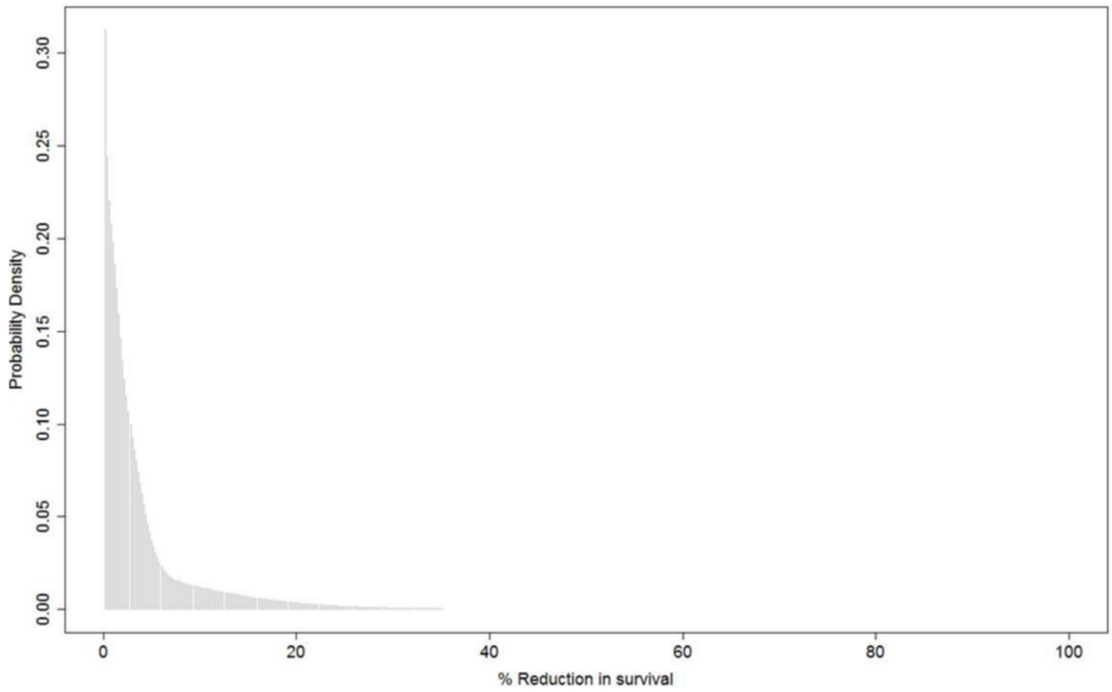


Plate 11-12 Probability distribution showing the consensus distribution for the effects on survival of juvenile or dependent calf bottlenose dolphin as a consequence of a maximum 6 dB of PTS within a 2–10 kHz band (Booth and Heinis, 2018)

Significance of the effect

242. The sensitivity of dolphins to PTS from WTG pile driving has been assessed as **Low** and the magnitude of unmitigated impact has been assessed as **Negligible.** Therefore, significance of the effect is assessed as **Negligible (Not significant).**

Primary mitigation

243. The CWP Project has committed to implementing a WTG/OSS piling **MMMP** (section 8 of the **MMMP**) to reduce the risk of auditory injury (PTS). This is in line with the guidance to manage the risk to marine mammals from man-made sound sources in Irish waters (NPWS, 2014). Primary mitigation measures outlined in the piling **MMMP** include those that are considered to be 'industry standard' and are supported by the NPWS (2014) guidance:

- Pre-piling visual watch by an MMO; and
- Pre-piling PAM (if required to supplement to visual observations).

244. These measures will further ensure the risk of PTS to bottlenose dolphins is negligible.

Additional mitigation

245. None required. The primary mitigation measures outlined in the WTG/OSS piling **MMMP** (section 8 of the **MMMP**) will ensure the risk of auditory injury (PTS) to bottlenose dolphins is negligible.

Residual effect

246. The significance of the residual effect remains **Negligible (Not significant).**

Minke whales

Magnitude of impact

247. For instantaneous PTS from 1 pile strike at full hammer energy, the PTS-onset range is at most 50 m at the SE location, impacting <1 minke whale at all locations (**Table 11-33**).

248. The cumulative PTS impact ranges vary significantly by piling location given the differences in water depths at each location (**Table 11-34**). The SE location results in significantly higher impact ranges compared to the other three locations as it is located in the deepest water and is adjacent to the deep waters to the east of the CWP Project array site where noise will propagate further.

249. For Scenario 1 (SE), the maximum cumulative PTS-onset range is 9.5 km, which is predicted to impact up to 1 minke whale using any of the three density estimates (<0.01% MU).

250. For Scenario 2 (SW and NE), the maximum cumulative PTS-onset range is 5.8 km, which is predicted to impact <1 minke whale using any of the three density estimates (<0.01% MU).

251. For Scenario 3 (NW), the maximum cumulative PTS-onset range is 2 km, which is predicted to impact <1 minke whale using any of the three density estimates (0.01% MU).

252. While the number of minke whales and proportion of the MU predicted to experience PTS-onset is low, PTS is a permanent effect, and thus the magnitude of unmitigated impact is **Medium**.

Table 11-33 Minke whale predicted auditory (instantaneous PTS) from WTG piling (all scenarios)

Instantaneous PTS (SPL_{peak})		SE	SW	NE	NW
Area (km^2)		0.01	0.01	0.01	0.01
Range (m)		<50	<50	<50	<50
SCANS III density surface (Lacey et al., 2022)	# animals	<1	<1	<1	<1
	% MU	<0.01	<0.01	<0.01	<0.01
SCANS IV (0.0137 in CS-D) (Gilles et al., 2023)	# animals	<1	<1	<1	<1
	% MU	<0.01	<0.01	<0.01	<0.01
Irish Sea density surface (Evans and Waggitt, 2023)	# animals	<1	<1	<1	<1
	% MU	<0.01	<0.01	<0.01	<0.01

Table 11-34 Minke whale predicted auditory (cumulative PTS) from WTG piling

		Scenario 1	Scenario 2		Scenario 3
Cumulative PTS (SEL_{cum})		**SE**	**SW**	**NE**	**NW**
Area (km^2)		82	8.5	26	1.1
Range (m)		9,500	3,000	5,800	2,000
SCANS III density surface (Lacey et al., 2022)	# animals	1	<1	<1	<1
	% MU	<0.01	<0.01	<0.01	<0.01
SCANS IV (0.0137 in CS-D) (Gilles et al., 2023)	# animals	1	<1	<1	<1
	% MU	<0.01	<0.01	<0.01	<0.01
Irish Sea density surface (Evans and Waggitt, 2023)	# animals	1	<1	<1	<1
	% MU	<0.01	<0.01	<0.01	<0.01

Receptor sensitivity

253. The PTS expert elicitation report (Booth and 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).

254. 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, personal communication).

255. Booth and 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 and 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'.

256. Data on minke whale hearing and potential effects of threshold shifts on vital rates are lacking. However, 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 (Booth and 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.

Significance of the effect

Prior to application of primary mitigation measures

257. The sensitivity of minke whales to PTS from WTG pile driving has been assessed as **Low** and the magnitude of unmitigated impact has been assessed as **Medium**. Therefore, significance of the effect is assessed as **Minor (Not significant)**.

Primary mitigation

258. While the number of minke whales and proportion of the MU predicted to experience PTS-onset is low, it is an offence to injure an EPS in the absence of a derogation licence. Therefore, the CWP Project has committed to implementing a WTG/OSS piling **MMMP** (section 8 of the **MMMP**) to reduce the risk of auditory injury (PTS). This is in line with the guidance to manage the risk to marine mammals from man-made sound sources in Irish waters (NPWS, 2014). Primary mitigation measures outlined in the WTG/OSS piling **MMMP** include those that are considered to be 'industry standard' and are supported by the NPWS (2014) guidance:

- Pre-piling visual watch by an MMO; and
- Pre-piling PAM (if required to supplement to visual observations).

259. These measures will ensure the risk of instantaneous PTS to minke whales is negligible.

Additional mitigation

260. The maximum predicted cumulative PTS impact ranges (15 km for minke whales) are beyond those that can be mitigated by 'industry standard' measures. As such, additional mitigation measures will be required if cumulative PTS is to be mitigated. The WTG/OSS piling **MMMP** (section 8 of the **MMMP**) provides an outline of the potential additional mitigation measures that could be implemented to reduce the risk of PTS to negligible levels, including:

- Use of ADDs to deter marine mammals from the immediate vicinity of the pile;
- Use of at source noise abatement methods; and
- Use of alternative piling methods.

261. The final **MMMP** with selected mitigation measures will be provided post consent once a piling contractor is in place and final detailed installation methods are known.

Residual effect

262. The WTG/OSS piling **MMMP** (section 8 of the **MMMP**) including both primary and additional mitigation measures will reduce the risk of auditory injury (PTS) to a negligible magnitude. Therefore, the significance of the residual effect of mitigated piling is assessed as **Negligible (Not significant).**

Seals

Magnitude of impact

263. Across all WTG piling scenarios and all four WTG locations, the predicted instantaneous PTS impact range is <50 m and the predicted cumulative PTS impact range is <100 m for both seal species (**Table 11-35**). The magnitude of impact is therefore **Negligible**.

Table 11-35 Seal species predicted auditory from WTG piling: all scenarios

	SE	SW	NE	NW
Instantaneous PTS (SPL_{peak})				
Area (km^2)	<0.01	<0.01	<0.01	<0.01
Range (m)	<50	<50	<50	<50
Cumulative PTS (SEL_{cum})				
Area (km^2)	<0.1	<0.1	<0.1	<0.1
Range (m)	<100	<100	<100	<100

Receptor sensitivity

264. As for harbour porpoise, the ecological consequences of PTS for seals are uncertain. At the same expert elicitation workshop detailed above for harbour porpoise, experts in marine mammal hearing discussed the nature, extent and potential consequence of PTS to harbour and grey seals arising from exposure to repeated low-frequency impulsive noise such as pile driving (Booth and Heinis, 2018). The predicted decline in harbour and grey seals 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 11-36**. The data provided in **Table 11-36** 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) (**Plate 11-13**).
- 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) (**Plate 11-14**).
- 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) (**Plate 11-15**).

265. 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 11-36 Predicted decline in 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
Pup survival	0	0.04	0.15	0.32	0.52	0.8	1.21	1.88	3

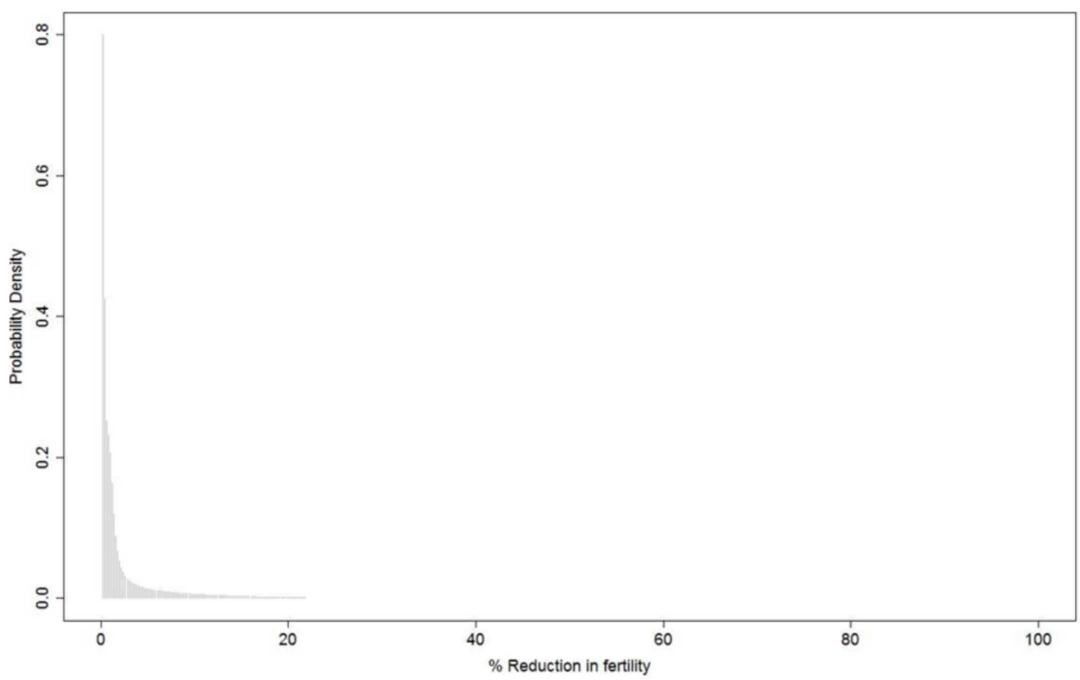


Plate 11-13 Probability distribution showing the consensus distribution for the effects on fertility of a mature female (harbour or grey) seal as a consequence of a maximum 6 dB of PTS within a 2–10 kHz band (Booth and Heinis, 2018)

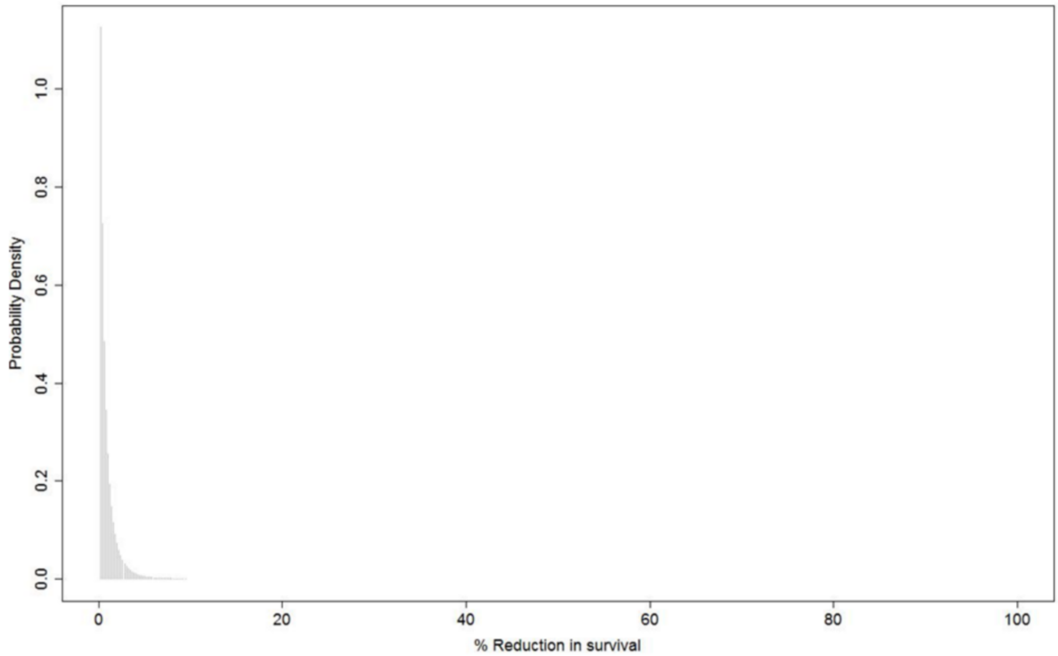


Plate 11-14 Probability distribution showing the consensus distribution for the effects on survival of a mature female (harbour or grey) seal as a consequence of a maximum 6 dB of PTS within a 2–10 kHz band (Booth and Heinis, 2018)

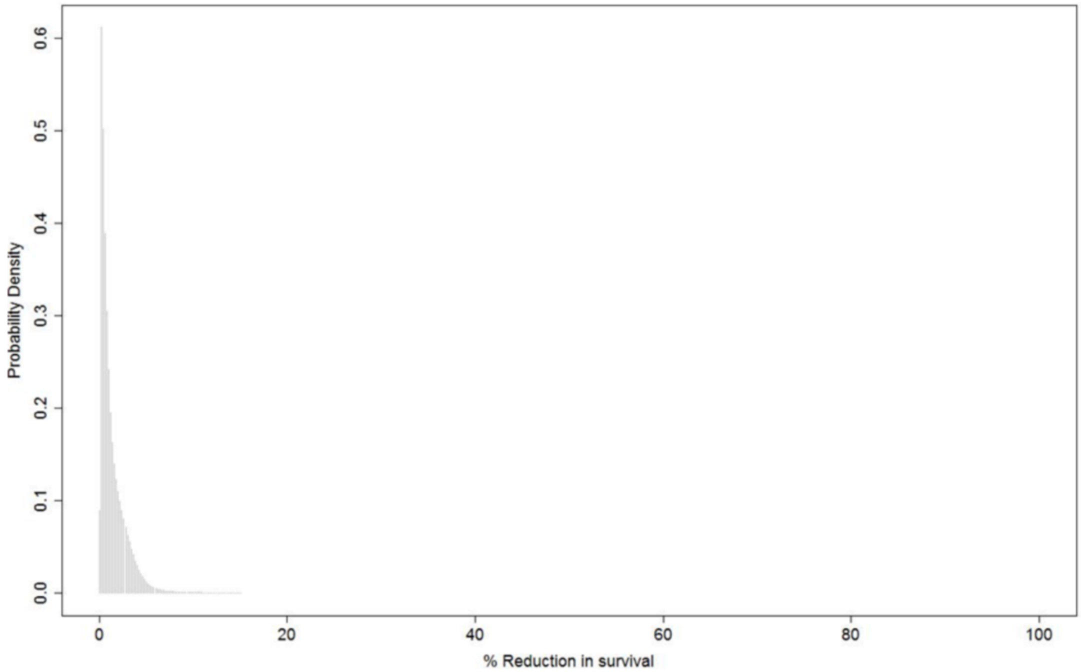


Plate 11-15 Probability distribution showing the consensus distribution for the effects on survival of juvenile or dependent pup (harbour or grey) seal as a consequence of a maximum 6 dB of PTS within a 2–10 kHz band (Booth and Heinis, 2018)

Significance of the effect

266. The sensitivity of seals to PTS from WTG pile driving has been assessed as **Low** and the magnitude of unmitigated impact has been assessed as **Negligible.** Therefore, significance of the effect is assessed as **Negligible (Not significant).**

Primary mitigation

267. The CWP Project has committed to implementing a WTG/OSS piling **MMMP** (section 8 of the **MMMP**) to reduce the risk of auditory injury (PTS). This is in line with the guidance to manage the risk to marine mammals from man-made sound sources in Irish waters (NPWS, 2014). Primary mitigation measures outlined in the WTG/OSS piling **MMMP** (section 8 of the **MMMP**) include those that are considered to be 'industry standard' and are supported by the NPWS (2014) guidance:

- Pre-piling visual watch by an MMO; and
- Pre-piling PAM (if required to supplement to visual observations).

268. These measures will further ensure the risk of PTS to seals is negligible.

Additional mitigation

269. None required. The primary mitigation measures outlined in the WTG/OSS piling **MMMP** (section 8 of the **MMMP**) will ensure the risk of auditory injury (PTS) to seals is negligible.

Residual effect

270. The significance of the residual effect remains **Negligible (Not significant).**

Impact 6: Disturbance from piling – WTGs and OSSs

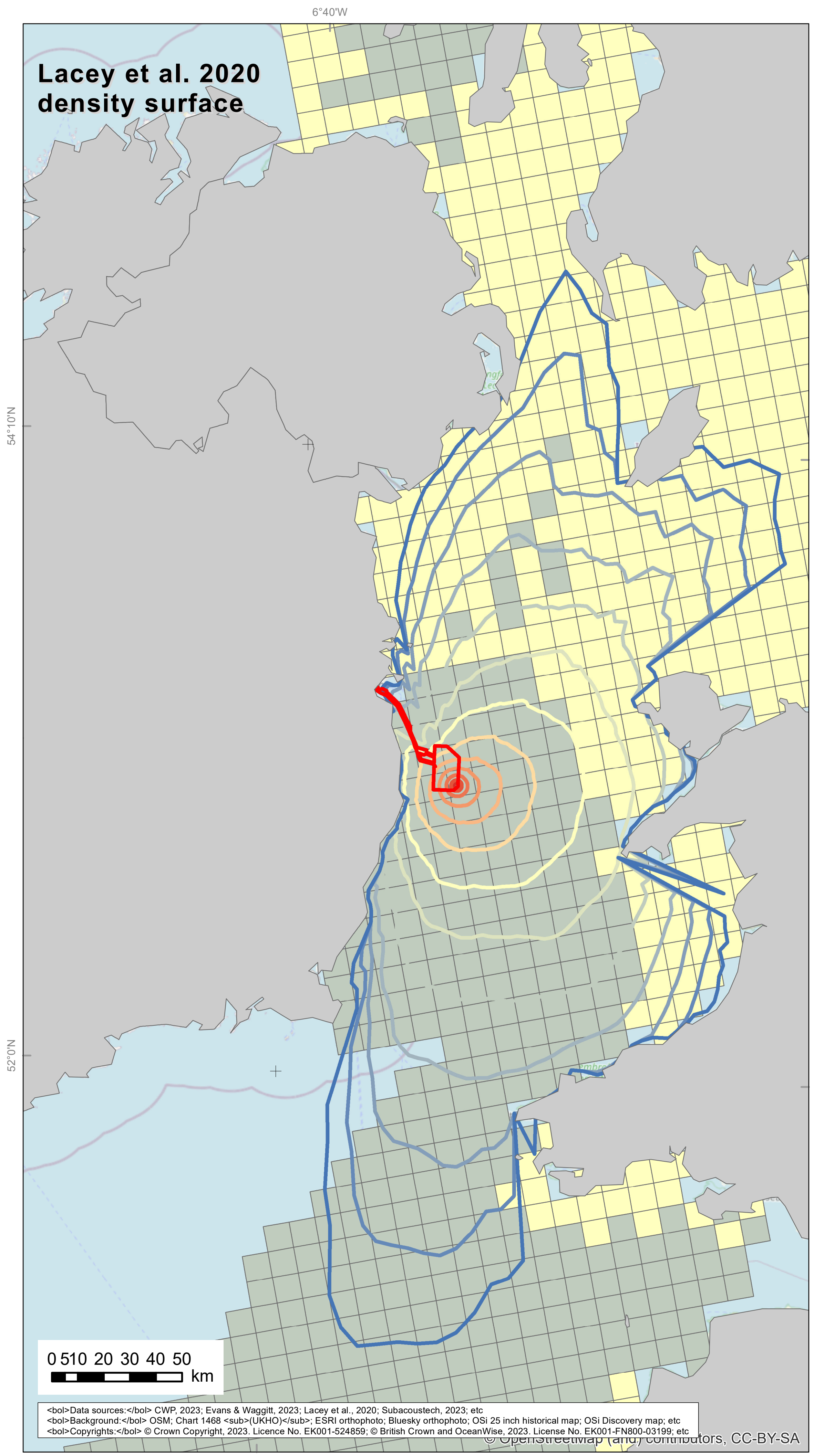
Harbour porpoise

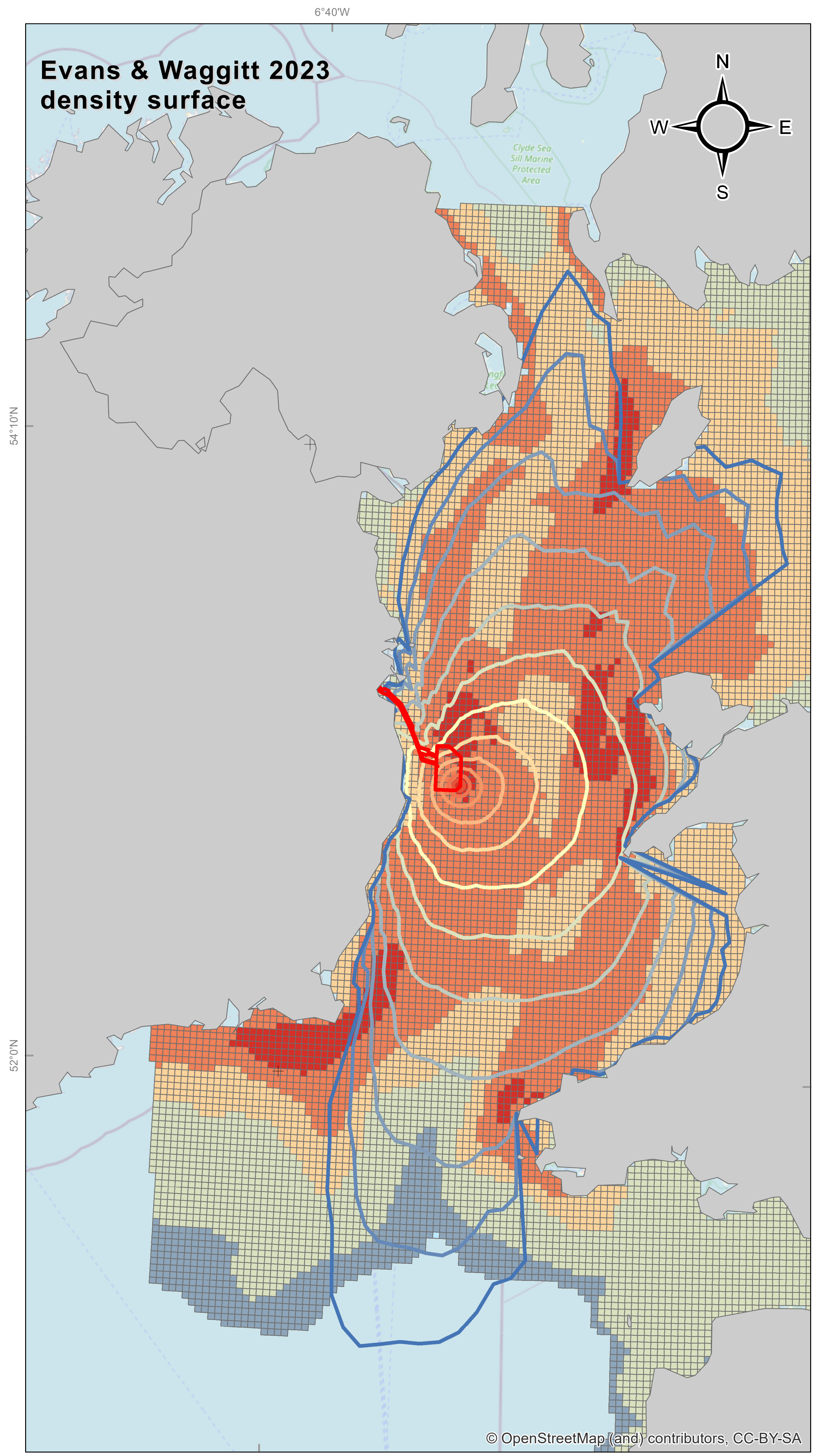
Magnitude of impact

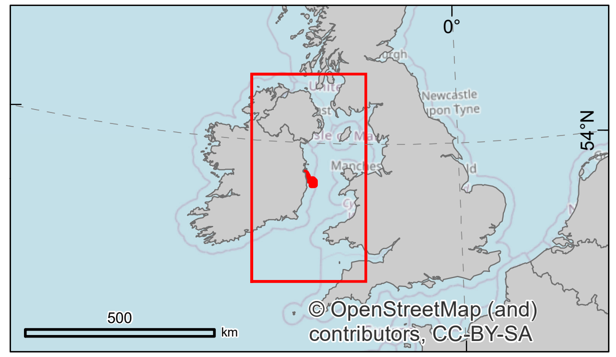
271. Dose-response function disturbance contours for harbour porpoise are shown in **Figure 11-4** for the SE location overlain on the harbour porpoise density surfaces by Lacey et al. (2022) and Evans and Waggitt (2023). The maximum number of harbour porpoise predicted to be disturbed on a single piling day is 2,667 porpoise, equating to 4.27% of the MU when a monopile foundation is installed at the SE location (**Table 11-37**, **Figure 11-4**). By contrast, using the same density surfaces (Evans and Waggitt, 2023) piling at the NW is predicted to disturb up to 1,186 individuals, which equates to 1.9%of the MU.

Table 11-37 Harbour porpoise predicted disturbance from WTG piling

		SE	SW	NE	NW
SCANS III density surface (Lacey et al., 2022)	# animals	1,936	1,048	1,681	842
	% MU	3.10%	1.68%	2.69%	1.35%
SCANS IV (0.2803 in CS-D) (Gilles et al., 2023)	# animals	2,303	1,308	1959	976
	% MU	3.68%	2.09%	3.13%	1.56%
Irish Sea density surface (Evans and Waggitt, 2023)	# animals	2,667	1,628	2,382	1,186
	% MU	4.27%	2.60%	3.81%	1.90%







Legend

Planning application boundary

SEL_{ss} dB re µPa^{2}s (5dB) SE location

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

Lacey et al. 2020 harbour porpoise density

- 0.00
- 0.001 - 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 0.80
- 0.80 - 1.00
- >1.00

Evans & Waggitt 2023 harbour porpoise density

- 0.00
- 0.001 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5

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Figure 11.4:
Disturbance contours for piling at the Southeast location overlain on the harbour porpoise density surfaces

CWP doc. number: CWP-SMR-ENG-08-01-MAP-1590

Internal descriptive code: IS - PAB..DPNM.CONT.WTG.SE - HARBOUR.PORPOISE.DENS - (EIAR.Vol.03.Ch.11.FIG.02)

Size: A3
Scale: 1:2,000,000

CRS: EPSG 25830

Rev.	Updates	Date	By	Chk'd	App'd
00	Final for issue	2024/07/16	JC	RRS/EA	EA

272. To determine the magnitude of this impact on a population level, iPCoD modelling was conducted. The modelling assumed 78 WTG piling days between April and October 2027 and that 2,667 harbour porpoise are disturbed on every piling day (based on the SE modelling). This is highly precautionary since the modelling shows that the number of animals impacted at other modelling locations (west locations) is significantly lower, and in practice the majority of piling events will be in the shallower areas to the west and north rather than the spatially limited deeper area in the SE.

273. The iPCoD results show that the level of disturbance is not sufficient to result in any changes at the population level, since the impacted population is predicted to continue at a stable trajectory, the same as the unimpacted population (**Table 11-38** and **Plate 11-16**). This is considered to be a **Negligible** magnitude since the disturbance is expected to be temporary and short term, will occur over less than a year (maximum 78 days WTG piling) and is predicted to impact a very small proportion of the MU population, which is not expected to result in any change to the population trajectory.

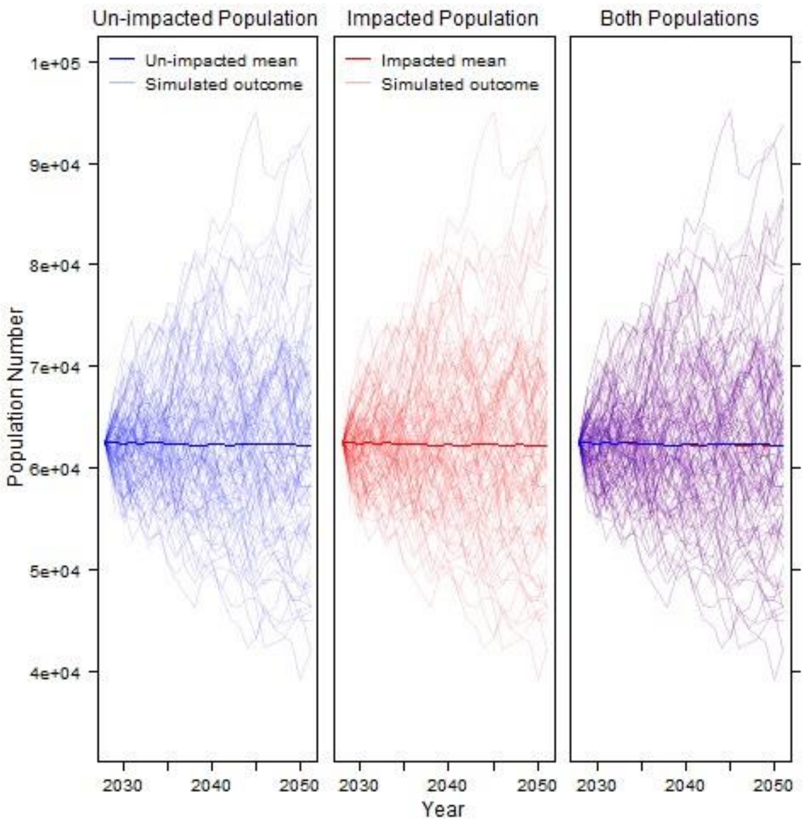


Plate 11-16 Predicted population trajectories for the unimpacted (baseline) and impacted harbour porpoise iPCoD simulations (78 days piling in 2027), impacting 2,667 harbour porpoise per day

Table 11-38 Predicted mean population size for the unimpacted (baseline) and impacted harbour porpoise iPCoD simulations (78 days piling in 2027), impacting 2,667 harbour porpoise per day

	Unimpacted population mean size	Unimpacted population mean size	Impacted population as a proportion of the unimpacted population
Start 2027 (before piling commences)	62,516	62,516	100.0%
End 2027 (after piling ends)	62,482	62,460	100.0%
End 2033 (6 years after piling ends)	62,381	62,334	99.9%
End 2039 (12 years after piling ends)	62,307	62,260	99.9%
End 2045 (18 years after piling ends)	62,281	62,234	99.9%

Receptor sensitivity

274. Previous studies have shown that harbour porpoises are displaced from the vicinity of piling events. For example, studies at windfarms in the German North Sea have recorded large declines in porpoise detections close to the piling location (>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 (1 to 3 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.

275. 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 summarised 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.

276. 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 but does not provide clear justification in their paper.

277. 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 to 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.

278. Monitoring of harbour porpoise activity at the Beatrice Offshore Windfarm 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.

279. 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 1µPa^{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 individual variability in responses among harbour porpoises exposed to low frequency broadband pulsed noise (including both airguns and pile-driving).

280. At the most recent expert elicitation workshop in 2018 (Booth et al., 2019), experts assessed the most likely potential consequences of a six hour period of zero energy intake for harbour porpoise, assuming that disturbance (from exposure to low frequency broadband pulsed noise, e.g., impact piling, airgun pulses) resulted in missed foraging opportunities (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 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.

281. 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 (**Plate 11-17**, 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 (**Plate 11-17** 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.

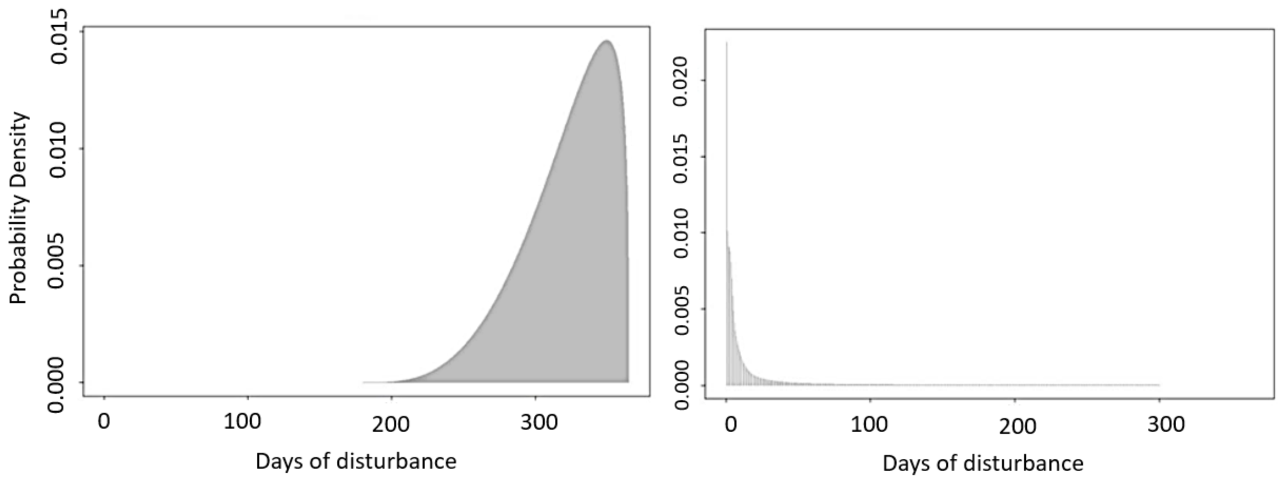


Plate 11-17 Probability distributions showing the consensus of the expert elicitation for harbour porpoise disturbance from piling (Booth et al., 2019). Left: the number of days of disturbance (i.e., days on which an animal does not feed for six hours) a pregnant female could 'tolerate' before it has 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.

282. A recent study by Benhemma-Le Gall et al. (2021b) 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 (**Plate 11-18**). Therefore, porpoise that experience displacement are expected to be able to compensate for the lost foraging opportunities and increased energy expenditure of fleeing.

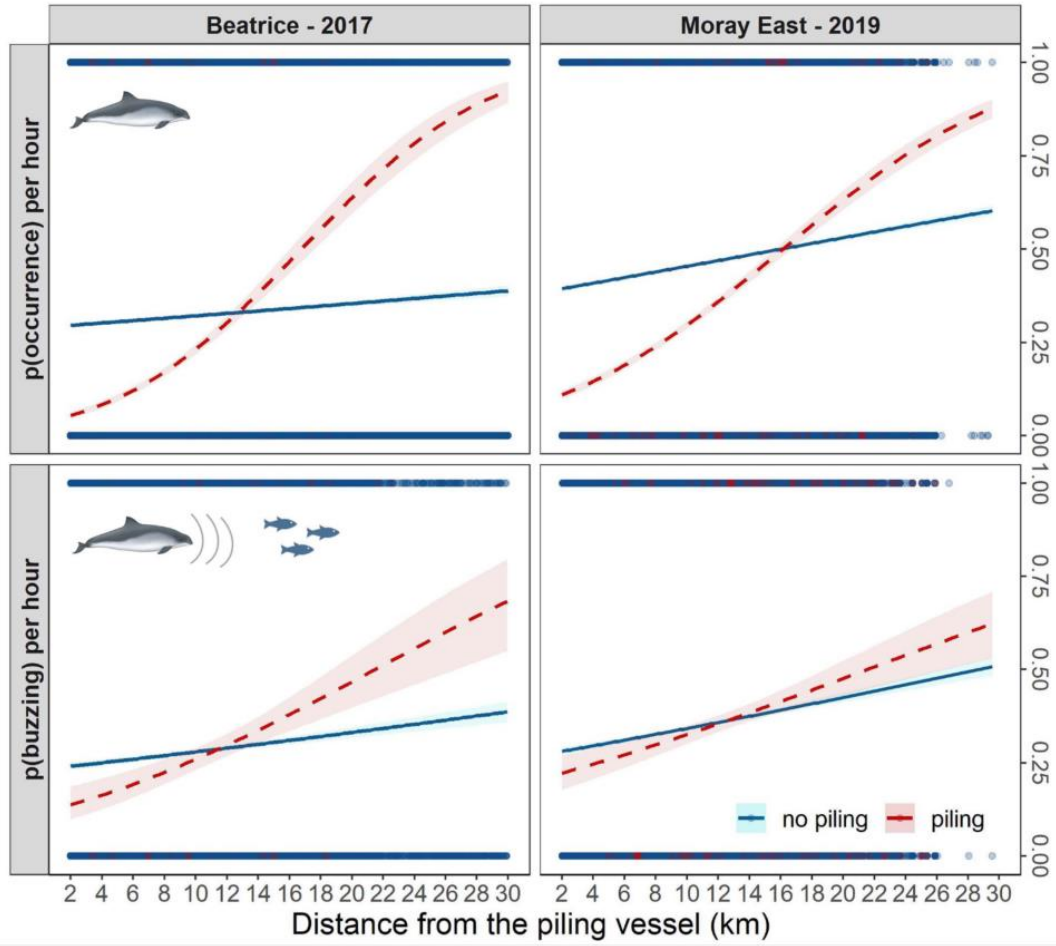


Plate 11-18 The probability of harbour porpoise occurrence and buzzing activity per hour during (dashed red line) and out with (blue line) pile-driving hours, in relation to distance from the pile-driving vessel at Beatrice (left) and Moray East (right)

283. Given all of the evidence summarised above, it is expected that harbour porpoise are somewhat resilient to and can compensate for temporary disturbance effects due to pile driving. Therefore, harbour porpoises have been assessed as having a **Low** sensitivity to disturbance from pile driving activities.

Significance of the effect

284. The sensitivity of harbour porpoise to disturbance from WTG pile driving has been assessed as **Low** and the magnitude of impact has been assessed as **Negligible.** Therefore, significance of the effect is assessed as **Negligible (Not significant).**

Additional mitigation

285. All WTG piling activity will follow procedures set out in the WTG/OSS piling **MMMP** (section 8 of the **MMMP**), as per NPWS (2014). The purpose of the WTG/OSS piling **MMMP** is to minimise the impact of auditory injury (PTS) from piling.

286. No specific additional mitigation is required to reduce the disturbance impact as the impact is not considered significant.

287. While this disturbance impact is not significant in EIA terms, it will require further consideration with regards to Annex IV in any future Annex IV risk assessments and license applications.

Residual effect

288. The significance of the residual effect of disturbance from WTG piling to harbour porpoise remains as **Negligible (Not significant).**

Bottlenose dolphins

Magnitude of impact

Dose-response function

289. The number of bottlenose dolphins predicted to be disturbed on a single piling day varies considerably depending on the density estimate used.

290. **SCANS III density surface:** The maximum number of bottlenose dolphins predicted to be disturbed on a single piling day using the porpoise dose-response function is 205 dolphins, equating to 19.18% of the MU (assuming the MU is 1,069) when a monopile foundation is installed at the SE location (**Table 11-39**, **Figure 11-5** left).

291. **SCANS IV block density:** The maximum number of bottlenose dolphins predicted to be disturbed on a single piling day using the porpoise dose-response function is 2,060 dolphins, equating to 24.74% of the MU (assuming the MU is 8,326) when a monopile foundation is installed at the SE location (**Table 11-39**).

292. **Irish Sea density surface:** The maximum number of bottlenose dolphins predicted to be disturbed on a single piling day using the porpoise dose-response function is 54 dolphins, equating to 10.89% of the MU (assuming the MU is 496) when a monopile foundation is installed at the SE location (**Table 11-39**, **Figure 11-6** left).

293. 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.

294. A literature review of recent (post Southall et al., 2007) behavioural responses by harbour porpoises and bottlenose dolphins to noise was conducted by Moray Offshore Renewables Limited (2012). Several studies have reported a moderate to high level of harbour porpoise 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 Limited 2012). This indicates that moderate level responses by bottlenose dolphins will be exhibited at a higher received SPL than harbour porpoise and, therefore,

they are likely to show a lesser response to disturbance than porpoise. Furthermore, the relatively dynamic social structure of bottlenose dolphins (Connor et al*.,* 2001), 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.

295. In light of this, the level B harassment threshold, as described below, has also been presented as an alternative disturbance threshold for bottlenose dolphins.

Level B harassment

296. The number of bottlenose dolphins predicted to be disturbed on a single piling day varies considerably depending on the density estimate used.

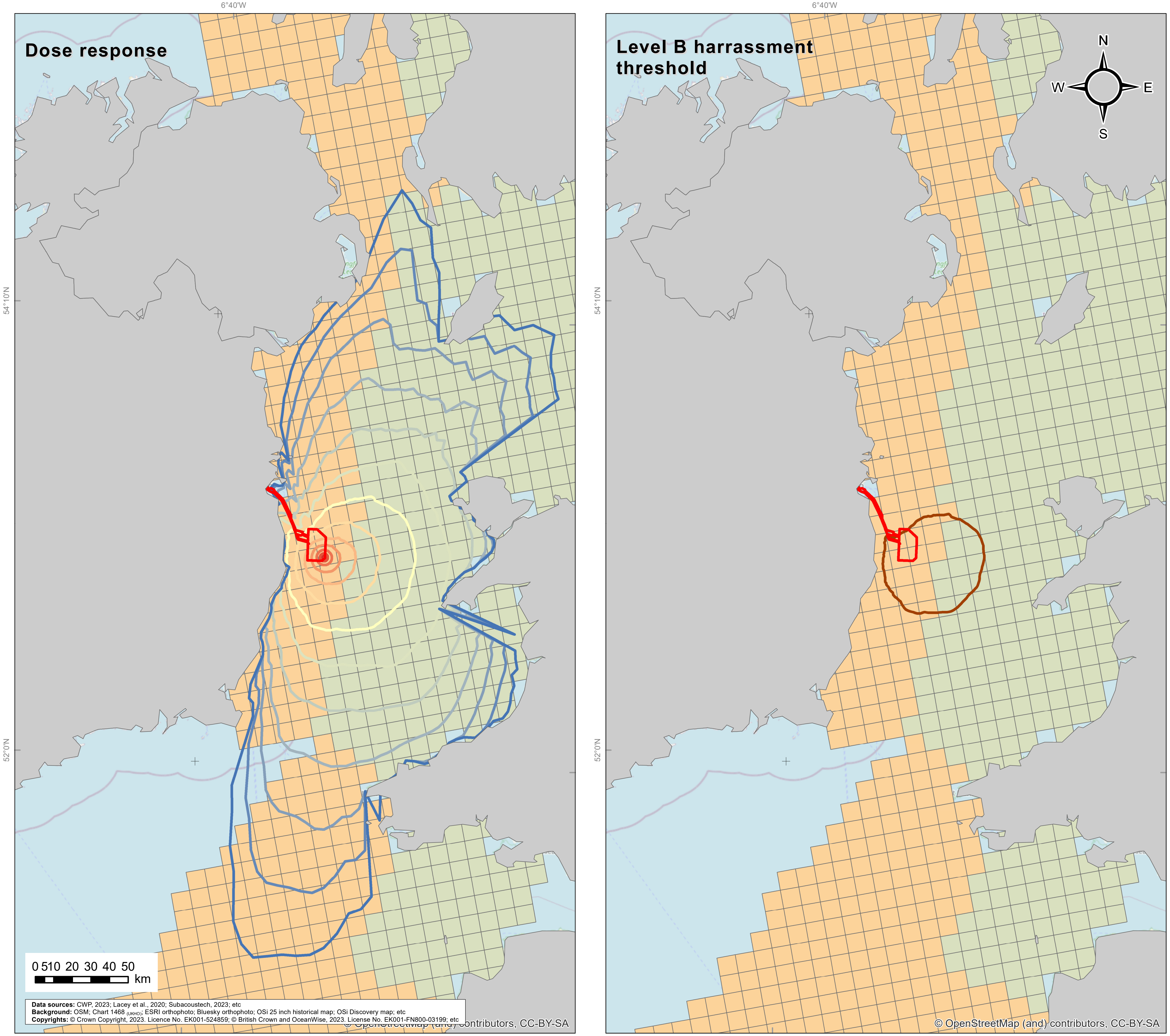
297. **SCANS III density surface:** The maximum number of bottlenose dolphins predicted to be disturbed on a single piling day using the level B harassment threshold is 59 dolphins, equating to 5.52% of the MU (assuming the MU is 1,069) when a monopile foundation is installed at the SE location (**Table 11-39**, **Figure 11-5** right).

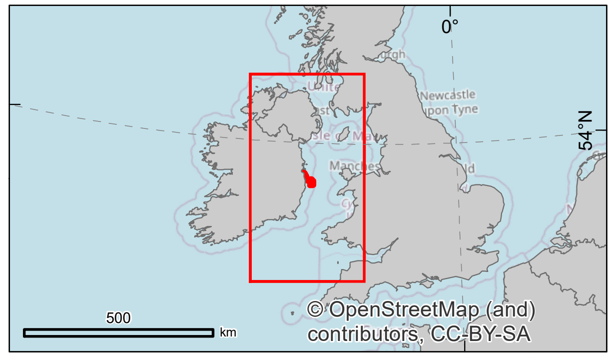
298. **SCANS IV block density:** The maximum number of bottlenose dolphins predicted to be disturbed on a single piling day using the level B harassment threshold is 532 dolphins, equating to 6.39% of the MU (assuming the MU is 8,326) when a monopile foundation is installed at the SE location (**Table 11-39**).

299. **Irish Sea density surface:** The maximum number of bottlenose dolphins predicted to be disturbed on a single piling day using the level B harassment threshold is 2 dolphins, equating to 0.40% of the MU (assuming the MU is 496) when a monopile foundation is installed at the SE location (**Table 11-39**, **Figure 11-6** right).

Table 11-39 Bottlenose dolphin predicted disturbance from WTG piling

		SE	SW	NE	NW
Dose-response function					
SCANS III density surface (Lacey et al., 2022)	# animals	205	119	170	90
	% MU (1,069)	19.18	11.13	15.90	8.42
SCANS IV (0.2352 in CS-D) (Gilles et al., 2023)	# animals	2,060	1,152	1,643	816
	% MU (8,326)	24.74	13.84	19.73	9.80
Irish Sea density surface (Evans and Waggitt, 2023)	# animals	54	24	31	8
	% MU (496)	10.89	4.84	6.25	1.61
Level B harassment					
SCANS III density surface (Lacey et al., 2022)	# animals	59	26	39	18
	% MU (1,069)	5.52	2.43	3.65	1.68
SCANS IV (0.2352 in CS-D) (Gilles et al., 2023)	# animals	532	208	339	139
	% MU (8,326)	6.39	2.50	4.07	1.67
Irish Sea density surface (Evans and Waggitt, 2023)	# animals	2	2	1	<1
	% MU (496)	0.40	0.40	0.20	<0.20





Legend

Planning application boundary

SEL_{ss} dB re µPa²s (5dB) SE

- 120 dB
- 125 dB
- 130 dB
- 135 dB
- 140 dB
- 145 dB
- 150 dB
- 155 dB
- 160 dB
- 165 dB
- 170 dB
- 175 dB
- 180 dB
- Level B threshold 160 dB re 1 µPa (SPL_{RMS})

Lacey et al. 2020 bottlenose dolphin density

- 0.00
- 0.001 - 0.01
- 0.01 - 0.025
- 0.025 - 0.05
- 0.05 - 0.1
- > 0.1

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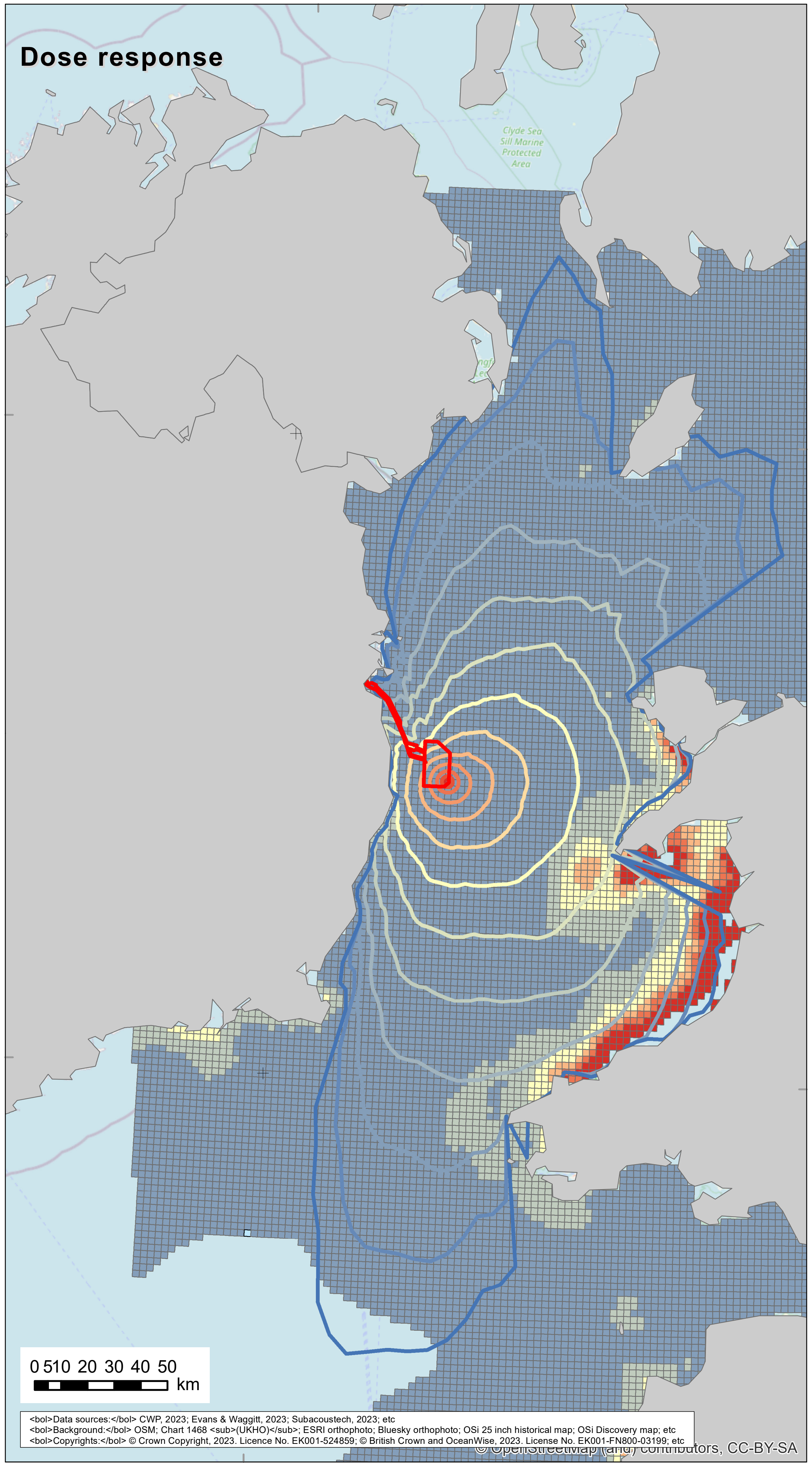
Figure 11.5:
Disturbance contours for piling at the southeast location overlain on the SCANS III bottlenose dolphin density surface

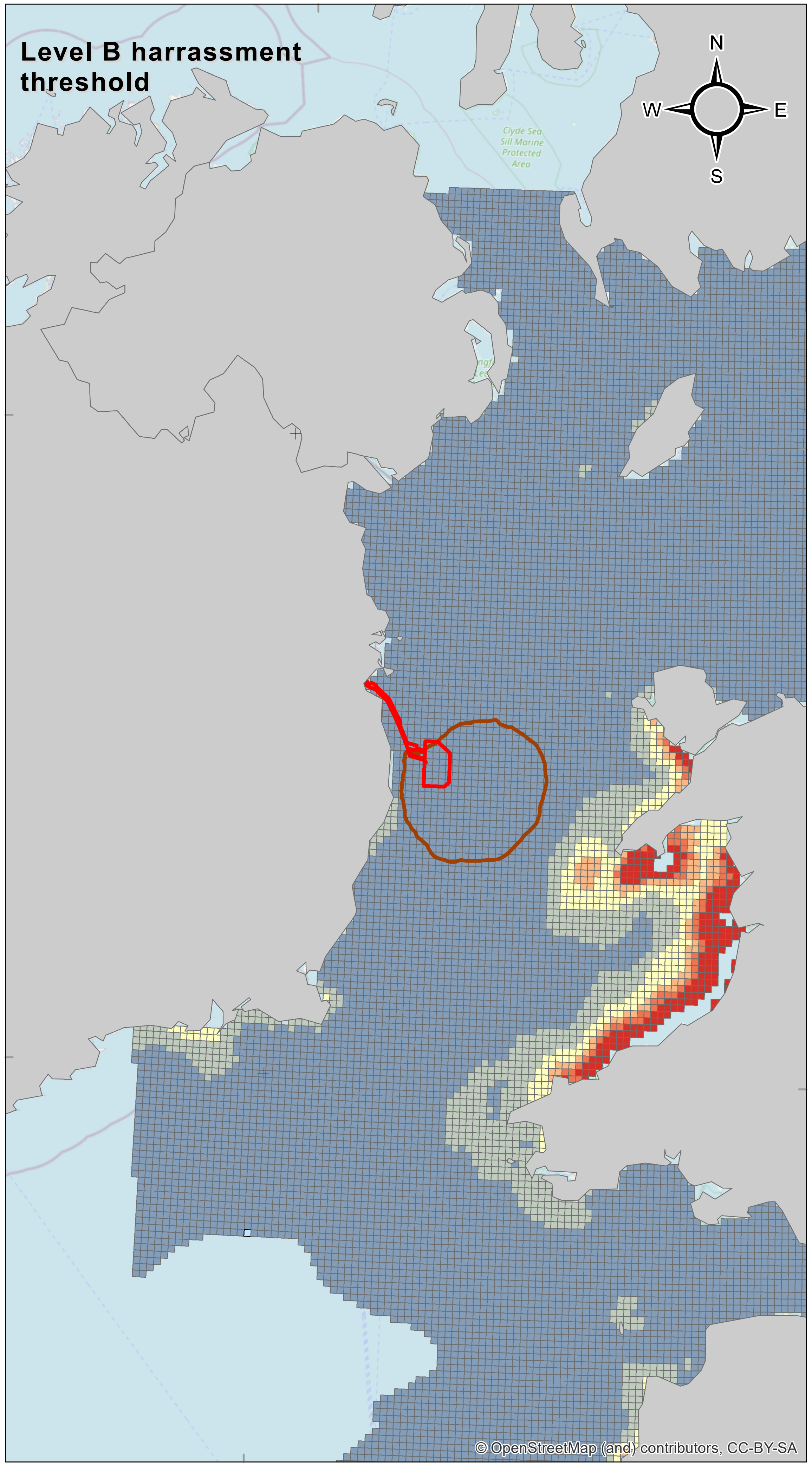
CWP doc. number: CWP-SMR-ENG-08-01-MAP-1591

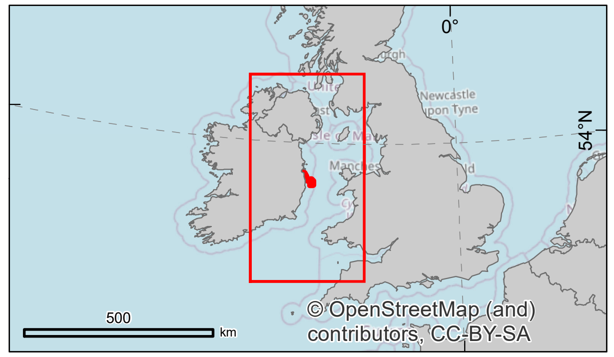
Internal descriptive code: IS - PAB..DPNM.CONT.WTG.SE..THRESH.B - BOTTLENOSE.DOLPHIN.DENS.L2020 - (EIAR.Vol.03.Ch.11.FIG.03)

Size: A3
Scale: 1:2,000,000
CRS: EPSG 25830

Rev.	Updates	Date	By	Chk'd	App'd
00	Final for issue	2024/03/07	JC	RRS/EA	EA







Legend

- Planning application boundary
- SEL_{ss} dB re μPa^2s (5dB) SE
  - 120 dB
  - 125 dB
  - 130 dB
  - 135 dB
  - 140 dB
  - 145 dB
  - 150 dB
  - 155 dB
  - 160 dB
  - 165 dB
  - 170 dB
  - 175 dB
  - 180 dB
- Level B threshold 160 dB re 1 μPa (SPL_{RMS})
- Evans & Waggitt 2023 bottlenose dolphin density
  - 0.00
  - 0.001 - 0.01
  - 0.01 - 0.025
  - 0.025 - 0.05
  - 0.05 - 0.075
  - 0.075 - 0.1
  - >0.1

Project: Codling Wind Park

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Figure 11.6:
Disturbance contours for piling at the southeast location overlain on the bottlenose dolphin density surface

CWP doc. number: CWP-SMR-ENG-08-01-MAP-1098

Internal descriptive code: IS - PAB..DPNM.CONT.WTG.SE..THRESH.B - BOTTLENOSE.DOLPHIN.DENS.EW2023 - (EIAR.Vol.03.Ch.11.FIG.04)

Size: A3

Scale: 1:2,000,000

CRS: EPSG 25830

Rev.	Updates	Date	By	Chk'd	App'd
00	Final for issue	2024/07/16	JC	RRS/EA	EA

Population modelling

300. To determine the magnitude of this impact at a population level, iPCoD modelling was conducted. The modelling assumed 78 WTG piling days between April and October 2027 and that the maximum number of bottlenose dolphins are disturbed on every piling day (based on the SE modelling using the dose-response function). This is highly precautionary since a) the modelling shows that the number of animals impacted at other modelling locations (west locations) is significantly lower and b) the porpoise dose-response function will likely overestimate dolphin response.

301. The results of the iPCoD modelling shows a clear deviation from the baseline resulting from the pile driving disturbance at CWP Project (**Plate 11-19** and **Table 11-40**). Under all density and MU size 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 98–99% 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 impacted population to increase in size after the piling disturbance. The impacted population does, however, continue on a stable trajectory in the long-term.

302. The duration of effect is days at most from each piling event, with piling occurring over less than a year. 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 considered to be an impact of **Medium** magnitude.

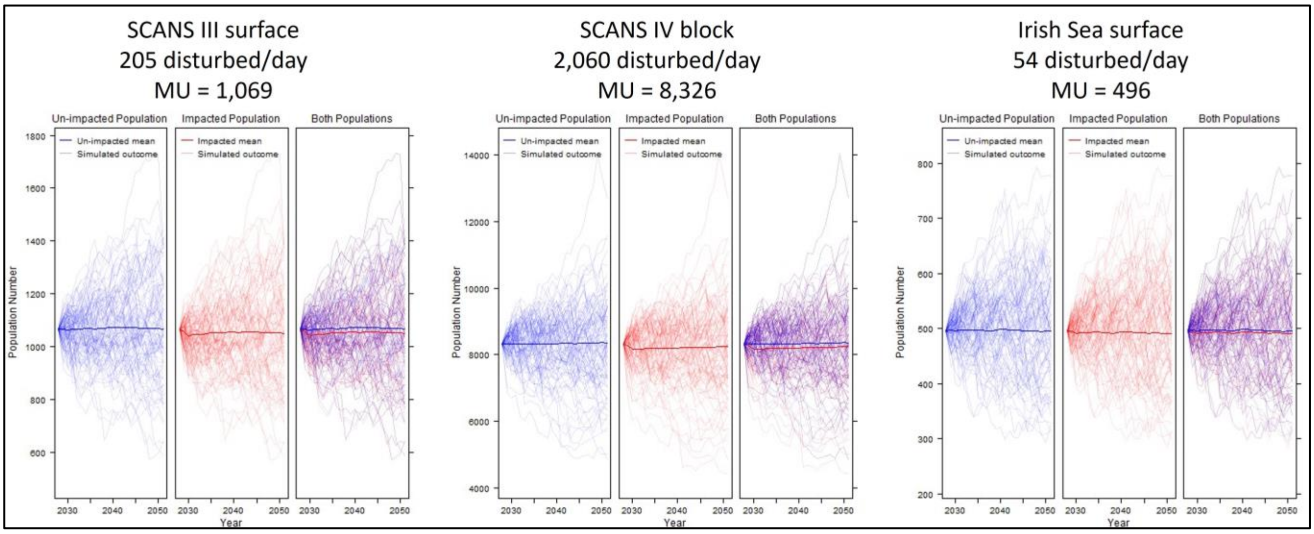


Plate 11-19 Predicted population trajectories for the unimpacted (baseline) and impacted bottlenose dolphin iPCoD simulations (78 days piling in 2027), using the results for the dose-response function and the three density estimates and MU sizes

Table 11-40 Predicted mean population size for the unimpacted (baseline) and impacted bottlenose dolphin iPCoD simulations (78 days piling in 2027), using the results for the dose-response function and the three density estimates and MU sizes

		Start 2027 (before piling commences)	End 2027 (after piling ends)	End 2033 (6 years after piling ends)	End 2039 (12 years after piling ends)	End 2045 (18 years after piling ends)
SCANS III surface **205 disturbed/day** **MU = 1,069**	Unimpacted population mean size	1,066	1,065	1,068	1,071	1,068
	Impacted population mean size	1,066	1,057	1,051	1,054	1,051
	Impacted as proportion of unimpacted	100.0	99.3	98.4	98.4	98.4
SCANS IV block **2,060 disturbed/day** **MU = 8,326**	Unimpacted population mean size	8,326	8,334	8,321	8,337	8,347
	Impacted population mean size	8,326	8,258	8,202	8,211	8,223
	Impacted as proportion of unimpacted	100.0	99.1	98.6	98.5	98.5
Irish Sea surface **54 disturbed/day** **MU = 496**	Unimpacted population mean size	496	496	498	498	496
	Impacted population mean size	496	495	494	494	492
	Impacted as proportion of unimpacted	100.0	99.8	99.2	99.2	99.2

Receptor sensitivity

303. 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 recent 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 μPa²s. 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.

304. 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).

305. 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.

Significance of the effect

306. The sensitivity of bottlenose dolphins to disturbance from WTG pile driving has been assessed as **Low** and the magnitude of impact has been assessed as **Medium.** Therefore, significance of the effect is assessed as **Minor (Not significant).**

Mitigation

307. All WTG piling activity will follow procedures set out in the WTG/OSS piling **MMMP** (section 8 of the **MMMP**), as per NPWS (2014). The purpose of the piling **MMMP** is to minimise the impact of auditory injury (PTS) from piling. No specific mitigation is required to reduce the disturbance impact as the impact is not considered significant.

Residual effect

308. The significance of the residual effect of disturbance from WTG piling to bottlenose dolphins remains as **Minor (Not significant).**

Common dolphins

Magnitude of impact

Dose-response function

309. The maximum number of common dolphins predicted to be disturbed on a single piling day using the porpoise dose-response function is 2,393 dolphins, equating to 2.33% of the MU when a monopile foundation is installed at the SE location (**Table 11-41**) using the site specific survey density estimate. It is acknowledged that the CWP Project site specific survey density estimate is an order of magnitude greater than the more recent SCANS-IV density for block CS-D and that this has led to large discrepancies in the predicted number of individuals impacted as a result of pile driving activities. While there is no evidence to suggest the higher densities of common dolphins persists beyond the site specific survey area at the CWP Project, this density estimate has been used when assessing the potential for disturbance from pile driving to acknowledge that common dolphin density in the Irish Sea may be higher than was predicted in the SCANS surveys. This is considered to be a highly precautionary approach. Although the disturbance is expected to be temporary and short term, will occur over less than a year (maximum 78 days WTG piling), this is considered to be of **Low** magnitude since temporary behavioural effects are expected in a small proportion of the population, any impact to vital rates of individuals may occur only in the short term (over a limited number of breeding cycles.

310. The harbour porpoise dose-response function has been used as a proxy for common dolphin response in the absence of similar empirical data (**Figure 11-7** left and **Figure 11-8** left). As described above for bottlenose dolphins, it is anticipated that this approach will be overly precautionary as evidence suggests that dolphins are less sensitive to disturbance compared to harbour porpoise. In light of this, the level B harassment threshold has also been presented as an alternative disturbance threshold for common dolphins (**Figure 11-7** right and **Figure 11-8** right).

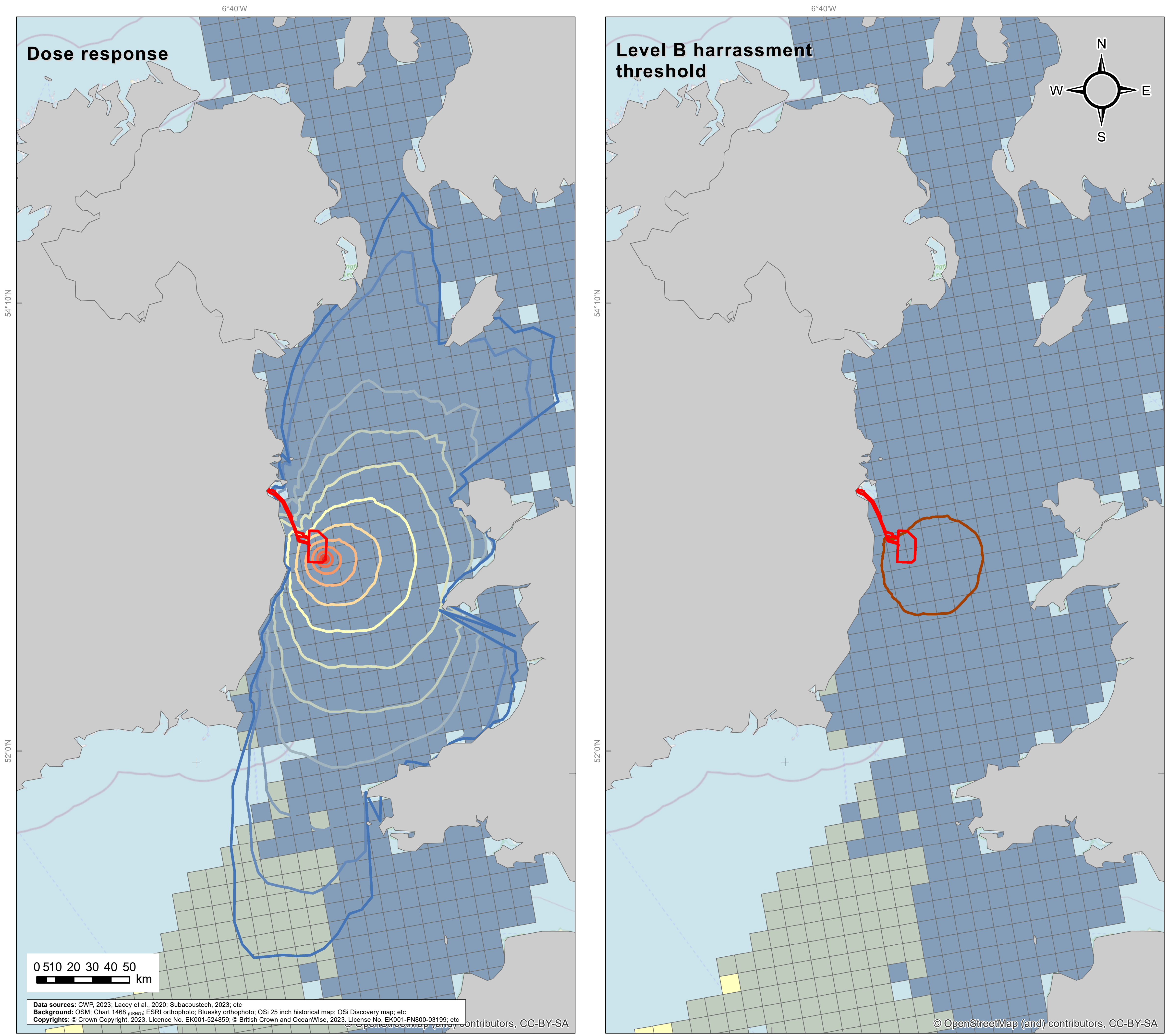
Level B harassment

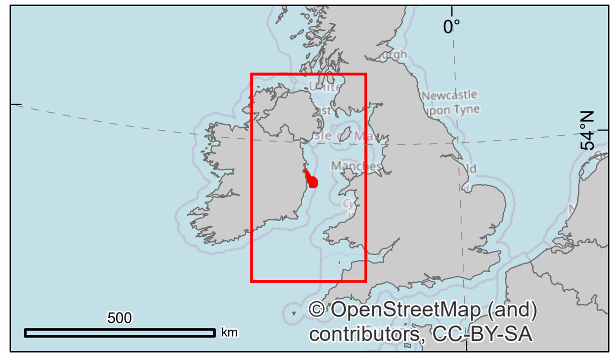
311. The maximum number of common dolphins predicted to be disturbed on a single piling day using the level B harassment threshold is 153 dolphins, equating to 0.15% of the MU when a monopile foundation is installed at the SE location (**Table 11-41**) when using the site specific survey density estimate. As stated in paragraph 309, this is considered to be highly precautionary. This is considered to be a **Negligible** magnitude since the disturbance is expected to be temporary and short term, will occur over less than a year (maximum 78 days WTG piling) and is predicted to impact a very small proportion of the MU population, which is not expected to result in any change to the population trajectory.

Table 11-41 Common dolphin predicted disturbance from WTG piling

		SE	SW	NE	NW
Dose-response function					
CWP Project site specific surveys (0.2810)[15]	# animals	2,393	1,346	1,965	977
	% MU	2.33%	1.31%	1.91%	0.95%
SCANS III density surface (Lacey et al., 2022)	# animals	289	179	190	93
	% MU	0.28%	0.17%	0.19%	0.09%
SCANS IV (0.0272 in CS-D) (Gilles et al., 2023)	# animals	509	239	227	94
	% MU	0.50%	0.23%	0.22%	0.09%
Irish Sea density surface (Evans and Waggitt, 2023)	# animals	426	213	227	74
	% MU	0.41%	0.21%	0.22%	0.07%
Level B harassment					
CWP Project site specific surveys (0.2810)	# animals	153	70	89	42
	% MU	0.15%	0.07%	0.09%	0.04%
SCANS III density surface (Lacey et al., 2022)	# animals	84	38	46	21
	% MU	0.08%	0.04%	0.04%	0.02%
SCANS IV (0.0272 in CS-D) (Gilles et al., 2023)	# animals	62	24	39	16
	% MU	0.06%	0.02%	0.04%	0.02%
Irish Sea density surface (Evans and Waggitt, 2023)	# animals	23	2	10	<1
	% MU	0.02%	0.00%	0.01%	0.00%

[15] Given how significantly higher the site specific density estimate is compared to the SCANS IV density estimate, this has been presented for larger scale disturbance impacts (e.g., pile driving), though it is noted that this is precautionary since there is no evidence of this higher density beyond the survey area.





Legend

Planning application boundary

SEL_{ss} dB re μPa²s (5dB) SE

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

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

Lacey et al. 2020 Common dolphin density

- 0.00
- 0.0001 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1.00
- >1.00

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Figure 11.7:
Disturbance contours for piling at the southeast location overlain on the SCANS III common dolphin density surface

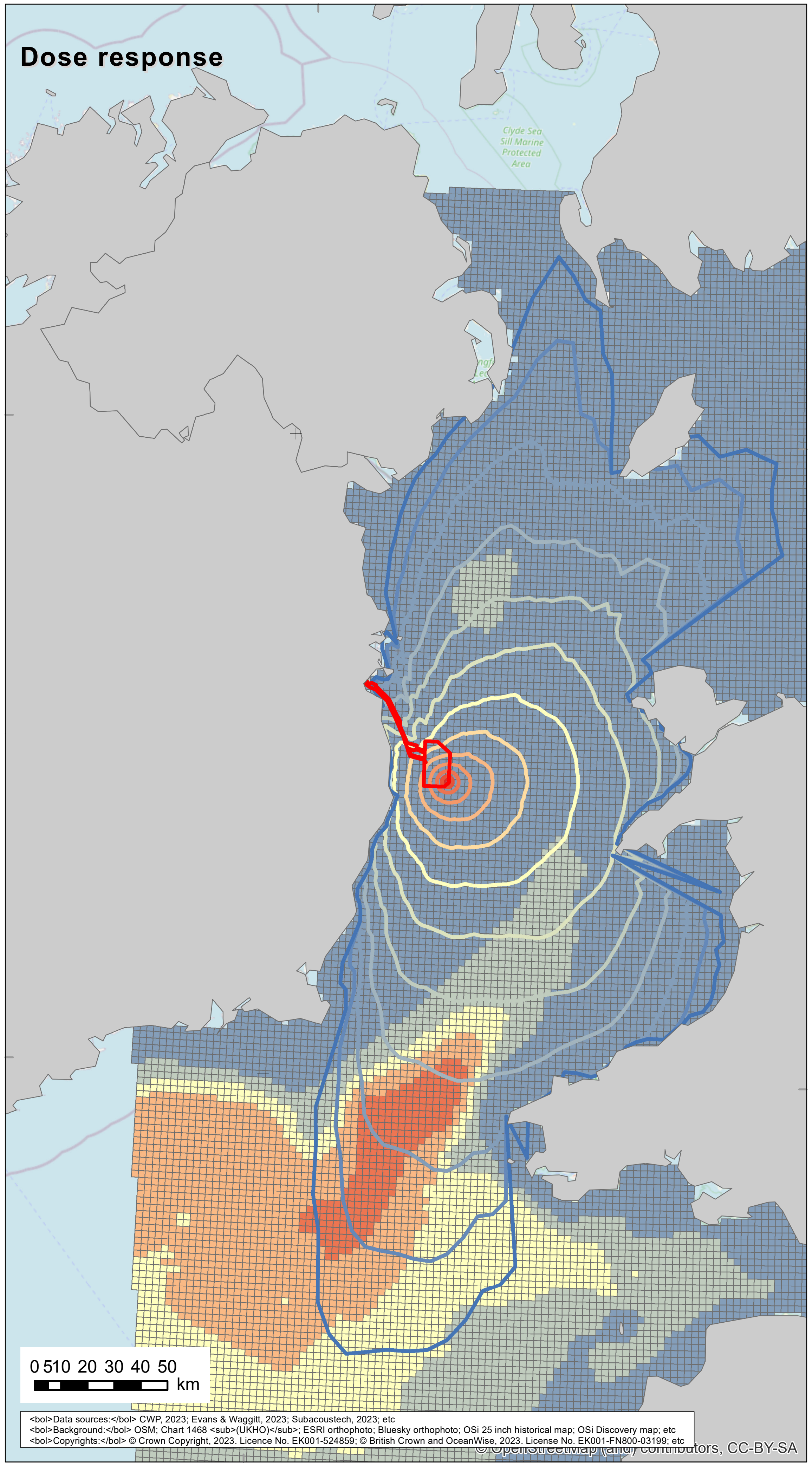
CWP doc. number: CWP-SMR-ENG-08-01-MAP-1592

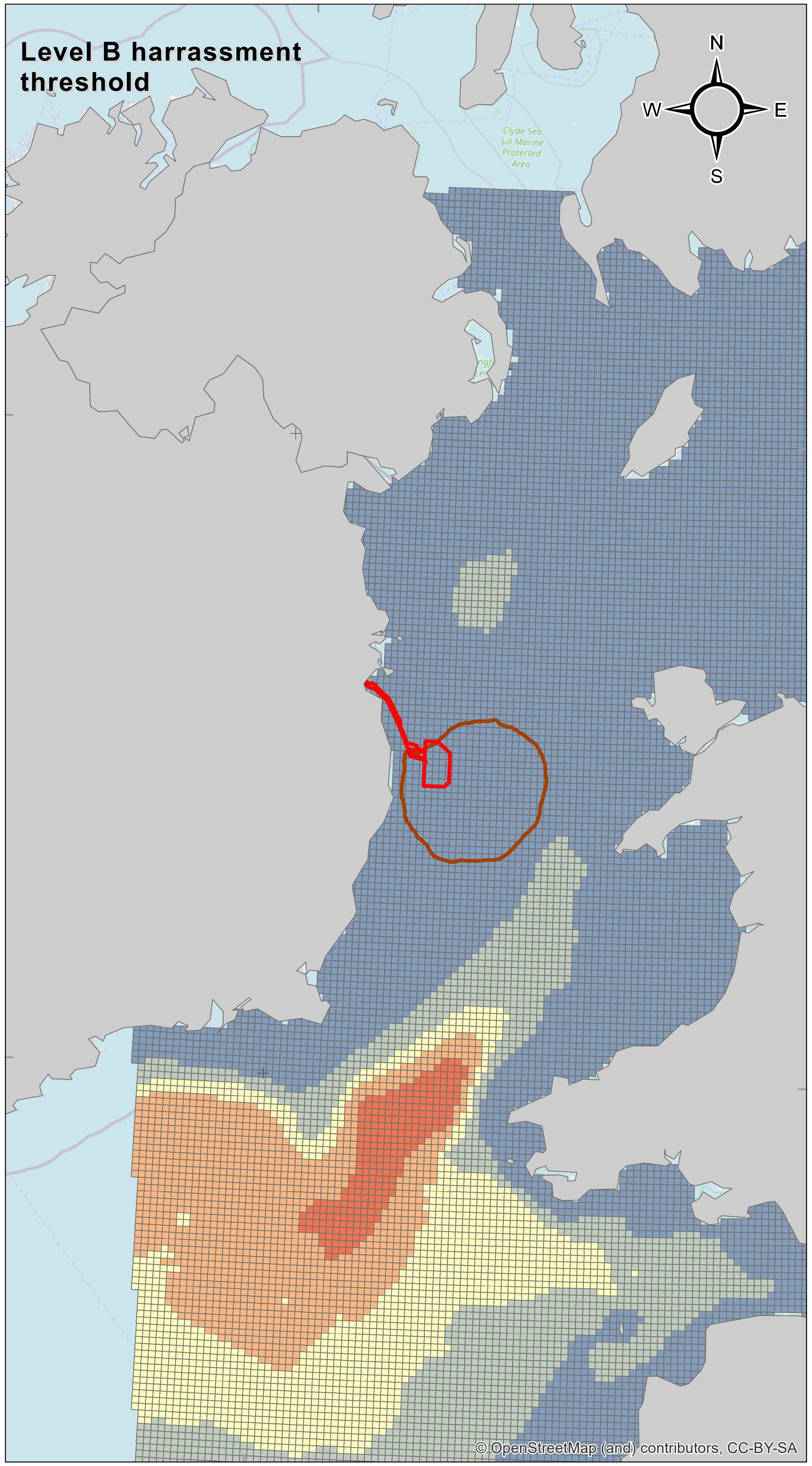
Internal descriptive code: IS - PAB..DPNM.CONT.WTG.SE..THRESH.B - COMMON. DOLPHIN.DENS.L2020 - (EIAR.Vol.03.Ch.11.FIG.05)

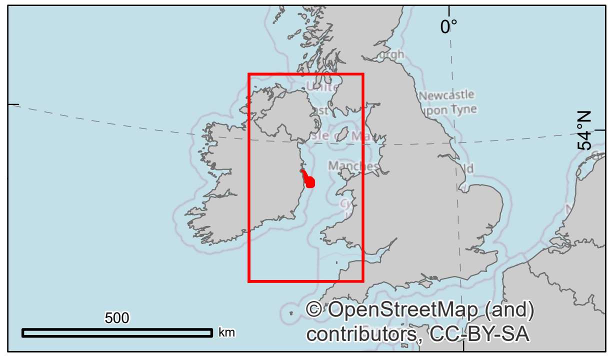
Size: A3
Scale: 1:2,000,000

CRS: EPSG 25830

Rev.	Updates	Date	By	Chk'd	App'd
00	Final for issue	2024/07/16	JC	RRS/EA	EA







Legend

Planning application boundary

SEL$_{ss}$ dB re μPa^{2}s (5dB) SE

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

Level B threshold 160 dB re 1 μPa (SPL$_{RMS}$)

Evans & Waggitt 2023 common dolphin density

- 0.00
- 0.001 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- >0.5

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Figure 11.8:
Disturbance contours for piling at the southeast location overlain on the common dolphin density surface

CWP doc. number: CWP-SMR-ENG-08-01-MAP-1593

Internal descriptive code: IS - PAB..DPNM.CONT.WTG.SE..THRESH.B - COMMON.DOLPHIN.DENS.EW2023 - (EIAR.Vol.03.Ch.11.FIG.06)

Size: A3

Scale: 1:2,000,000

CRS: EPSG 25830

Rev.	*Updates*	*Date*	*By*	*Chk'd*	*App'd*
00	Final for issue	2024/07/16	JC	RRS/EA	EA

Sensitivity

312. 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 with 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). Conversely, increased vessel presence during the construction period was associated with a decrease of common dolphins in the surrounding area. 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. The sparse information available for the impacts of construction (and other) activities on common dolphins makes it difficult to assess the risk for this species.

313. Given that they are grouped as high-frequency cetaceans alongside the other dolphin species considered in this assessment, common dolphins are also considered to have a **Low** sensitivity to behavioural disturbance from piling.

Significance of the effect

314. The sensitivity of common dolphins to disturbance from WTG pile driving has been assessed as **Low** and the magnitude of impact has been assessed as **Low.** Therefore, significance of the effect is assessed as **Minor (Not significant).**

Mitigation

315. All WTG piling activity will follow procedures set out in the WTG/OSS piling **MMMP** (section 8 of the **MMMP**), as per NPWS (2014). The purpose of the WTG/OSS piling **MMMP** is to minimise the impact of auditory injury (PTS) from piling.

316. No specific mitigation is required to reduce the disturbance impact as the impact is not considered significant.

Residual effect

317. The significance of the residual effect of disturbance from WTG piling to common dolphins remains as **Minor (Not significant).**

Risso's dolphins

Magnitude of impact

Dose-response function

318. The maximum number of Risso's dolphins predicted to be disturbed on a single piling day using the porpoise dose-response function is 89 dolphins, equating to 0.73% of the MU when a monopile foundation is installed at the SE location (**Table 11-42**). This is considered to be a **Negligible** magnitude since the disturbance is expected to be temporary and short term, will occur over less than a year (maximum 78 days WTG piling) and is predicted to impact a very small proportion of the MU population, which is not expected to result in any change to the population trajectory.

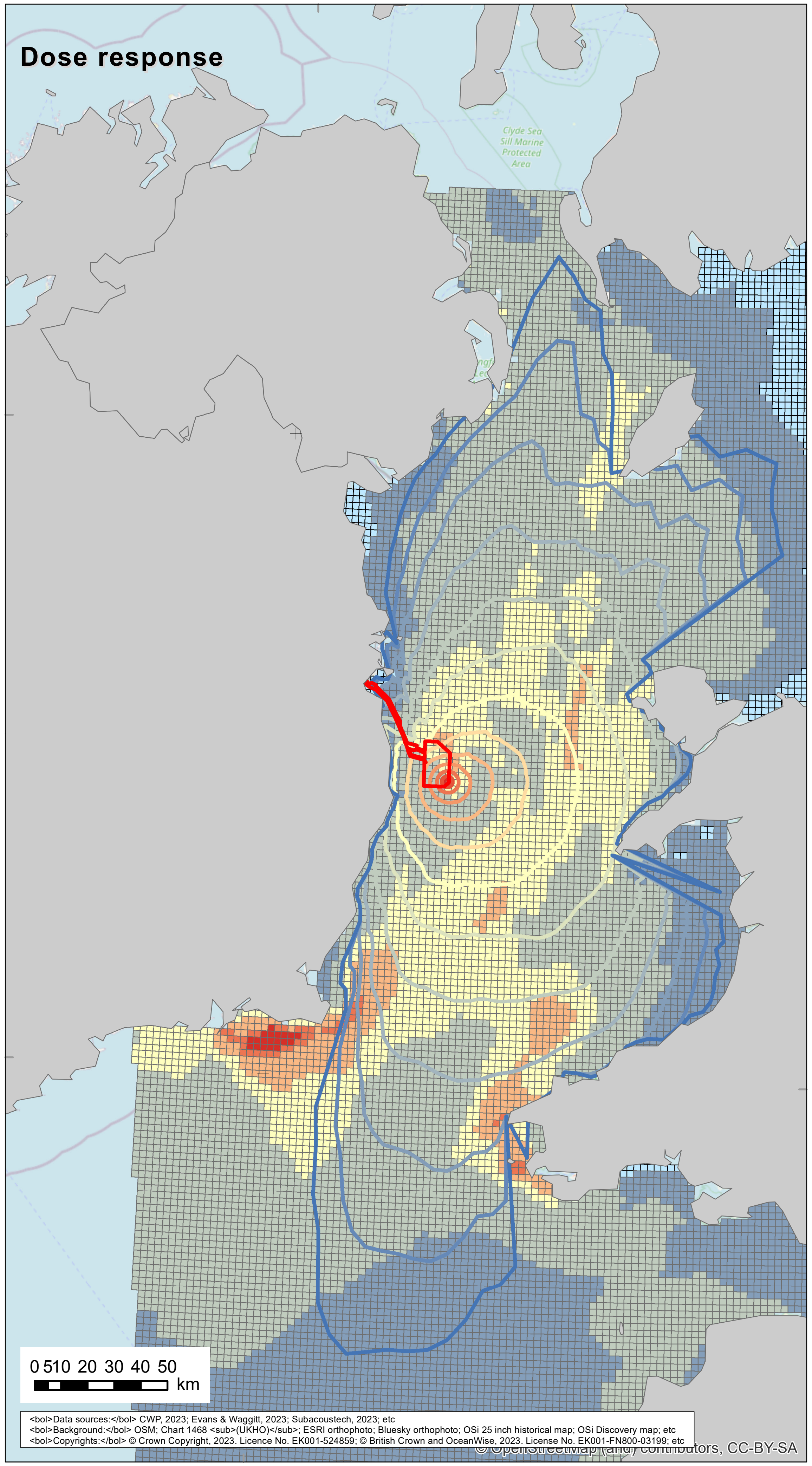
319. The harbour porpoise dose-response function has been used as a proxy for Risso's dolphin response in the absence of similar empirical data (**Figure 11-9** left). As described above for bottlenose and common dolphins, it is anticipated that this approach will be overly precautionary as evidence suggests that dolphins are less sensitive to disturbance compared to harbour porpoise. In light of this, the level B harassment threshold has also been presented as an alternative disturbance threshold for Risso's dolphins (**Figure 11-9** right).

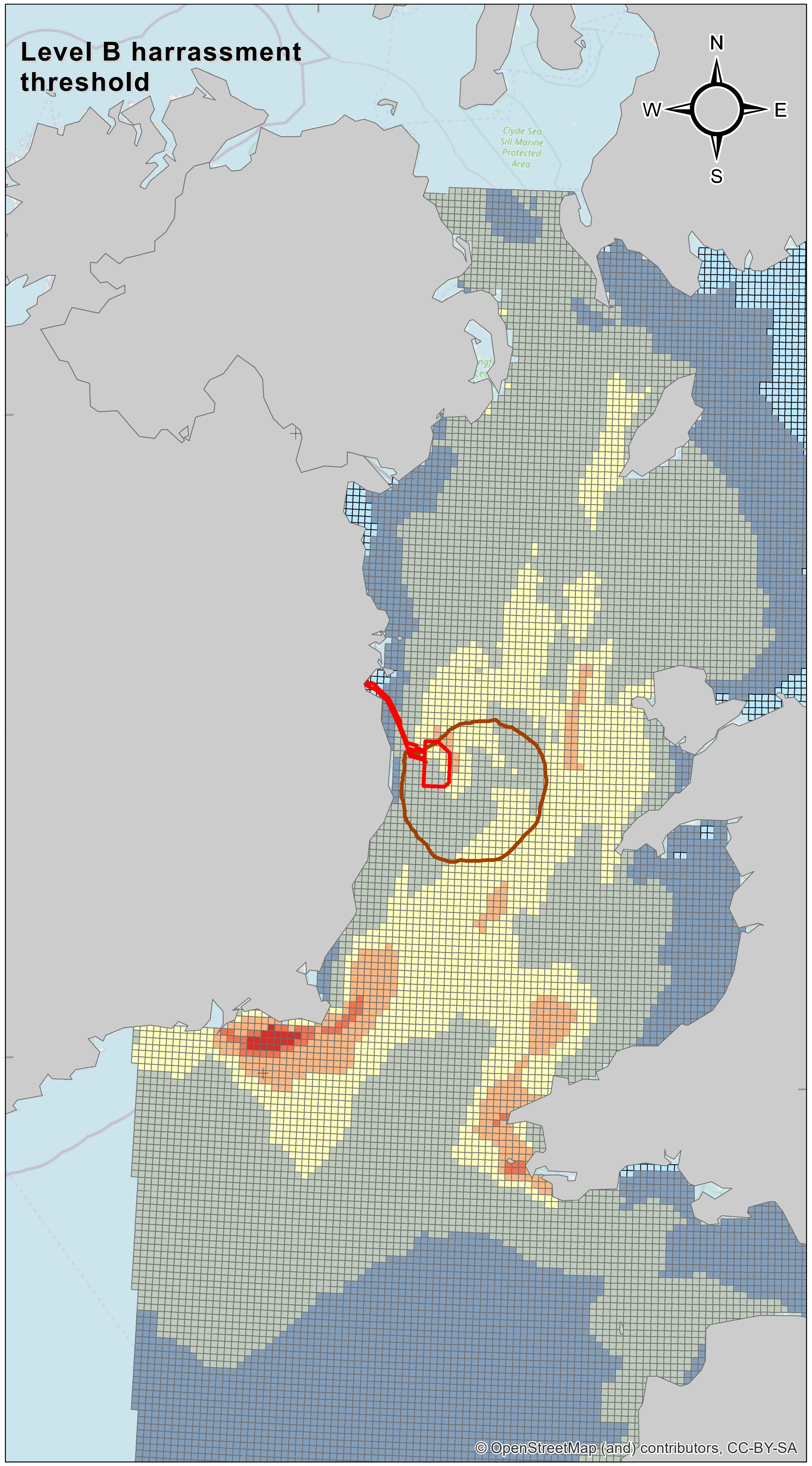
Level B harassment

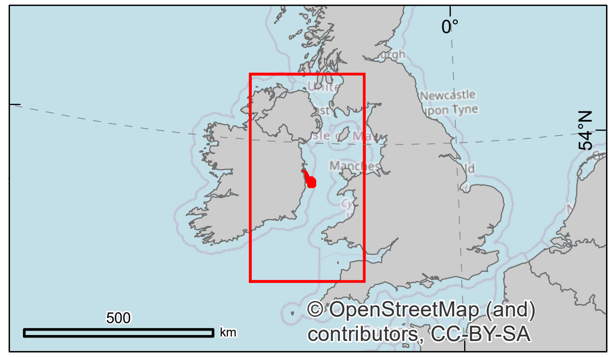
320. The maximum number of Risso's dolphins predicted to be disturbed on a single piling day using the level B harassment threshold is 21 dolphins, equating to 0.17% of the MU when a monopile foundation is installed at the SE location (**Table 11-42**). This is considered to be a **Negligible** magnitude since the disturbance is expected to be temporary and short term, will occur over less than a year (maximum 78 days WTG piling) and is predicted to impact a very small proportion of the MU population, which is not expected to result in any change to the population trajectory.

Table 11-42 Risso's dolphin predicted disturbance from WTG piling

		SE	SW	NE	NW
Dose-response function					
SCANS IV (0.0022 in CS-D) (Gilles et al., 2023)	# animals	20	11	15	8
	% MU	0.16	0.09	0.12	0.07
Irish Sea density surface (Evans and Waggitt, 2023)	# animals	89	50	69	32
	% MU	0.73%	0.41%	0.56%	0.26%
Level B harassment					
SCANS IV (0.0022 in CS-D) (Gilles et al., 2023)	# animals	5	2	3	1
	% MU	0.04	0.02	0.02	0.01
Irish Sea density surface (Evans and Waggitt, 2023)	# animals	21	5	17	7
	% MU	0.17	0.04	0.14	0.06







Legend

- Planning application boundary

SEL_{ss} dB re μPa²s (5dB) SE

- 120 dB
- 125 dB
- 130 dB
- 135 dB
- 140 dB
- 145 dB
- 150 dB
- 155 dB
- 160 dB
- 165 dB
- 170 dB
- 175 dB
- 180 dB
- Level B threshold 160 dB re 1 μPa (SPL_{RMS})

Evans & Waggitt 2023 Risso's dolphin density

- 0.00
- 0.0001 - 0.001
- 0.001 - 0.01
- 0.01 - 0.02
- 0.02 - 0.04
- 0.04 - 0.05
- >0.05

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Figure 11.9:
Disturbance contours for piling at the southeast location overlain on the Risso's dolphin density surface

CWP doc. number: CWP-SMR-ENG-08-01-MAP-1594

Internal descriptive code: IS - PAB..DPNM.CONT.WTG.SE..THRESH.B - RISSO'S. DOLPHIN.DENS.EW2023 - (EIAR.Vol.03.Ch.11.FIG.07)

Size: A3

Scale: 1:2,000,000

CRS: EPSG 25830

Rev.	Updates	Date	By	Chk'd	App'd
00	Final for issue	2024/07/16	JC	RRS/EA	EA

Receptor sensitivity

321. In the absence of any species specific data, given that they are grouped as high-frequency cetaceans, and are therefore likely to have similar hearing abilities to other dolphin species, Risso's dolphins are also considered to have a **Low** sensitivity to behavioural disturbance from piling.

Significance of the effect

322. The sensitivity of Risso's dolphins to disturbance from WTG pile driving has been assessed as **Low** and the magnitude of impact has been assessed as **Negligible.** Therefore, significance of the impact is assessed as **Negligible (Not significant)**.

Mitigation

323. All WTG piling activity will follow procedures set out in the WTG/OSS piling **MMMP** (section 8 of the **MMMP**), as per NPWS (2014). The purpose of the WTG/OSS piling **MMMP** is to minimise the impact of auditory injury (PTS) from piling.

324. No specific mitigation is required to reduce the disturbance impact as the impact is not considered significant.

Residual effect

325. The significance of the residual effect of disturbance from WTG piling to Risso's dolphins remains as **Negligible (Not significant).**

Minke whales

Magnitude of impact

Dose-response function

326. The maximum number of minke whales predicted to be disturbed on a single piling day using the porpoise dose-response function is 134 whales, equating to 0.67% of the MU when a monopile foundation is installed at the SE location (**Table 11-43**). This is considered to be a **Negligible** magnitude since the disturbance is expected to be temporary and short term, will occur over less than a year (maximum 78 days WTG piling) and is predicted to impact a very small proportion of the MU population, which is not expected to result in any change to the population trajectory.

327. The harbour porpoise dose-response function has been used as a proxy for minke whale response in the absence of similar empirical data. As described above for dolphin species, it is anticipated that this approach will be overly precautionary. In light of this, the level B harassment threshold has also been presented as an alternative disturbance threshold for minke whales.

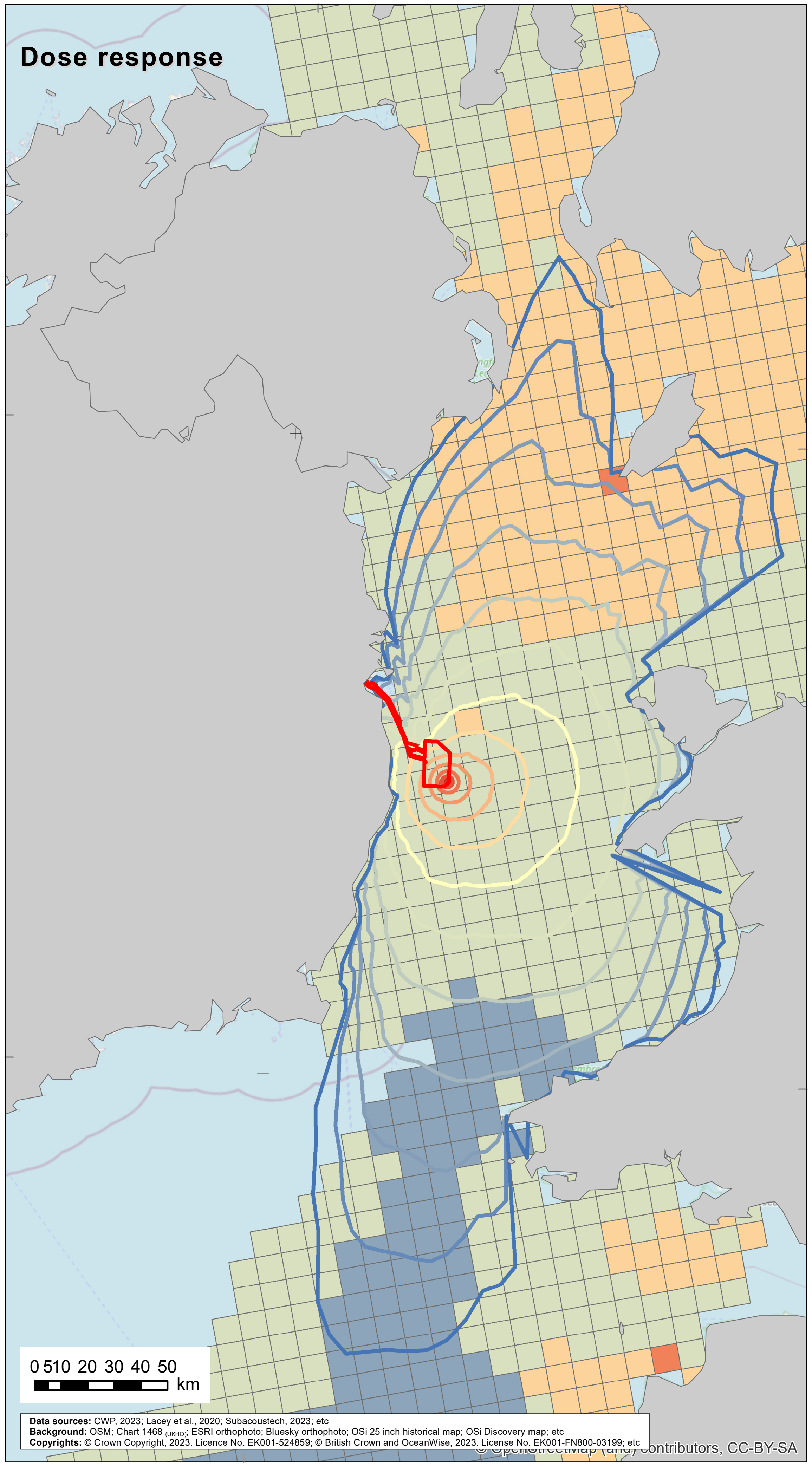
Level B harassment

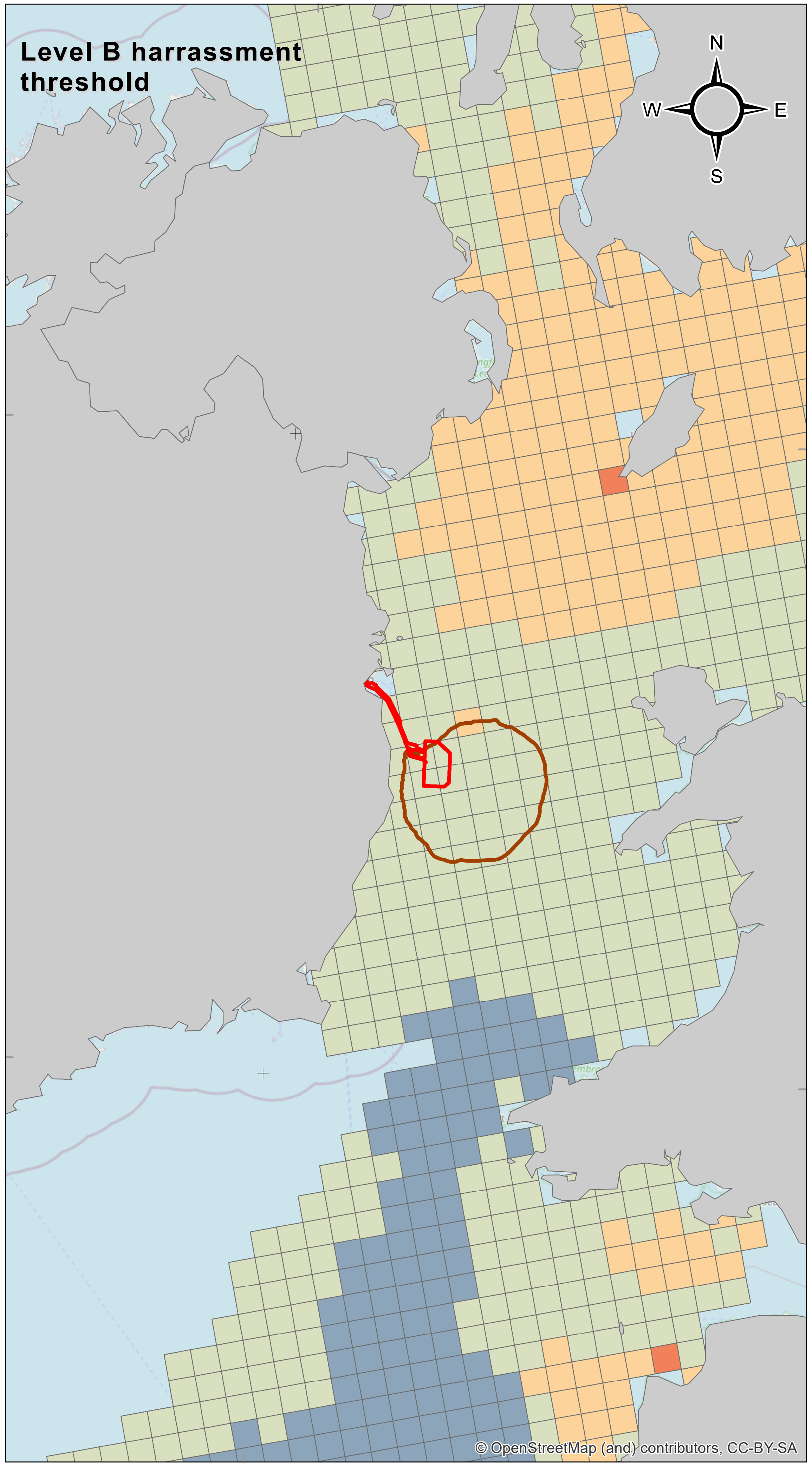
328. The maximum number of minke whales predicted to be disturbed on a single piling day using the level B harassment threshold is 36 whales, equating to 0.18% of the MU when a monopile foundation is installed at the SE location (**Table 11-43**). This is considered to be a **Negligible** magnitude since the

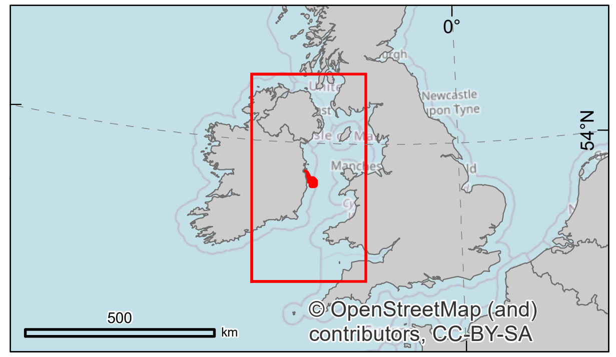
disturbance is expected to be temporary and short term, will occur over less than a year (maximum 78 days WTG piling) and is predicted to impact a very small proportion of the MU population, which is not expected to result in any change to the population trajectory.

Table 11-43 Minke whale predicted disturbance from WTG piling

		SE	SW	NE	NW
Dose-response function					
SCANS III density surface (Lacey et al., 2022)	# animals	130	69	122	63
	% MU	0.65%	0.34%	0.61%	0.31%
SCANS IV (0.0137 in CS-D) (Gilles et al., 2023)	# animals	115	65	95	48
	% MU	0.57%	0.32%	0.47%	0.24%
Irish Sea density surface (Evans and Waggitt, 2023)	# animals	134	73	109	50
	% MU	0.67%	0.36%	0.54%	0.25%
Level B harassment					
SCANS III density surface (Lacey et al., 2022)	# animals	33	14	23	10
	% MU	0.16%	0.07%	0.11%	0.05%
SCANS IV (0.0137 in CS-D) (Gilles et al., 2023)	# animals	31	12	20	8
	% MU	0.15%	0.06%	0.10%	0.04%
Irish Sea density surface (Evans and Waggitt, 2023)	# animals	36	7	25	6
	% MU	0.18%	0.03%	0.12%	0.03%







Legend

- Planning application boundary

SEL_{ss} dB re μPa²s (5dB) SE

- 120 dB
- 125 dB
- 130 dB
- 135 dB
- 140 dB
- 145 dB
- 150 dB
- 155 dB
- 160 dB
- 165 dB
- 170 dB
- 175 dB
- 180 dB
- Level B threshold 160 dB re 1 μPa (SPL_{RMS})

Lacey et al. 2020 Minke whale density

- 0.00
- 0.001 - 0.01
- 0.01 - 0.02
- 0.02 - 0.04
- 0.04 - 0.05
- >0.05

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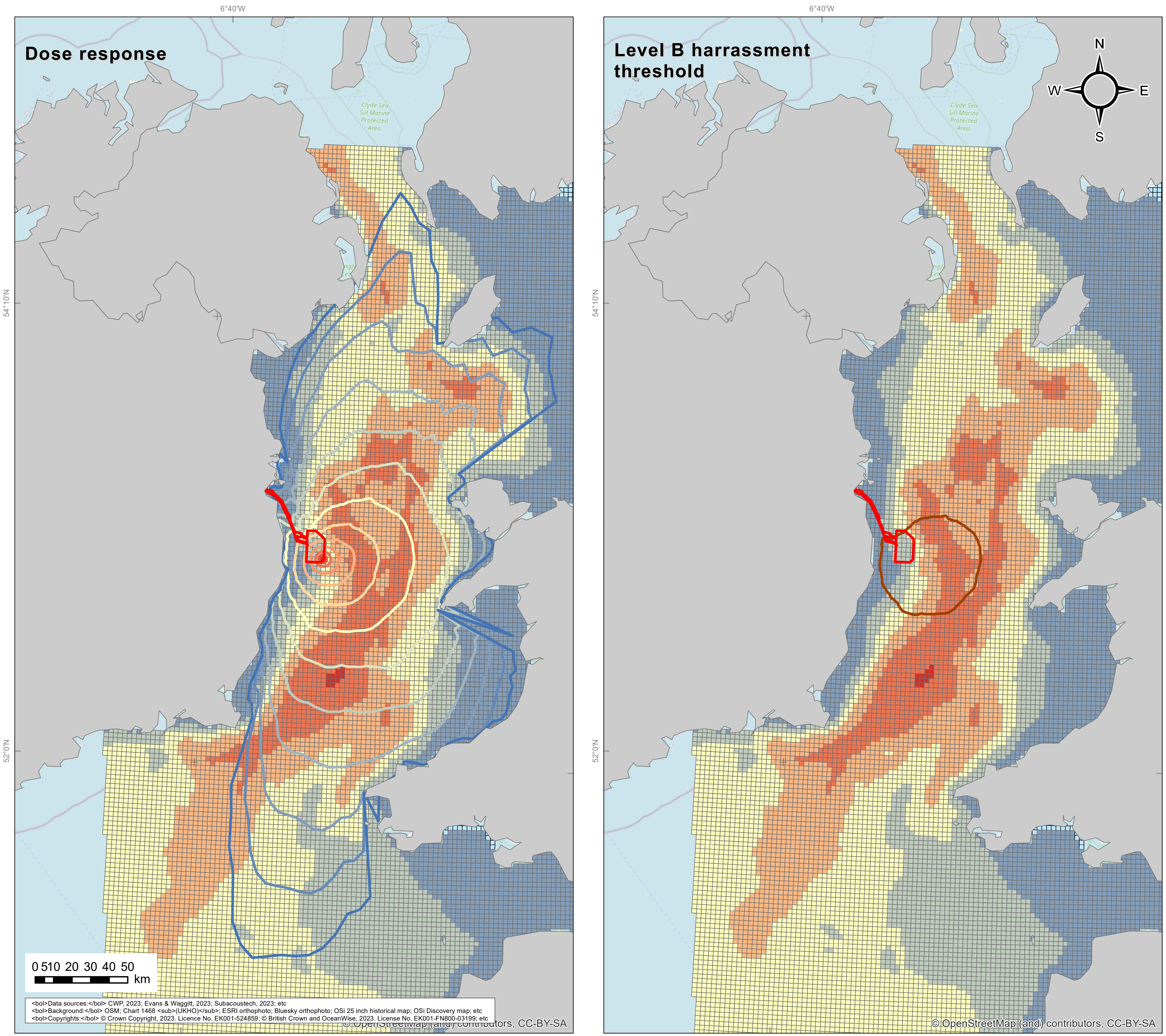
Figure 11.10:
Disturbance contours for piling at the southeast location overlain on the SCANS III minke whale density surface

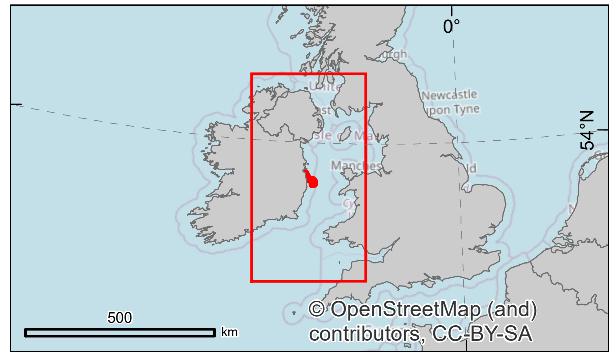
CWP doc. number: CWP-SMR-ENG-08-01-MAP-1595

Internal descriptive code: IS - PAB..DPNM.CONT.WTG.SE..THRESH.B - MINKE. WHALE.DENS.L2020 - (EIAR.Vol.03.Ch.11.FIG.08)

Size: A3
Scale: 1:2,000,000
CRS: EPSG 25830

Rev.	*Updates*	*Date*	*By*	*Chk'd*	*App'd*
00	Final for issue	2024/07/16	JC	RRS/EA	EA





Legend

- Planning application boundary
- SEL_{ss} dB re μPa^{2}s (5dB) SE
  - 120 dB
  - 125 dB
  - 130 dB
  - 135 dB
  - 140 dB
  - 145 dB
  - 150 dB
  - 155 dB
  - 160 dB
  - 165 dB
  - 170 dB
  - 175 dB
  - 180 dB
- Level B threshold 160 dB re 1 μPa (SPL_{RMS})
- Evans & Waggitt 2023 minke whale density
  - 0.00
  - 0.0001 - 0.005
  - 0.005 - 0.01
  - 0.01 - 0.015
  - 0.015 - 0.02
  - 0.02 - 0.025
  - >0.025

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Figure 11.11:
Disturbance contours for piling at the southeast location overlain on the minke whale density surface

CWP doc. number: CWP-SMR-ENG-08-01-MAP-1596

Internal descriptive code: IS - PAB..DPNM.CONT.WTG.SE..THRESH.B - MINKE.WHALE.DENS.EW2023 - (EIAR.Vol.03.Ch.11.FIG.09)

Size: A3

Scale: 1:2,000,000

CRS: EPSG 25830

Rev.	Updates	Date	By	Chk'd	App'd
00	Final for issue	2024/07/16	JC	RRS/EA	EA

Receptor sensitivity

329. 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; 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*.,* 2013). There is only one study showing minke whale reactions to sonar signals (Sivle et al*.,* 2015) with behavioural response severity scores above 4 (the stage at which avoidance to a sound source first occurs) for a received SPL of 146 dB re 1µPa (score 7) and a received SPL of 158 dB re 1µPa (score 8). There is a study detailing minke whale responses to a Lofitech ADD which has a source level of 204 dB re 1µPa @ 1 m, which showed minke whales within 500 m and 1,000 m of the source exhibiting a sustained behavioural response. The estimated received level at 1,000 m was 136.1 dB re 1µPa (McGarry et al., 2017). There are no equivalent such studies of responses to pile-driving noise.

330. Since minke whales are known to forage in UK waters in the summer months, there is the potential for displacement to impact on reproductive rates. However, 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, minke whales have been assessed as having a **Low** sensitivity to disturbance from pile driving.

Significance of the effect

331. The sensitivity of minke whales to disturbance from WTG pile driving has been assessed as **Low** and the magnitude of impact has been assessed as **Negligible.** Therefore, significance of the effect is assessed as **Negligible (Not significant).**

Mitigation

332. All WTG piling activity will follow procedures set out in the WTG/OSS piling **MMMP** (section 8 of the **MMMP**), as per NPWS (2014). The purpose of the WTG/OSS piling **MMMP** is to minimise the impact of auditory injury (PTS) from piling.

333. No specific mitigation is required to reduce the disturbance impact as the impact is not considered significant.

Residual effect

334. The residual effect of disturbance from WTG piling to minke whales remains as **Negligible (Not significant).**

Harbour seals

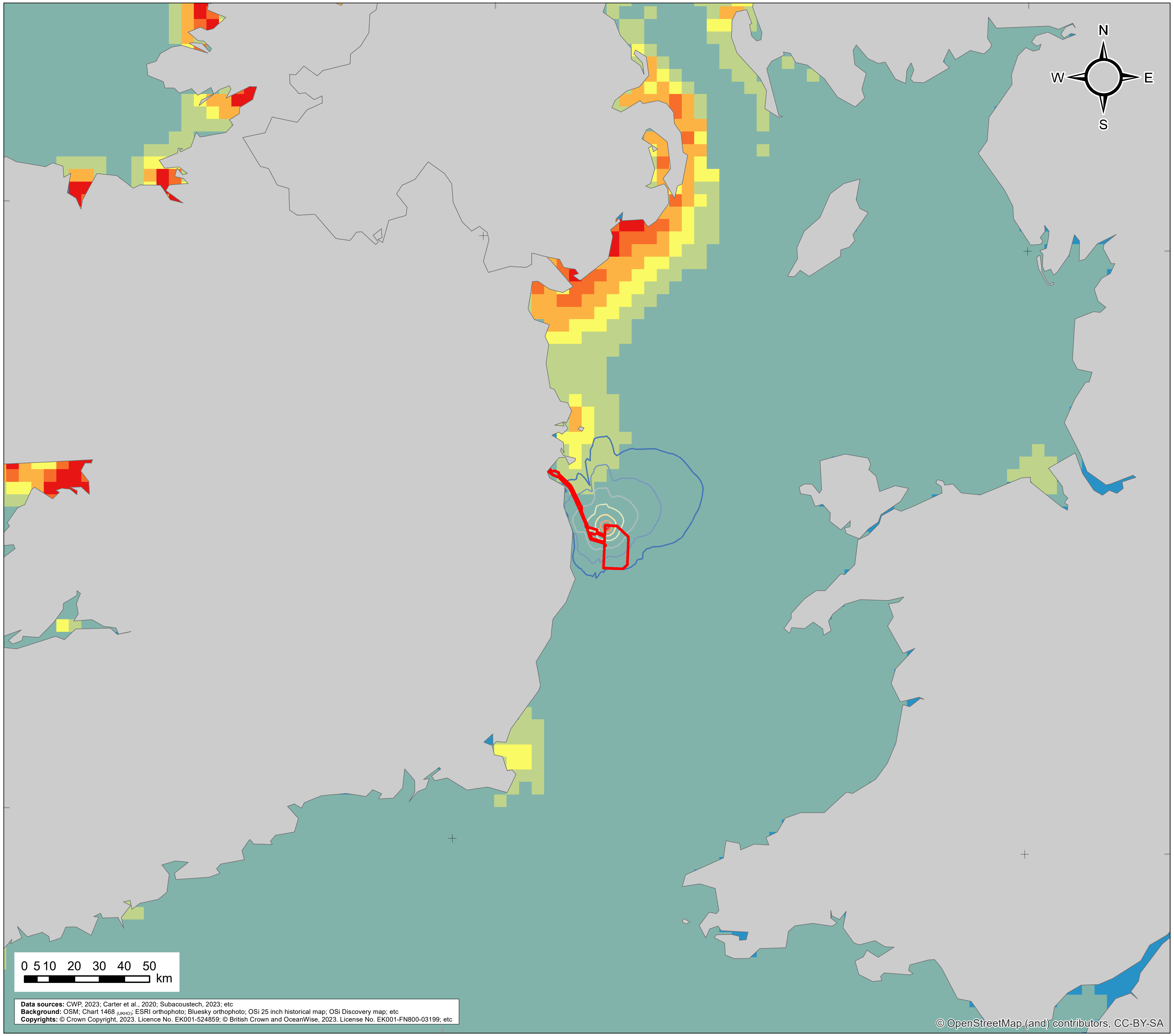
Magnitude of impact

335. The maximum number of harbour seals predicted to be disturbed on a single piling day using the harbour seal dose-response function is six seals, equating to 0.44% of the MU when a monopile foundation is installed at the NW location (**Table 11-44**). The NW location generates the highest

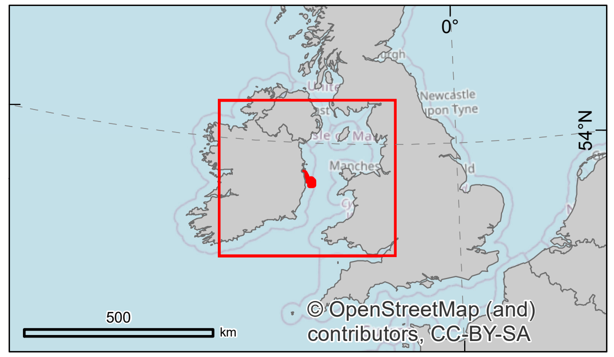
predicted impact to harbour seals given the underlying density surface which identifies higher densities of harbour seals to the north west of the CWP Project. This is considered to be a **Negligible** magnitude since the disturbance is expected to be temporary and short term, will occur over less than a year (maximum 78 days WTG piling) and is predicted to impact a very small proportion of the MU population, which is not expected to result in any change to the population trajectory and therefore iPCoD modelling was not undertaken.

Table 11-44 Harbour seal predicted disturbance from WTG piling

		SE	SW	NE	NW
Dose-response function					
Habitat preference map (Carter et al., 2020, Carter et al., 2022)	# animals	1	1	5	6
	95% CI	0–3	0–8	0–10	0–11
	% MU	0.07	0.07	0.37	0.44
	95% CI	0.00–0.22	0.00–0.59	0.00–0.73	0.00–0.81



Data sources: CWP, 2023; Carter et al., 2020; Subacoustech, 2023; etc
Background: OSM; Chart 1468 (UKHO); ESRI orthophoto; Bluesky orthophoto; OSi 25 inch historical map; OSi Discovery map; etc



Legend

Planning application boundary

SEL_{ss} dB re μPa^{2}s (5dB) NW location
- 145 dB
- 150 dB
- 155 dB
- 160 dB
- 165 dB
- 170 dB
- 175 dB
- 180 dB

% British Isles At-Sea Population of Harbour Seal per cell
- 0.00
- 0.00 - 0.001
- 0.001 - 0.005
- 0.005 - 0.01
- 0.01 - 0.025
- 0.025 - 0.05
- >0.05

Project: Codling Wind Park

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Figure 11.12:
Disturbance contours for piling at the Northwest location overlain on the harbour seal density surfaces

CWP doc. number: CWP-SMR-ENG-08-01-MAP-1597

Internal descriptive code: IS - PAB..DPNM.CONT.WTG.NW - HARBOUR. SEAL.DENS.C2020 - (EIAR.Vol.03.Ch.11.FIG.10)	*Size:* A3 *Scale:* 1:1,500,000	*CRS:* EPSG 25830

Rev.	*Updates*	*Date*	*By*	*Chk'd*	*App'd*
00	Final for issue	2024/07/16	JC	RRS/EA	EA

Receptor sensitivity

336. A study of tagged harbour seals in the Wash has shown that they are displaced from the vicinity of piles during impact piling activities. Russell et al., (2016a) 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 impact piling 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 piling 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.

337. At an expert elicitation workshop in 2018 (Booth et al., 2019), experts assessed the most likely potential consequences of a six-hour period of zero energy intake for harbour seals, assuming that disturbance (from exposure to low frequency broadband pulsed noise, e.g., impact piling, airgun pulses) 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 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 (**Plate 11-20** left); however, there was a large amount of uncertainty in this estimate. 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 (**Plate 11-20** right); however, again, there was a lot of uncertainty surrounding this estimate. It is considered unlikely that individual harbour seals would repeatedly return to a site where they had been previously displaced from in order to experience this number of days of repeated disturbance.

338. Based on the evidence presented above, due to observed responsiveness to piling, harbour seals have been assessed as having a **Low** sensitivity to disturbance and resulting displacement from foraging grounds during impact piling events.

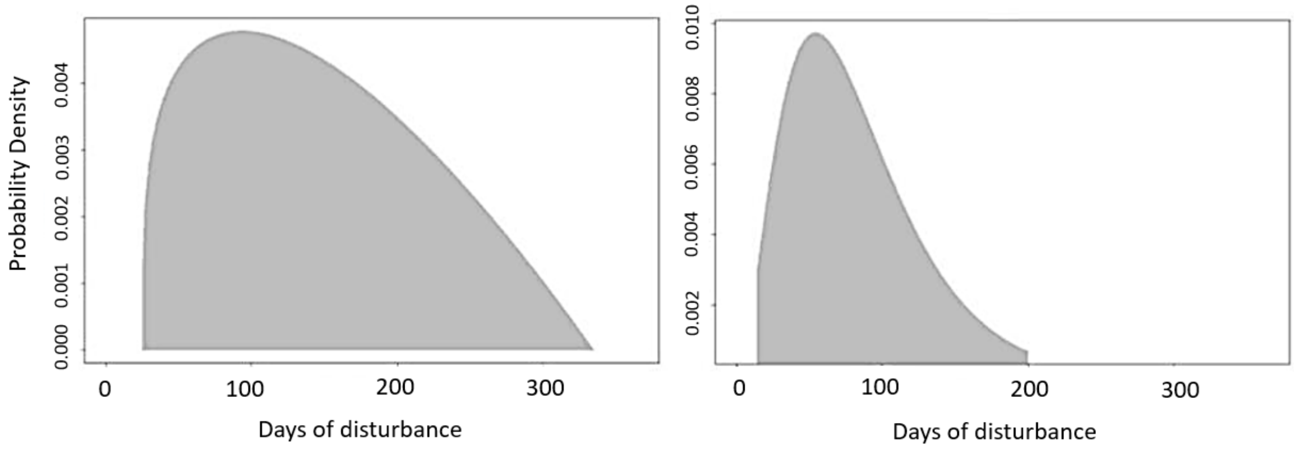


Plate 11-20 Probability distributions showing the consensus of the expert elicitation for harbour seal disturbance from piling. X-axis = days of disturbance; y-axis = probability density. Left: the number of days of disturbance (i.e., days on which an animal does not feed for six hours) a pregnant female 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. Figures obtained from Booth et al. (2019).

Significance of the effect

339. The sensitivity of harbour seals to disturbance from WTG pile driving has been assessed as **Low** and the magnitude of impact has been assessed as **Negligible.** Therefore, significance of the effect is assessed as **Negligible (Not significant).**

Mitigation

340. All WTG piling activity will follow procedures set out in the WTG/OSS piling **MMMP** (section 8 of the **MMMP**), as per NPWS (2014). The purpose of the WTG/OSS piling **MMMP** is to minimise the impact of auditory injury (PTS) from piling.

341. No specific mitigation is required to reduce the disturbance impact as the impact is not considered significant.

Residual effect

342. The significance of the residual effect of disturbance from WTG piling to harbour seals remains as **Negligible (Not significant).**

Grey seals

Magnitude of impact

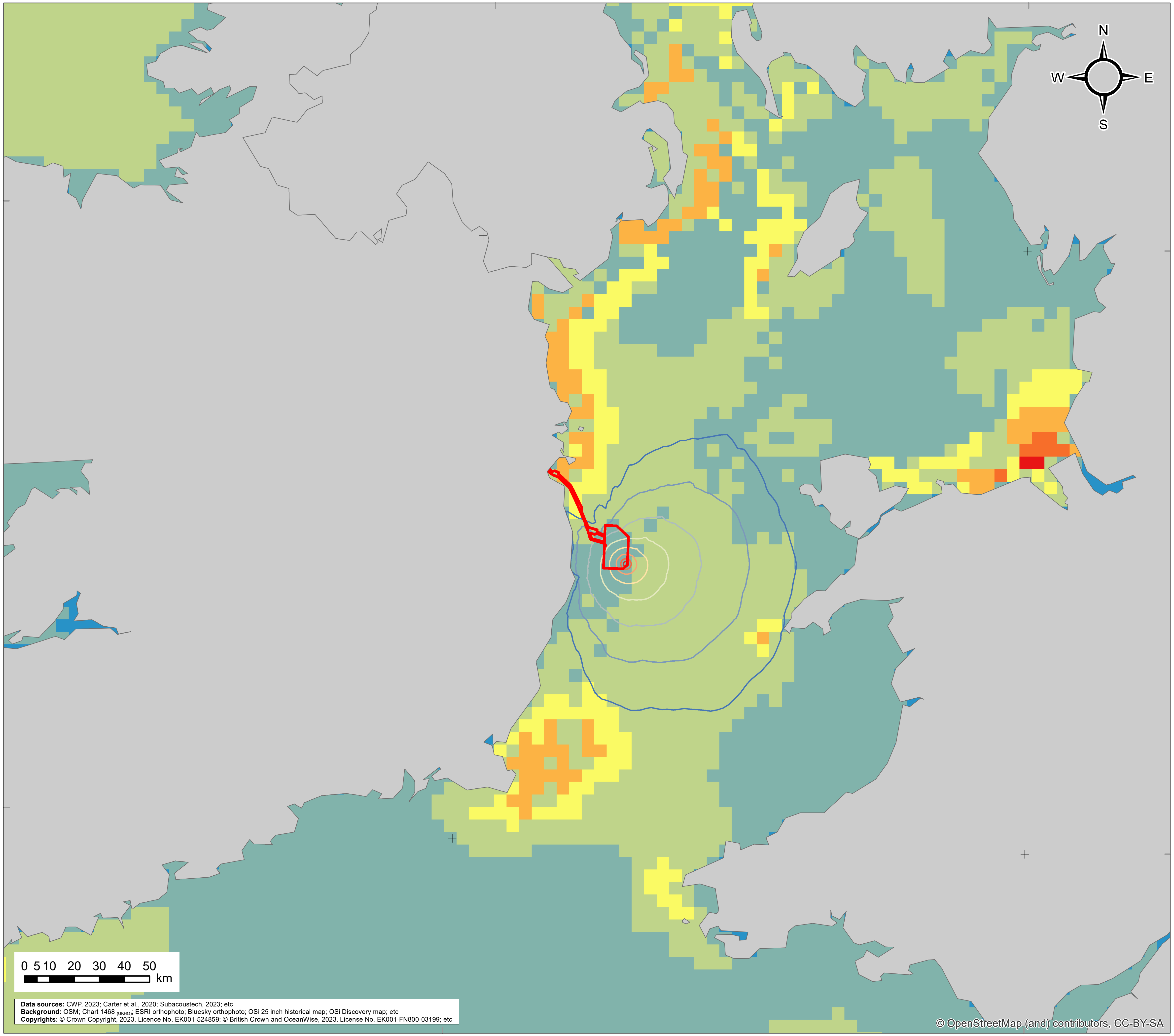
343. The maximum number of grey seals predicted to be disturbed on a single piling day using the harbour seal dose-response function is 394 seals, equating to 6.51% of the MU when a monopile foundation is installed at the SE location (**Table 11-45**). To determine the magnitude of this impact on a population

level, iPCoD modelling was conducted. The modelling assumed 78 WTG piling days between April and October 2027 and that 394 grey seals are disturbed on every piling day (based on the SE modelling). This is highly precautionary since the modelling shows that the number of animals impacted at other modelling locations (west locations) is much lower.

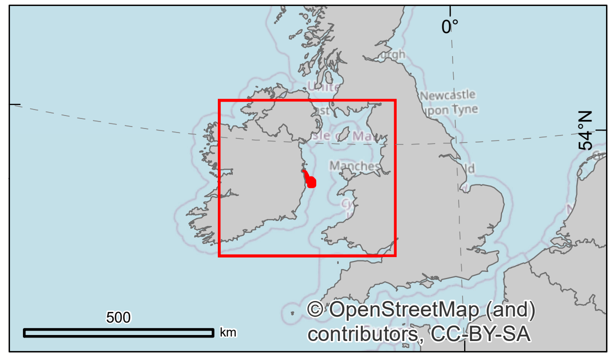
344. The iPCoD results show that the level of disturbance is not sufficient to result in any changes at the population level, since the impacted population is predicted to continue on the same stable trajectory as the unimpacted population (**Table 11-46**). This is considered to be a **Negligible** magnitude since the disturbance is expected to be temporary and short term, will occur over less than a year (maximum 78 days WTG piling) and is predicted to impact a very small proportion of the MU population, which is not expected to result in any change to the population trajectory.

Table 11-45 Grey seal predicted disturbance from WTG piling

		SE	SW	NE	NW
Dose-response function					
Habitat preference map (Carter et al., 2020, Carter et al., 2022)	# animals	394	139	271	136
	95% CI	34–770	9–279	22–529	11–266
	% MU	6.51	2.30	4.47	2.25
	95% CI	0.56–12.71	0.15–4.61	0.36–8.74	0.18–4.39



Data sources: CWP, 2023; Carter et al., 2020; Subacoustech, 2023; etc
Background: OSM; Chart 1468 (UKHO); ESRI orthophoto; Bluesky orthophoto; OSi 25 inch historical map; OSi Discovery map; etc



Legend

- Planning application boundary
- SEL_{ss} dB re μPa^2s (5dB) SE location
  - 145 dB
  - 150 dB
  - 155 dB
  - 160 dB
  - 165 dB
  - 170 dB
  - 175 dB
  - 180 dB
- % British Isles at-sea population of grey seal per cell
  - 0.00
  - 0.00 - 0.001
  - 0.001 - 0.005
  - 0.005 - 0.01
  - 0.01 - 0.025
  - 0.025 - 0.05
  - >0.05

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Figure 11.13:
Disturbance contours for piling at the Southeast location overlain on the grey seal density surfaces

CWP doc. number: CWP-SMR-ENG-08-01-MAP-1097

Internal descriptive code: IS - PAB..DPNM.CONT.WTG.SE - GREY. SEAL.DENS.C2020 - (EIAR.Vol.03.Ch.11.FIG.11)

Size: A3
Scale: 1:1,500,000

CRS: EPSG 25830

Rev.	Updates	Date	By	Chk'd	App'd
00	Final for issue	2024/07/16	JC	RRS/EA	EA

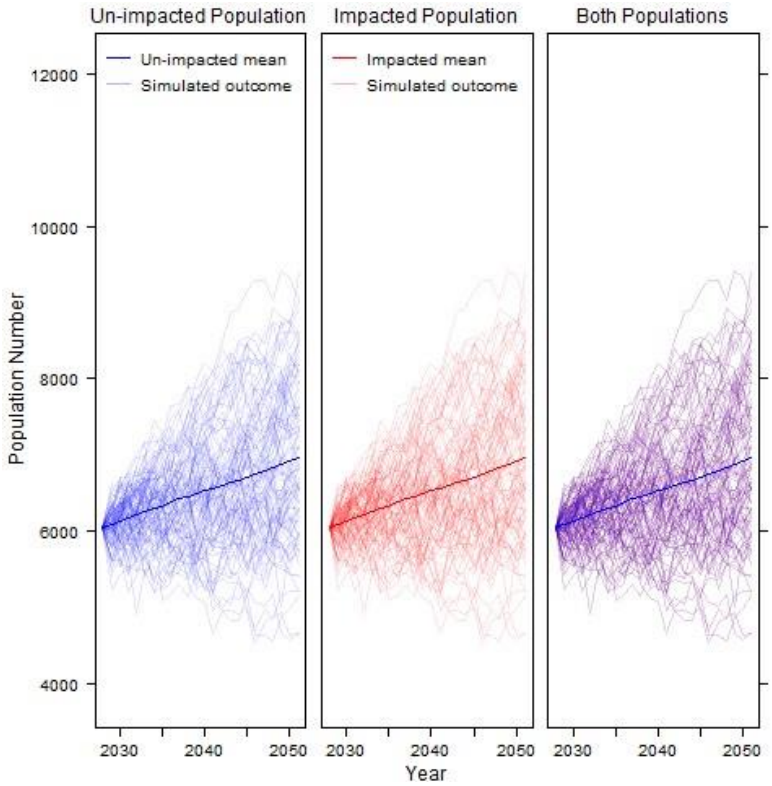

Plate 11-21 Predicted mean population trajectory for the unimpacted (baseline) and impacted grey seal iPCoD simulations (78 days piling in 2027), impacting 394 grey seals per day

Table 11-46 Predicted mean population size for the unimpacted (baseline) and impacted grey seal iPCoD simulations (78 days piling in 2027), impacting 394 grey seals per day

	Unimpacted population mean size	Unimpacted population mean size	Impacted population as a proportion of the unimpacted population
Start 2027 (before piling commences)	6,054	6,054	100.0%
End 2027 (after piling ends)	6,079	6,079	100.0%
End 2033 (6 years after piling ends)	6,330	6,330	100.0%
End 2039 (12 years after piling ends)	6,557	6,557	100.0%
End 2045 (18 years after piling ends)	6,790	6,790	100.0%

Receptor sensitivity

345. 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 windfarms: 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.

346. 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. Potential reasons for these differences in responses include 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. The telemetry data also showed that seals returned to the pile driving area after pile driving ceased. While this evidence base is from studies of grey seals tagged in the Wadden Sea, it is expected that grey seals in the Irish Sea would respond in a similar way, and therefore the data are considered to be applicable.

347. 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 the 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 (**Plate 11-22** 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 (**Plate 11-22** right); however, there was a lot of uncertainty surrounding this estimate.

348. Grey seals are capital breeders 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.

349. In an experimental study on captive seals, Hastie et al., (2021) found that grey seal avoidance rates in response to pile driving sounds were dependent on the quality of the prey patch, with grey seals continuing to forage at high density prey patches when exposed to pile driving sounds but showing reduced foraging success at low density prey patches when exposed to pile driving sounds. Additionally, the seals showed an initial aversive response to the pile driving playbacks (lower proportion of dives spent foraging) but this diminished during each trial. Therefore, the likelihood of grey seal response is expected to be linked to the quality of the prey patch.

350. Based on the evidence presented above, 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.

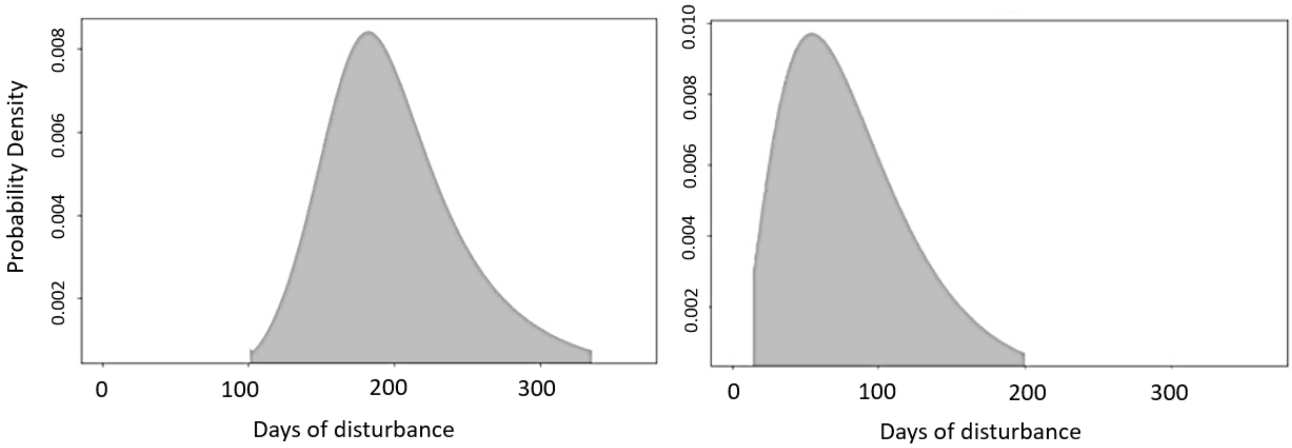

Plate 11-22 Probability distributions showing the consensus of the expert elicitation for grey seal disturbance from piling (Booth et al., 2019). Left: the number of days of disturbance (i.e., days on which an animal does not feed for six hours) a pregnant female could 'tolerate' before it has any effect on fertility. Right: the number of days of disturbance (of six hours zero energy intake) a 'weaned of the year' grey seal could 'tolerate' before it has any effect on survival.

Significance of the effect

351. The sensitivity of grey seals to disturbance from WTG pile driving has been assessed as **Negligible** and the magnitude of impact has been assessed as **Negligible.** Therefore, significance of the effect is assessed as **Negligible (Not significant)**.

Mitigation

352. All WTG piling activity will follow procedures set out in the WTG/OSS piling **MMMP** (section 8 of the **MMMP**), as per NPWS (2014). The purpose of the WTG/OSS piling **MMMP** is to minimise the impact of auditory injury (PTS) from piling.

353. No specific mitigation is required to reduce the disturbance impact as the impact is not considered significant.

Residual effect

354. The significance of the residual effect of disturbance from WTG piling to grey seals remains as **Negligible (Not significant)**.

Impact 7: Auditory injury (PTS) from piling – onshore substation

Magnitude of impact

355. The maximum number of marine mammals predicted to experience auditory injury (PTS) on a single piling day is one harbour porpoise (**Table 11-47**). While the number of marine mammals and proportion

of their respective MUs predicted to experience PTS-onset is low, PTS is a permanent effect, and thus the magnitude of unmitigated impact is **Medium**.

Table 11-47 Predicted auditory injury (PTS, SEL_{cum}) from piling at the onshore substation

	LF	HF	VHF	PCW
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}) 1 vessel				
Area (km^2)	0.7	<0.01	1.5	<0.1
Max range (m)	1,100	<50	2,000	130
# animals	<1	BND: <1 CD: <1 RD: <1	<1	HS: <1 GS: <1
Cumulative PTS (SEL_{cum}) 2 vessels				
Area (km^2)	1.4	<0.1	2.8	<0.1
Max range (m)	2,000	<100	3,000	300
# animals	MW: <1	BND: <1 CD: <1 RD: <1	HP: 1	HS: <1 GS: <1

Receptor sensitivity

356. As detailed above for WTG piling (**Impact 5: Auditory injury (PTS) from piling – WTGs**, the sensitivity of marine mammals to auditory injury from pile driving has been assessed as follows:

- Harbour porpoise: Low;
- Dolphins: Low;
- Minke whale: Low; and
- Seals: Low.

Significance of the effect

357. The sensitivity of all marine mammals to auditory injury from pile driving has been assessed as **Low** and the magnitude of impact has been assessed as **Medium**. Therefore, significance of the impact is assessed as **Minor (Not significant)**.

Additional mitigation

358. All WTG piling activity will follow procedures set out in the WTG/OSS piling **MMMP** (section 8 of the **MMMP**), as per NPWS (2014). The purpose of the WTG/OSS piling **MMMP** is to minimise the impact of auditory injury (PTS) from piling.

Residual effect

359. The significance of the residual effect of auditory injury (PTS) from onshore substation piling to all marine mammals remains as **Negligible (Not significant).**

Impact 8: Disturbance from piling – onshore substation

Magnitude of impact

360. The maximum number of marine mammals predicted to be disturbed on a single piling day at the onshore substation is three harbour porpoise (**Table 11-48**). This is considered to be a **Negligible** magnitude for all species since the disturbance is expected to be temporary and short term, will occur over less than a year and is predicted to impact a very small proportion of the MU population, which is not expected to result in any change to the population trajectory.

Table 11-48 Predicted disturbance from piling at the onshore substation

Species	Density (#/km^2)[16]	# animals
Harbour porpoise	0.2803 (SCANS IV)	3
Bottlenose dolphin	0.2352 (SCANS IV)	2
Common dolphin	0.0272 (SCANS IV)	<1
Risso's dolphin	0.0022 (SCANS IV)	<1
Minke whale	0.0137 (SCANS IV)	<1
Harbour seal	Grid cell specific (Carter et al., 2020, 2022)	<1 (0–<1)
Grey seal	Grid cell specific (Carter et al., 2020, 2022)	1 (0–1)

Receptor sensitivity

361. As detailed above for WTG piling (**Impact 6: Disturbance from piling – WTGs**), the sensitivity of marine mammals to disturbance from pile driving has been assessed as follows:

- Harbour porpoise: Low;
- Dolphins: Low;
- Minke whale: Low;

[16] Note: the onshore substation modelling location was outside of both the SCANS III density surface (Lacey *et al.*, 2022) and the Irish Sea density surface (Evans and Waggitt, 2023). Therefore the SCANS IV block density is the only one used for cetaceans.

- Harbour seals: Low; and
- Grey seals: Negligible.

Significance of the effect

362. The sensitivity of all marine mammals to disturbance from pile driving has been assessed as **Negligible** to **Low** and the magnitude of impact has been assessed as **Negligible.** Therefore, significance of the effect is assessed as **Negligible (Not significant)**.

Additional mitigation

363. All piling activity will follow procedures set out in the onshore substation piling **MMMP** (section 9 of the **MMMP**), as per NPWS (2014). The purpose of the onshore substation piling **MMMP** is to minimise the impact of auditory injury (PTS) from piling.

364. No specific additional mitigation is required to reduce the disturbance impact as the impact is not considered significant.

Residual effect

365. The significance of the residual effect of disturbance from onshore substation piling to all marine mammals remains as **Negligible (Not significant)**.

Impact 9: Auditory injury (PTS) from other construction activities

366. During the construction of the CWP Project, boulder clearance (plough or subsea grab), Pre-lay Grapnel Run. Sandwave reduction (dredger or mass flow excavation), IAC burial (jetting, trenching or ploughing) activities are proposed. Each of these activities is an additional underwater noise generating activity occurring in the marine environment. As such, the PTS-onset impact ranges for cable laying, dredging, drilling, trenching and rock placement activities are assessed below.

Magnitude of impact

367. For all non-piling construction activities assessed (**Table 11-49**), the PTS-onset impact ranges are <100 m. Non-piling construction noise sources will have an extremely local spatial extent and will be transient and intermittent. While auditory injury is a permanent effect from which an animal cannot recover, no animals are expected to be within the impact ranges for PTS-onset predicted in **Table 11-49** and thus the overall magnitude for all non-piling construction noise is **Negligible**.

Table 11-49 Auditory injury impact ranges for non-piling construction noise (using weighted SEL_{cum})

	LF (199 dB)	HF (198 dB)	VHF (173 dB)	PCW (201 dB)
Dredging (Backhoe)	<100 m	<100 m	<100 m	<100 m
Dredging (Suction)	<100 m	<100 m	<100 m	<100 m
Drilling	<100 m	<100 m	<100 m	<100 m
Cable laying	<100 m	<100 m	<100 m	<100 m
Trenching	<100 m	<100 m	<100 m	<100 m
Rock placement	<100 m	<100 m	<100 m	<100 m

Receptor sensitivity

Dredging

368. 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). For the offshore CWP Project, dredging will potentially be required for seabed preparation work for foundations as well as for export cable, array cable and interconnector cable installations. 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).

369. 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**.

370. 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., 2014b). 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 whale to PTS from dredging is precautionarily assessed as **Medium**.

Drilling

371. 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 windfarm suggest that the sound produced has a fundamental frequency at 125 Hz (Nedwell et al., 2003).

372. 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**.

373. 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 drilling is precautionarily assessed as **Medium**.

Cable laying

374. 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.

375. 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**.

376. 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**.

Trenching

377. 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).

378. 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**.

379. 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**.

Rock placement

380. 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.

381. Therefore, the sensitivity of harbour porpoise, dolphins and seals to PTS from rock placement is expected to be **Low**.

382. 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**.

Significance of the effect

383. The sensitivity of porpoise, dolphins and seals to auditory injury (PTS) from other construction activities has been assessed as **Low** and the magnitude of impact has been assessed as **Negligible**. Therefore, significance of the effect is assessed as **Negligible (Not significant)**.

384. The sensitivity of minke whales to auditory injury (PTS) from other construction activities has been assessed as **Medium** and the magnitude of impact has been assessed as **Negligible**. Therefore, significance of the effect is assessed as **Minor (Not significant)**.

Additional mitigation

385. As the assessment of auditory injury on marine mammals from pre-construction survey equipment has been assessed as **Negligible** to **Minor (Not significant)**, no additional mitigation measures have been proposed.

Residual effect

386. The significance of the residual effect of auditory injury from other construction activities to all marine mammals remains as **Minor (Not significant).**

Impact 10: Disturbance from other construction activities

387. During the construction of the CWP Project, boulder clearance (plough or subsea grab), Pre-lay Grapnel Run. Sandwave reduction (dredger or mass flow excavation), IAC burial (jetting, trenching or ploughing) activities are proposed. Each of these activities is an additional underwater noise generating activity occurring in the marine environment. As such, disturbance impacts for cable laying, dredging, drilling, trenching and rock placement activities are assessed below.

All cetaceans

Magnitude of impact

Dredging

388. Harbour porpoise: Dredging activities with a source level of 184 dB re 1 μPa @ 1 m have been noted to result in harbour porpoise avoidance responses 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 (~3 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).

389. Other dolphin species: 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).

390. Minke whale: 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).

Drilling

391. Information on the disturbance effects of drilling 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).

392. Whilst information is not available for the species of concern for the CWP Project, 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, for which more information is available for species relevant to the CWP 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, as this literature is considered slightly outdated.

Other activities

393. 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).

Summary

394. 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 cetacean species since the impact will be of short-term duration, will occur intermittently at low intensity and is expected to be of limited spatial extent.

Receptor sensitivity

395. 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 attributable 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).

396. 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 windfarm 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.**

397. 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 five weeks (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., 2017b). 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**.

398. 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**.

Significance of the effect

399. The sensitivity of all cetaceans to disturbance from other construction activities has been assessed as **Low** and the magnitude of impact has been assessed as **Low**. Therefore, significance of the effect is assessed as **Minor (Not significant).**

Additional mitigation

400. As the assessment of disturbance to cetaceans from other construction activities has been assessed as Minor (Not significant), no additional mitigation measures have been proposed.

Residual effect

401. The significance of the residual effect of disturbance from other construction activities remains as **Minor (Not significant).**

Seals

Magnitude of impact

Dredging

402. Grey and harbour seal: 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).

Drilling

403. Impacts of disturbance on seals associated with drilling are thought to be synonymous with those assessed for cetaceans. As such, 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.

Other activities

404. Impacts of disturbance on seals associated with other activities are thought to be synonymous with those assessed for cetaceans. As such, any impact related to acoustic surveys, dredging, rock trenching, pipe laying and rock placement activities are thought to be localised and temporary.

Summary

405. 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 seal 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.

Receptor sensitivity

406. 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 windfarm, 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. The array site is located in a relatively low-density area for both species of seal (compared to the coastal waters surrounding Orkney and the Moray Coast), and thus it is not expected that any short term-local displacement caused by other non-piling 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 **Very Low**.

Significance of the effect

407. The sensitivity of all seals to disturbance from other construction activities has been assessed as **Very Low** and the magnitude of impact has been assessed as **Low.** Therefore, significance of the effect is assessed as **Negligible (Not significant)**.

Additional mitigation

408. As the assessment of disturbance to cetaceans from other construction activities has been assessed as **Negligible (Not significant)**, no additional mitigation measures have been proposed.

Residual effect

409. The significance of the residual effect of disturbance from other construction activities remains as Negligible **(Not significant)**.

Impact 11: Vessel collision

410. The area surrounding the CWP Project already experiences high levels of vessel traffic. As outlined in the shipping and navigation baseline (**Appendix 16.3 Navigational Risk Assessment**), the vessel levels vary:

- Summer 2022 (14 survey days): on average, the number of vessels present in the study area was 54 unique vessels (min: 38, max: 70). The vessel types included: recreational vessels (35%), cargo ships (29%), fishing vessels (14%), unspecified vessels (8%), tankers (7%), other (4%) and passenger vessels (3%).
- Summer 2021 (57 survey days): on average, the number of vessels present in the study area was 37 unique vessels (min: 8, max: 63). The vessel types included: recreational vessels (35%), unspecified vessels (25%), cargo ships (15%), fishing vessels (10%), tankers (8%), passenger vessels (6%) and other vessels (2%).

411. Most of the vessels in the area passes either offshore or inshore of the array site, which is reflective of the vessels avoiding the local shallow banks.

412. 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 influenced by ambient noise levels underwater and the behaviour the marine mammal is engaged in.

413. 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 RoI that injury from vessel collisions is an important source of mortality. In the UK, the 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, 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.

414. 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, Lusseau et al., 2009).

Receptor sensitivity

415. 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 cause mortality. 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.

Magnitude of impact

416. It is highly likely that a proportion of vessels will be stationary or slow moving throughout construction activities for significant periods of time as a result of measures introduced through the Ecological Vessel Management Plan (EVMP). In addition, 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 vicinity of the CWP Project, the introduction of additional vessels during construction of the CWP Project is not a novel impact for marine mammals present in the area.

417. It is not expected that the level of vessel activity during construction would cause an increase in the risk of mortality from collisions. Therefore, the magnitude of the risk of vessel collisions occurring is **Negligible**.

Significance of the effect

418. The sensitivity of all marine mammals to vessel collision has been assessed as **High** and the magnitude of impact has been assessed as **Negligible** with the adoption of an embedded EVMP. Therefore, significance of the effect is assessed as **Minor (Not significant)**.

Additional mitigation

419. The CWP Project has committed to an EVMP as embedded mitigation, which will ensure that vessel traffic moves along predictable routes and will define how vessels should behave in the presence of marine mammals. The magnitude of impact has been remains as **Negligible** with the adoption of an embedded EVMP.

Residual effect

420. The significance of the residual effect of vessel collisions with marine mammals remains as **Minor (Not significant)**.

Impact 12: Disturbance from vessels

421. 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). 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.

422. Vessel noise levels from construction vessels will result in an increase in non-impulsive, continuous sound in the vicinity of the CWP Project, typically in the range of 10–100 Hz (although higher frequencies will also be produced) (Erbe et al., 2019) with an estimated source level of 161–168 dB re 1 µPa @ 1m (RMS) for medium and large construction vessels, travelling at a speed of 10 knots (**Appendix 9.4: UWN Assessment**).

423. 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 1 µPa, 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.

424. The area surrounding CWP Project already experiences high levels of vessel traffic. As outlined in the shipping and navigation baseline (**Appendix 16.3 Navigational Risk Assessment**), the vessel levels vary (see Paragraphs 410 and 411).

425. Therefore, the introduction of additional vessels during construction of the CWP Project is not a novel impact for marine mammals present in the area. However, as vessel presence is likely to impact each marine mammal species differently, the impacts of disturbance from vessel presence have been considered on a species-by-species basis. This includes a quantitative assessment on the number of individuals, and percentage of the MU, for each marine mammal receptor which will experience behavioural disturbance as a result of the presence of construction vessels. Where multiple density estimates for a species were available, the higher value has been used in this impact assessment as a precautionary approach.

426. The results of the quantitative assessment are presented in **Table 11-50** as the estimated number of animals and the percentage of the MU predicted to be disturbed at any one time by a single construction vessel. The following expected disturbance ranges were used in the assessment:

- Harbour porpoise: it has been shown that beyond 4 km no significant effects of construction vessels could be detected (Benhemma-Le Gall et al., 2021a). As such, a 4 km disturbance range has been used to determine the magnitude of impact.
- Bottlenose dolphins: vessels within 400 m of a dolphin group have been found to result in short-term changes to bottlenose dolphin behaviour through both targeted and non-targeted approaches (Bas et al., 2017, Clarkson et al., 2020, Puszka et al., 2021). As such, a 400 m disturbance range has been used to determine the magnitude of impact.
- Common dolphin: vessels within 300 m of a dolphin group have been found to result in short-term changes to common dolphin behaviour (Meissner et al., 2015). As such, a 300 m disturbance range has been used to determine the magnitude of impact.
- Risso's dolphin: no disturbance range has been presented amongst the literature for Risso's dolphins. Thus, a worst-case scenario of 400 m has been used to determine the magnitude of impact as this was the maximum range given in the literature for bottlenose dolphins.
- Minke whale: in baleen whales, observed changes in foraging behaviour were apparent when whale-watching vessels were within ~250 m of an animal (Sullivan and Torres, 2018). As such, a 250 m disturbance range has been used to determine the magnitude of impact.
- Seals: vessel disturbance studies on seals have demonstrated flushing of seals in response to large vessels can occur out as far as 1 km (Young et al., 2014). As such, a 1 km disturbance range has been used to determine the magnitude of impact.

Table 11-50 Estimated number of animals and the percentage of the MU predicted to be disturbed at any one time (i.e., radius from the source, and the area around the source) by construction vessels

Species	Density (animals/km^2)	Disturbance Radius	Area (km^2)	# Impacted	% MU
Harbour porpoise	0.1225 Site specific density estimate	4 km	50.27	6	<0.01%
	0.2803 (Gilles et al., 2023)			14	<0.01%
Bottlenose dolphin	0.2352 (Gilles et al., 2023)	400 m	0.5	<1	<0.1%
Common dolphin	0.2810 Site specific density surface estimate	300 m	0.28	<1	<0.001%
	0.0272 (Gilles et al., 2023)			<1	<0.001%
Risso's dolphin	0.0008 Site specific point density estimate	400 m	0.5	<1	<0.01%
	0.0022 (Gilles et al., 2023)			<1	<0.01%
Minke whale	0.0019 Site specific point density estimate	250 m	0.2	<1	<0.05%
	0.0137 (Gilles et al., 2023)			<1	<0.05%

Species	Density (animals/km^2)	Disturbance Radius	Area (km^2)	# Impacted	% MU
Grey seal	0.1536 seals/km^2 (average across array site and OECC area)	1 km	3.14	<1	<0.01%
Harbour seal	0.0075 seals/km^2 (average across array site and OECC area)			<1	<0.001%

Harbour porpoise

Receptor sensitivity

427. In a large-scale study of harbour porpoise density in UK waters, increased vessel activity was generally associated with lower harbour porpoise densities. However, in northwest Scottish waters, shipping had little effect on the density of individuals given the low shipping densities in the area (Heinänen and Skov, 2015).

428. During the construction of the Beatrice and Moray East offshore windfarms within the Moray Firth, harbour porpoise occurrence decreased with increasing vessel presence, with the magnitude of decrease depending on the distance to the vessel (Benhemma-Le Gall et al., 2021a). For example, the probability of harbour porpoise occurrence at a mean vessel distance of 2 km decreased by up to 95% from a probability of occurrence of 0.37 when no vessels were present to 0.02 for the highest vessel intensity of 9.8 min per km^2 (the sum of residence times for all vessels present in that hour per kilometre squared). At a mean vessel distance of 3 km, the probability decreased by up to 57% to 0.16 for the highest vessel intensity, and no apparent response was observed at 4 km.

429. Additional studies conducted during offshore windfarm construction demonstrated that harbour porpoise detections in the vicinity of the pile driving location decline prior to a piling event (Brandt et al., 2018, Benhemma-Le Gall et al., 2021a). For example, during a study conducted at seven offshore wind farms in the German Bight, Brandt et al. (2018) observed a decline in harbour porpoise detections within 2 km of the construction site, and continued to be reduced for 1 to 2 days after. This was considered to be attributed in part to the increased vessel activity and traffic associated with construction related activities (Brandt et al., 2018). During this study, six of the wind farms used noise abatement techniques to reduce source noise levels. However, it is possible that the use of such techniques may require additional vessel presence or extend the construction timeline, thereby increasing the likelihood of a disturbance response (Brandt et al., 2018, Graham et al., 2019, Thompson et al., 2020). Therefore, management efforts to reduce the risk of injury and disturbance from piling activities must also take into consideration potential increases in disturbance from vessel activity (Graham et al., 2019, Thompson et al., 2020).

430. Behavioural responses of harbour porpoises to vessel noise have also been observed in more controlled conditions. Dyndo et al. (2015) conducted an exposure study using four harbour porpoise contained in a semi-natural net pen and exposed to noise from passing vessels. Behavioural responses were observed as a result of low levels of medium to high frequency vessel noise. During

80 high quality recordings of boat noise, porpoising[17], a stereotypical disturbance behaviour, was observed in 27.5% of cases (Dyndo et al., 2015).

431. Data examining the surfacing behaviour of harbour porpoise in relation to vessel traffic in Swansea Bay from land-based surveys found a significant correlation between harbour porpoise sightings and the number of vessels present. When vessels were up to 1 km away, 26% of the interactions observed were considered to be negative (animal moving away or prolonged diving). The proximity of the vessel being an important factor, with the greatest reaction occurring just 200 m from the vessel. The type of vessel was also relevant, as smaller motorised boats (e.g., jet-ski, speed boat, small fishing vessels), were associated with more negative behaviours than larger cargo ships, although this type of vessel was a less common occurrence (Oakley et al., 2017). Vessels associated with offshore wind farm construction are typically larger than these types of small, motorised vessels, and therefore, it would be anticipated that the behavioural response would not be as severe.

432. Telemetry data can also be used to identify fine-scale changes in behaviour. Between 2012–2016, seven harbour porpoises were tagged in a region of high shipping density in the inner Danish waters and Belt seas. Periods of high vessel noise coincided with erratic behaviour including 'vigorous fluking', bottom diving, interrupted foraging, and the cessation of vocalisations. Four out of six of the animals that were exposed to noise levels above 96 dB re 1 µPa (16 kHz third octave levels) produced significantly fewer buzzes with high quantities of vessel noise. In one case, the proximity of a single vessel resulted in a 15 minute cessation in foraging (Wisniewska et al., 2018).

433. Behaviour-based modelling has indicated the potential for vessel disturbance to have population-level effects under certain circumstances. Nabe-Nielsen et al. (2014) reported that harbour porpoise responses to vessels did not result in further population decline when prey sources recovered fast (after two days), but if prey availability remained low then vessels were estimated to have a significant negative impact on the population. However, whilst this negative trend was estimated, when comparing the theoretical impact of vessel presence versus bycatch, the latter was found to have a greater effect on population size as it causes direct mortality.

434. In conclusion, there is evidence that changes in harbour porpoise behaviour and presence can result from disturbance by vessel presence. Behavioural reactions observed include increased fluking, interrupted foraging, change to vocalisations, prolonged dives and directed movement away from the sound source (Oakley et al., 2017, Wisniewska et al., 2018). Several studies have also observed an increase in vessel presence to correlate with a decrease in harbour porpoise presence (Brandt et al., 2018, Benhemma-Le Gall et al., 2021a). While disturbance from vessels can result in short term changes to porpoise behaviour, it is unlikely to result in alterations in vital rates in the longer term and no population level impacts are expected (unless there is simultaneously a significant impact to their prey species). Therefore, the sensitivity of harbour porpoise to disturbance from vessel activity assessed as **Low**.

Magnitude of impact

435. Benhemma-Le Gall et al. (2021a) found no apparent response of harbour porpoise to construction vessels in the Moray Firth at 4 km. Therefore, a 4 km disturbance range for harbour porpoise disturbance from construction vessels has been used to determine the magnitude of impact (**Table 11-50**). Using the 4 km disturbance radii, up to 14 harbour porpoise individuals are anticipated to be disturbed by construction vessels, which equates to <0.1% of the MU. When considering the impact

[17] Erratic surfacing movements (see https://static-content.springer.com/esm/art%3A10.1038%2Fsrep11083/MediaObjects/41598_2015_BFsrep11083_MOESM2_ESM.mov).

of disturbance from vessel presence and noise, this is predicted to be of local spatial extent, short-term and temporary. In addition, given the percentage of the MU predicted to be impacted, disturbance effects will only impact a very small proportion of the population. As such, the magnitude of disturbance from construction vessel activity can be assessed as **Negligible**.

Significance of the effect

436. The sensitivity of harbour porpoise to disturbance from vessels has been assessed as **Low** and the magnitude of impact has been assessed as **Negligible.** Therefore, significance of the effect is assessed as **Negligible (Not significant)**.

Additional mitigation

437. As the project has already committed to the adoption of an EVMP, no additional mitigation measures are required to reduce the significance of the impact.

Residual effect

438. The significance of the residual effect of vessel collisions with harbour porpoise remains as **Negligible (Not significant)**.

Bottlenose dolphins

Sensitivity

439. Vessel disturbance has been shown to negatively affect foraging activity. Pirotta et al*.* (2015b) used passive acoustic monitoring to quantify how vessel disturbance affected foraging activity. The results indicated a short-term 49% reduction in foraging activity (though this did not vary with noise level), with animals resuming foraging after the vessel had travelled through the area. The susceptibility to disturbance was variable depending on the location and year, suggesting circumstantial impacts of vessel noise on bottlenose dolphins. The study concluded that the physical presence of vessels, and not just the noise created, plays a large role in disturbance responses (Pirotta et al*.*, 2015b). The variability in disturbance from vessels is also observed in Aberdeen harbour, a busy shipping area that is frequently occupied by bottlenose dolphins (Pirotta et al*.*, 2013).

440. A study of Indo-Pacific bottlenose dolphin habitat occupancy along the coast of Western Australia found dolphin density to be negatively affected by vessels at one site, but no significant impact at the other (Marley et al*.*, 2017a). It is hypothesised that, as the latter habitat is a known foraging site, the quality of the habitat impacts the behavioural response to disturbance. Differences in water depth were also hypothesised as important, as the site that was characterised by changes in dolphin density with vessel activity was shallower than the other location (average depths of 1 m and 13 m respectively). Dolphins have been demonstrated to avoid shallow waters as a predator avoidance response, and similar responses have resulted from vessel disturbance (Lusseau, 2006).

441. In the same area of Western Australia, increased vessel presence was also associated with significantly increased swimming speeds for individuals when resting or socialising. In addition, animals exposed to high levels of shipping traffic were found to generally spend more time travelling and less time resting or socialising. Finally, the characteristics of their whistles were found to change with increased broadband exposure, with the greatest variation occurring in the presence of low

frequency noise (Marley et al., 2017b). These findings are further supported by a study of common bottlenose dolphins in Galveston Ship Channel (Piwetz, 2019). The presence of boats was associated with significantly less foraging and socialising activity states. For this population, a significant increase in swimming speeds was observed during the presence of recreational and tourism vessels and shrimp trawlers.

442. Bottlenose dolphins have also been known to exhibit different behavioural responses to different vessel types. In New Zealand, a CATMOD analysis undertaken showed that bottlenose dolphin resting behaviour decreased as the number of tour boats increased (Constantine et al., 2004). In a study conducted in Italy, dolphins exhibited an avoidance response to motorboats once disturbance became too great but changed their acoustic behaviour in response to trawler vessels, presumably to compensate for masking (La Manna et al., 2013). This study also found that bottlenose dolphins would tolerate vessel presence within certain levels and were more likely to leave an area if disturbance was persistent (La Manna et al., 2013). Similarly, high levels of tolerance to vessel disturbance were observed in Aberdeen harbour where vessel traffic is consistently high (Pirotta et al., 2013). Therefore, the degree to which an animal will be disturbed is likely linked to their baseline level of tolerance (Bejder et al., 2009).

443. New et al. (2013) developed a mathematical model simulating the complex interactions of the coastal bottlenose dolphin population in the Moray Firth to determine if an increased rate of disturbance resulting from vessel traffic was biologically significant. The scenario modelled increased vessel traffic from 70 to 470 vessels a year to simulate the potential increase from the proposed offshore development. An increase in commercial vessel traffic only is not anticipated to result in a biologically significant increase in disturbance because the dolphins have the ability to compensate for their immediate behavioural response and, therefore, their health and vital rates are unaffected (New et al., 2013).

444. In conclusion, vessel disturbance can elicit a variety of responses in bottlenose dolphins including changes to foraging behaviour, swim speed, behavioural state and acoustic behaviour, as well as causing avoidance responses (Constantine et al., 2004, La Manna et al., 2013, Pirotta et al., 2015b, Marley et al., 2017a, Marley et al., 2017b). However, bottlenose dolphins have been observed to display tolerance to vessel disturbance, particularly in areas where vessel traffic has always been high (Pirotta et al., 2013). Furthermore, behavioural changes in bottlenose dolphins are not always considered biologically significant (New et al., 2013). The sensitivity of bottlenose dolphins to disturbance from vessel activity is therefore classified as **Low**.

Magnitude of impact

445. Vessels within 400 m of a dolphin group have been found to result in short-term changes to bottlenose dolphin behaviour through both targeted and non-targeted approaches (Bas et al., 2017, Clarkson et al., 2020, Puszka et al., 2021). As such, a 400 m disturbance range has been used to determine the magnitude of impact, Using the 400 m disturbance radii, <1 bottlenose dolphin individual is predicted to be disturbed by vessel presence, which equates to <0.1% of the MU.

446. When considering the impact of disturbance from vessel presence and noise, this is predicted to be of local spatial extent, short-term and reversible. In addition, given the percentage of the MU predicted to be impacted, disturbance effects will only impact a very small proportion of the population. As such, the magnitude of disturbance from vessel activity can be assessed as **Negligible**.

Significance of the effect

447. The sensitivity of bottlenose dolphin to disturbance from vessels has been assessed as **Low** and the magnitude of impact has been assessed as **Negligible.** Therefore, significance of the effect is assessed as **Negligible (Not significant).**

Additional mitigation

448. As the project has already committed to the adoption of an EVMP, no additional mitigation measures are required to reduce the significance of the impact.

Residual effect

449. The significance of the residual effect of vessel collisions with bottlenose dolphin remains as **Negligible (Not significant).**

Common dolphins

Receptor sensitivity

450. There are currently limited studies available regarding the effects of vessel disturbance on short-beaked common dolphins. Of the few studies available, disturbance effects on common dolphins have mainly focused on those from cetacean watching vessels.

451. 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).

452. 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. Therefore, it is assumed that the sensitivity of short-beaked common dolphin to disturbance from vessel activity can be classified as **Low**.

Magnitude of impact

453. As vessels within 300 m of a dolphin group have been found to result in short-term changes to common dolphin behaviour, a 300 m disturbance range has been used to determine the magnitude of impact. Using the 300 m disturbance radii, <1 common dolphin individual is predicted to be disturbed by vessel presence, which equates to <0.1% of the MU.

454. When considering the impact of disturbance from vessel presence and noise, this is predicted to be of local spatial extent, short-term and reversible. In addition, given the percentage of the MU predicted

to be impacted, disturbance effects will only impact a very small proportion of the population. As such, the magnitude of disturbance from vessel activity can be assessed as **Negligible**.

Significance of the effect

455. The sensitivity of common dolphin to disturbance from vessels has been assessed as **Low** and the magnitude of impact has been assessed as **Negligible.** Therefore, significance of the effect is assessed as **Negligible (Not significant).**

Additional mitigation

456. As the project has already committed to the adoption of an EVMP, no additional mitigation measures are required to reduce the significance of the impact.

Residual effect

457. The significance of the residual effect of vessel collisions with common dolphin remains as **Negligible (Not significant)**.

Risso's dolphins

Receptor sensitivity

458. There are currently limited studies available regarding the effects of vessel disturbance on Risso's dolphins. Of the few studies available, disturbance effects on Risso's dolphins have mainly focused on those from cetacean watching vessels.

459. Of the studies available, Bellomo et al. (2021) presented information on the positive, neutral and negative responses of Risso's dolphins to a research vessel in the Gulf of Taranto, Italy. The study highlighted that a neutral response by Risso's dolphins were observed in 81.3% behavioural observations in the presence of a research vessel, whilst negative and positive responses were observed in 17% and 1.7% of cases respectively (Bellomo et al., 2021). Results provided in this study indicated that Risso's dolphins displayed a neutral response in the most of sightings; however, the authors highlighted that further studies are necessary to better understand if the presence of vessels may induce behavioural responses by Risso's dolphins and to what extent these may be classified as disturbance (Bellomo et al., 2021). In addition, as these observations were made when Risso's dolphins were in the presence of only a single vessel, the results of this study may not be useful as inferences of Risso's dolphin behavioural responses in the presence of construction vessels at-sea.

460. By contrast, Visser et al. (2010) explored the behavioural responses of Risso's dolphins to whale watching vessels in the Azores, Portugal. Dolphin behaviour was studied from a land-based lookout, enabling observations of groups in the absence and presence of vessels. The study indicated that changes in resting behaviour were associated with vessel abundance and when more than five vessels were present, Risso's dolphins spent significantly less time resting and socialising (Visser et al., 2010).

461. When considering the impacts of cetacean-watching vessels reported by Visser et al. (2010) to those likely to occur from construction vessel activities, they cannot be directly transposed, as the likely interactions between Risso's dolphins and vessels during the construction of the project are unlikely to be deliberate and targeted to dolphin groups. Therefore, it is assumed that the sensitivity of Risso's dolphin to disturbance from vessel activity can be classified as **Low**.

Magnitude of impact

462. As no disturbance range has been presented amongst the literature for Risso's dolphins, a worst-case scenario of 400 m has been used to determine the magnitude of impact as this was the maximum range given in the literature for all dolphin species assessed. Using the 400 m disturbance radii, <1 Risso's dolphin individual is predicted to be disturbed by vessel presence, which equates to <0.1% of the MU.

463. When considering the impact of disturbance from vessel presence and noise, this is predicted to be of local spatial extent, short-term and reversible. In addition, given the percentage of the MU predicted to be impacted, disturbance effects will only impact a very small proportion of the population. As such, the magnitude of disturbance from vessel activity can be assessed as **Negligible**.

Significance of the effect

464. The sensitivity of Risso's dolphin to disturbance from vessels has been assessed as **Low** and the magnitude of impact has been assessed as **Negligible.** Therefore, significance of the effect is assessed as **Negligible (Not significant)**.

Additional mitigation

465. As the project has already committed to the adoption of an EVMP, no additional mitigation measures are required to reduce the significance of the impact.

Residual effect

466. The significance of the residual effect of vessel collisions with Risso's dolphins remains as **Negligible (Not significant)**.

Minke whales

Receptor sensitivity

467. There are currently limited studies available regarding the effects of vessel disturbance on minke whale. Of the few studies available, minke whale foraging activity has been found to decrease with increased vessel interactions (Christiansen et al., 2013), exemplified by shorter dives and changes in movement patterns. In addition, by analysing the respiration rate of minke whales, energy expenditure was estimated to be 28% higher during boat interactions, regardless of swim speed. Swim speed was also found to increase with vessel presence and these combined physiological and behavioural changes are thought to represent a stress response. As noise levels were not measured within the study, behavioural responses were therefore related to vessel presence. In addition, when considering the temporal and spatial rates of individuals' exposure over an entire season, there appeared to be no potential for a population-level effect of these acute disturbances (Christiansen et al., 2015).

468. Further study by Christiansen and Lusseau (2015) developed a mechanistic model for minke whales to examine the bioenergetic effects of disturbance from whale watching vessels, specifically on foetal growth. The presence of whale watching vessels resulted in an immediate 63.5% reduction in net energy intake. However, the impact of disturbance was considered to be below the threshold value at

which whale watching would have a significant impact on foetal growth as the number of interactions with vessels was low during the feeding season and was, therefore, of negligible impact.

469. When considering the impacts of whale watching vessels 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, and the vessel types and underwater noise produced are very different. However, as there are little empirical data on the behavioural plasticity of minke whale as a result of vessel disturbance, the information presented above is used as a proxy to inform this assessment.

470. As Christiansen and Lusseau (2015) reported negligible impacts of whale watching activity on foetal growth and no potential for a population-level effect from acute disturbances (Christiansen et al., 2015), it is assumed that the sensitivity of minke whale to disturbance from vessel activity can be classified as **Low**.

Magnitude of impact

471. Although an estimated range of disturbance on minke whales from vessel presence has not been presented within the literature, estimated disturbance ranges have been presented for other baleen whale species. For example, Currie et al. (2021) observed changes in the swim direction of humpback whales when whale watching vessels were within ~150 m of the individuals. In gray whales, observed changes in foraging behaviour were apparent when whale-watching vessels were within ~250 m of an animal (Sullivan and Torres, 2018). To remain precautionary, the largest observed range of disturbance has been used to determine the magnitude of impact. Using the 250 m disturbance radii, <1 minke whale individual is predicted to be disturbed by vessel presence, which equates to <0.1% of the MU.

472. When considering the impact of disturbance from vessel presence and noise, this is predicted to be of local spatial extent, short-term and reversible. In addition, given the percentage of the MU predicted to be impacted, disturbance effects will only impact a very small proportion of the population. As such, the magnitude of disturbance from vessel activity can be assessed as **Negligible.**

Significance of the effect

473. The sensitivity of minke whale to disturbance from vessels has been assessed as **Low** and the magnitude of impact has been assessed as **Negligible.** Therefore, significance of the effect is assessed as **Negligible (Not significant).**

Additional mitigation

474. As the project has already committed to the adoption of an EVMP, no additional mitigation measures are required to reduce the significance of the impact.

Residual effect

475. The significance of the residual effect of vessel collisions with minke whale remains as **Negligible (Not significant)**.

Grey and harbour seals

Receptor sensitivity

476. A telemetry study that included the tagging of 28 harbour seals in the UK found high exposure levels of harbour seals to shipping noise (Jones et al., 2017). Twenty individuals may have experienced a temporary threshold shift due to SEL_{cum} exceeding the TTS-threshold for pinnipeds exposed to continuous underwater noise (183 dB re 1 μPa^2) proposed by Southall et al. (2007). The overlap between seals and vessel activity most frequently occurred within 50 km of the coast, and in proximity to seal haul outs. Despite the distributional overlap and high cumulative sound levels, there was no evidence of reduced harbour seal presence as a result of vessel traffic (Jones et al., 2017). The sensitivity of harbour seals to disturbance from vessel activity is therefore classified as **Low**.

477. A combined study of grey seal pup tracks in the Celtic Sea and adult grey seals in the English Channel found that no animals were exposed to cumulative shipping noise that exceeded thresholds for TTS (using the Southall et al., 2019 thresholds) (Trigg et al., 2020). On the northwest coast of Ireland, a study of vessel traffic and marine mammal presence found grey seals sightings decreased with increased vessel activity in the surrounding area, though the effect size was small (Anderwald et al., 2013); and the authors noted that relationships between sightings and vessel numbers were weaker than those with environmental variables such as sea state. The sensitivity of grey seals to disturbance from vessel activity is therefore classified as **Low**.

Magnitude of impact

478. Vessel disturbance studies on seals as the target species have demonstrated flushing of seals in response to large vessels (i.e., cruise ships) can occur out as far as 1 km (Young et al., 2014), whilst alertness in seals at the haul-out site can increase when small vessels (i.e., kayaks and small motor boats) are within 300 m of a seal (Henry and Hammill, 2001). To remain precautionary, the largest observed range of disturbance has been used to determine the magnitude of impact. Using the 1 km disturbance radii, <1 grey seal individual and <1 harbour seal individual is predicted to be disturbed by vessel presence, which equates to <0.01% of the MU for grey seals, and <0.001% of the MU for harbour seals. The impact magnitude is therefore assessed as **Negligible**.

Significance of the effect

479. The magnitude of disturbance from construction vessels has been assessed as **Negligible** and the sensitivity of both seal species has been assessed as **Low.** Therefore, the significance of the effect is **Negligible (Not significant).**

Additional mitigation

480. As the CWP Project has already committed to the adoption of an EVMP, no additional mitigation measures are required to reduce the significance of the impact.

Residual effect

481. The significance of the residual effect of vessel collisions with seals remains as **Negligible (Not significant)**.

Impact 13: Indirect impacts to prey

Receptor sensitivity

482. 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. During construction activities, there is the potential for impacts upon key prey 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.

483. The key prey species for each marine mammal receptor are listed in **Table 11-51**.

Table 11-51 Key prey species of the marine mammal receptors (bold = species present at CWP Project)

Receptor	Site	Key prey species	Reference
Harbour porpoise	Ireland	**Small 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, **small cod**, **silvery cod**, **ling**, **hake**, **Atlantic horse mackerel**, **Atlantic mackerel**, gobies, **sand smelt**, lanternfish, flounder, **plaice**, dab, brill, **sole**, various squid and octopus spp.	Hernandez-Milian et al. (2015)
Common dolphin	British Isles	Seabass, goby, **cod**, cephalopods, **mackerel**, lanternfish, blue whiting.	Brophy et al. (2009)
Risso's dolphin	Ireland	Squid, cuttlefish and octopus.	IWDG[18]
Minke whale	British Isles	**Sandeel**, **herring**, **sprat**, **mackerel**, goby, **Norway pout / poor cod**.	Pierce et al. (2004)
Harbour seal	British Isles	**Lamprey**, eels, **herring**, **salmonids**, **haddock**, pollock, saithe, **whiting**, blue whiting, Norway pout, **poor cod**, bib, **rockling**, **ling**, **hake**, perch, scad, wrasse, **sandeel**, goby, **mackerel**, flounder, dab, **sole**, witch, halibut and squid species.	Gosch et al. (2014)
Grey seal	Ireland	**Atlantic herring**, **sprat**, **salmonids**, pollock, **haddock**, saithe, **whiting**, **poor cod**, rockling, **ling**, wrasse, **Atlantic horse mackerel**,	Kavanagh et al. (2010)

[18] https://iwdg.ie/cms_files/wp-content/uploads/2019/04/Risso_s-dolphin-profile.pdf.

		sandeel, dragonet, red bandfish, **plaice**, flounder, **sole**, squid and octopus species.	

484. 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 (Booth, 2020, Carmen et al., 2021, Eerkes-Medrano et al., 2021) 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.

Magnitude of impact

485. **Chapter 9 Fish, Shellfish and Turtle Ecology** assessed the following impacts of the CWP Project on fish species:

- Temporary habitat disturbance / loss;
- Noise and vibration;
- Temporary disturbance of the seabed leading to increases in SSC and associated deposition;
- Accidental pollution events; and
- The introduction of non-native invasive species.

486. For each of the above impacts assessed, the magnitude of impact was assessed as **Very Low** to **Low** for all impacts with the exception of noise and vibration. For noise and vibration, the magnitude of impact was assessed as **Very Low** to **Medium** depending upon the receptor.

487. Noise and vibration impacts assessed as **Medium** in magnitude were for Atlantic salmon, sea trout, Atlantic mackerel, whiting, Atlantic horse mackerel, ling, European hake and haddock, each of which comprise part of the diet of each of the marine mammal species assessed in this EIA with the exception of Risso's dolphins. Despite noise impacts being assessed as medium in magnitude for these species, the assessment concluded no significant effects (**Negligible to Minor**) in respect of fish and shellfish ecological receptors from construction activities, including noise and vibration.

488. Since there is expected to be no significant impacts on fish species, the potential magnitude of impact on marine mammals is assessed as **Negligible**.

Significance of the effect

489. The sensitivity of marine mammals from indirect impacts on prey species has been assessed as **Low** and the magnitude of impact has been assessed as **Negligible**. Therefore, significance of the effect is assessed as **Negligible (Not significant)**.

Additional mitigation

490. The significance of effect from changes in prey availability and distribution is not significant in EIA terms. In addition, no additional mitigation measures were proposed as part of **Chapter 9 Fish, Shellfish and Turtle Ecology** to reduce the significance of the impacts assessed. Therefore, no additional mitigation measures relating to indirect impacts to prey species are proposed.

Residual effect

491. As no further mitigation measures have been proposed, the significance of the residual effect of indirect impacts to marine mammal prey from construction activities remains **Negligible (Not significant)**.

11.10.2 Operation and maintenance (O&M) phase

Impact 1: Auditory injury (PTS) from operational noise

Receptor sensitivity

492. Operational noise derived from operational wind turbines is primarily low frequency (well below 1 kHz) (Thomsen et al., 2006). For the majority of marine mammal species, the hearing sensitivity below 1 kHz is relatively poor (Ketten, 2004) and thus it is expected that a PTS at this frequency would result in little impact to vital rates. Therefore, the sensitivity of all marine mammals with the exception of minke whale to PTS from operational noise is assessed as **Low**.

493. The low frequency noise produced during operations 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., 2014b). 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 whale to PTS from operational noise is assessed as **Medium**.

Magnitude of impact

494. The PTS and TTS-onset impact areas and ranges for operational noise are detailed in **Appendix 9.4 UWN Assessment**.

495. **Table** 11-52 shows that both PTS and TTS impact ranges, using the non-impulsive noise criteria from Southall et al*.* (2019), are <100 m. Therefore, the magnitude of impact of PTS from operational noise is considered **Negligible**.

Table 11-52 Operational WTG noise impact ranges using the non-impulsive noise criteria from Southall et al*.* (2019)

Southall et al. (2019) weighted SEL_{cum}		**250 m Rotor Diameter**	**276 m Rotor Diameter**
PTS (non-impulsive)	173 dB (VHF)	<100 m	<100 m
	198 dB (HF)	<100 m	<100 m
	199 dB (LF)	<100 m	<100 m
	201 dB (PCW)	<100 m	<100 m
TTS (non-impulsive)	153 dB (VHF)	<100 m	<100 m
	178 dB (HF)	<100 m	<100 m
	179 dB (LF)	<100 m	<100 m
	181 dB (PCW)	<100 m	<100 m

Significance of the effect

496. The sensitivity of marine mammals to PTS from operational noise has been assessed as **Low**, with the exception of minke whales which have been assessed as having a **Medium** sensitivity. The magnitude of impact of PTS to marine mammals from operational noise has been assessed as **Negligible** and therefore, the effect significance of PTS from operational noise is assessed as **Negligible (Not significant)** for porpoise, dolphins and seals to Minor **(Not significant)** for minke whale.

Additional mitigation

497. The significance of auditory injury from operational noise is not significant in EIA terms and as such, no additional mitigation measures are proposed.

Residual effect

498. As no further mitigation measures have been proposed, the significance of the residual effect of auditory injury from operational noise to marine mammals from operational and maintenance activities remains **Negligible to Minor (Not significant).**

Impact 2: Disturbance from operational noise

Receptor sensitivity

499. Operational noise is primarily low frequency (well below 1 kHz) (Thomsen et al*.*, 2006). For the majority of marine mammal species, the hearing sensitivity below 1 kHz is relatively poor and, thus, it is expected that a disturbance at this frequency would result in little impact to vital rates. Therefore, the sensitivity of porpoise, dolphins and seals to disturbance from operational noise is assessed as **Low**.

500. The low frequency noise produced during operations 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., 2014b). 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. Furthermore, since minke whales are known to forage in UK waters in the summer months, there is the potential for displacement to impact on reproductive rates. 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 other smaller cetaceans. Therefore, it has been precautionarily assumed that minke whales have a **Medium** sensitivity to disturbance from operational noise.

Magnitude of impact

501. A number of studies have reported the presence of marine mammals within windfarm footprints. For example, at the Horns Rev and Nysted offshore windfarms 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) indicating the presence of the windfarm was not adversely affecting harbour porpoise presence. Other studies at Dutch and Danish OWFs (Scheidat et al., 2011) and in the Moray Firth in Scotland (Fernandez-Betelu et al., 2022) also suggest that harbour porpoise may be attracted to 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 patten 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). In addition, 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. Previous reviews have also concluded that operational windfarm noise will have negligible barrier effects (Madsen et al., 2006, Teilmann et al., 2006a, Teilmann et al., 2006b, CEFAS, 2010, Brasseur et al., 2012).

502. These studies were all conducted at windfarms with relatively small sized turbines, and thus there is uncertainty as to how applicable the results are to future larger turbine sizes. Tougaard et al. (2020) and Stöber and Thomsen (2021) showed that as WTG size increases, the underwater sound pressure level also increases. Both studies highlighted that as the size of turbines continues to increase it is expected that the operational noise they produce will also increase. One important factor to consider is that all data used in the studies to date have been measured at geared turbines, and it is the gearbox that is one of the main contributing factors to the generated underwater noise levels. However, recent advances in technology mean that newer WTGs use direct drive technology rather than gears, which are expected to generate lower operational underwater noise levels (sound reduction of around 10 dB compared to the same size geared turbine) (Stöber and Thomsen, 2021).

503. *Bellmann* et al. (2023) did not find a strong correlation between WTG capacity and noise levels. Contrary to previous studies (Tougaard et al., 2020), there was a tendency for lower noise emissions from turbines with higher nominal capacity. The authors suggested that this observation may be explained by larger, newer turbine designs generally featuring direct-drive instead of a gearbox, with direct-drive tending to be 'quieter' and with the frequency of noise emissions lower (≤ 80 Hz) than that of geared turbines. From a broader spatial perspective, Bellmann et al. (2023) reported that tonal, low-frequency components of WTG noise could usually be measured up to a few kilometres outside of wind farm arrays, albeit mixing with general background noise which was mostly dominated by non-OWF-related shipping traffic. Further, compared to permanent, non-OWF-related shipping traffic outside wind farms, the contribution of OWF-related vessels within the array to the wider soundscape was considered to be negligible. In terms of potentially ecological effects, Bellmann et al. (2023) highlight the low-frequency nature of turbine noise and conclude that such noise cannot be perceived by harbour porpoises, even at distances of 100 m from the turbine. Other species with more sensitive hearing at lower frequencies, such as seals and minke whales, would be able to perceive such noise.

504. Therefore, while underwater sound is expected to increase with increasing turbine size, new direct drive technology means that new turbines will produce considerably less underwater noise compared to the older geared turbines. Additionally, as turbines increase in size fewer are required to be installed to meet a projects capacity. It is acknowledged that there is still a lack of data on operational noise generated by larger size turbines; however, given the presence of marine mammals (both porpoise and seals) within operational windfarms, it is unlikely that operational noise is expected to be of a level that would result in any disturbance effect. As such, the magnitude of disturbance from operational noise is assessed as **Negligible**.

Significance of the effect

505. The sensitivity of marine mammals to disturbance from operational noise has been assessed as **Low**, with exception of minke whales which have been precautionarily assessed as having a **Medium** sensitivity. The magnitude of the impact to marine mammals for disturbance from operational noise has been assessed as **Negligible.** Therefore, the effect significance of disturbance from operational noise is assessed as **Negligible (Not significant)** for porpoise, dolphins and seals to **Minor (Not significant)** for minke whales.

Additional mitigation

506. The significance of disturbance from operational noise is not significant in EIA terms and as such, no additional mitigation measures were proposed.

Residual effect

507. As no further mitigation measures have been proposed, the significance of the residual effect of disturbance from operational noise to marine mammals from operational and maintenance activities remains **Negligible to Minor (Not significant).**

Impact 3: Vessel collision

Receptor sensitivity

508. 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 result in mortality. 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.

Magnitude of impact

509. The area surrounding CWP Project already experiences high levels of vessel traffic. As outlined in the shipping and navigation baseline (**Appendix 16.3 Navigational Risk Assessment**), the vessel levels vary (see Paragraphs 410 and 411).

510. Therefore, the introduction of additional vessels during operations and maintenance at the CWP Project is not a novel impact for marine mammals present in the area. A proportion of these vessels will be stationary or slow moving throughout O&M activities for significant periods of time.

511. 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 an EVMP will also minimise the potential for any impact by ensuing that vessel traffic moves along predictable routes and will define how vessels should behave in the presence of marine mammals. Therefore, the magnitude of the risk of vessel collisions occurring is **Negligible**.

Significance of the effect

512. The sensitivity of all marine mammals to vessel collision has been assessed as **High** and the magnitude of impact has been assessed as **Negligible** with the adoption of an embedded EVMP. Therefore, significance of the effect is assessed as **Minor (Not significant).**

Additional mitigation

513. The project has already committed to the adoption of an EVMP, and no additional mitigation measures are required to reduce the significance of the impact.

Residual effect

514. The significance of the residual effect of vessel collisions with marine mammals remains as **Minor (Not significant)**.

Impact 4: Disturbance from vessels

Receptor sensitivity

515. The sensitivity of all marine mammals to disturbance from vessel activity during construction was assessed as Low. When considering the nature of the vessels that will be used during operation and maintenance at the CWP Project, sensitivity of all marine mammals to disturbance from vessel activity during operations and maintenance remains classified as **Low**.

Magnitude of impact

516. The area surrounding CWP Project already experiences high levels of vessel traffic. As outlined in the shipping and navigation baseline (**Appendix 16.3 Navigational Risk Assessment**), the vessel levels vary (see Paragraphs 410 and 411).

517. Therefore, the introduction of additional vessels during operations and maintenance at CWP Project is not a novel impact for marine mammals present in the area.

518. When considering the impact of disturbance from vessel noise, this is predicted to be of local spatial extent, with only short-term disturbance resulting from individual vessels and reversible since animals are expected to return after the vessel has passed (though it is noted that vessel disturbance will occur across multiple years). The magnitude of disturbance from vessel activity during operation and maintenance is therefore assessed as **Low (adverse)**.

Significance of the effect

519. The sensitivity of all marine mammals to disturbance from vessels has been assessed as **Low** and the magnitude of impact has been assessed as **Low.** Therefore, significance of the effect is assessed as **Minor (Not significant).**

Additional mitigation

520. The project has already committed to the adoption of an EVMP, and no additional mitigation measures are required to reduce the significance of the impact.

Residual effect

521. The residual impact of vessel collisions with marine mammals remains as **Minor (Not significant).**

Impact 5: Indirect impacts to prey

Receptor sensitivity

522. As assessed within the Construction Impacts section of this impact assessment chapter (**Section 11.10.1**), while there may be certain prey species that comprise the main part of marine mammals diets, all marine mammals in this assessment are considered generalist feeders and are thus not reliant on a single prey species. Therefore, all marine mammals are assessed as having a **Low** sensitivity to changes in prey abundance and distribution.

Magnitude of impact

523. Any change in fish abundance and / or distribution as a result of operation and maintenance activities is important to assess as, given marine mammals are dependent on fish as prey species, there is the potential for indirect effects on marine mammals. For operational and maintenance activities, **Chapter 9 Fish, Shellfish and Turtle Ecology** assessed the following impacts on fish species:

- Long-term loss of habitat;
- Electromagnetic field (EMF) impacts;
- Accidental pollution events; and
- The introduction of non-native invasive species.

524. For each of the impacts assessed in **Chapter 9 Fish, Shellfish and Turtle Ecology**, the assessment has concluded that the magnitude of impact was assessed as **Very Low** to **Low** for all impacts. Overall, adverse impacts to fish species from the operational and maintenance phases of the CWP Project will be of Negligible to Moderate significance (Not significant) and thus the predicted resulting magnitude of impact on marine mammals is of **Negligible** magnitude.

Significance of the effect

525. As the sensitivity of all marine mammals to impacts on prey species has been assessed as **Low**, and the magnitude of the impact on fish and shellfish have been assessed as **Negligible**, effect significance of indirect impacts to prey species is assessed as being **Negligible (Not significant)**.

Additional mitigation

526. The significance of effect from changes in prey availability and distribution is not significant in EIA terms. In addition, no additional mitigation measures were proposed as part of **Chapter 9 Fish,**

Shellfish and Turtle Ecology to reduce the significance of the impacts assessed. Therefore, no additional mitigation measures relating to indirect impacts to prey items are proposed.

Residual effect

527. As no further mitigation measures have been proposed, the residual effect of indirect impacts to marine mammal prey species from operational and maintenance activities remains **Negligible (Not significant)**.

11.10.3 Decommissioning phase

528. It is recognised that legislation and industry best practice change over time. However, for the purposes of the EIA, at the end of the operational lifetime of the CWP Project, it is assumed that all offshore infrastructure will be removed where practical to do so. In this regard, for the purposes of a representative scenario for decommissioning impacts, the following assumptions have been made:

- The WTGs and OSS topsides will be completely removed.
- Following WTG and OSS topside decommissioning and removal, the monopile foundations will be cut below the seabed level, to a depth that will ensure the remaining foundation is unlikely to become exposed. This is likely to be approximately one metre below seabed, although the exact depth will depend upon the seabed conditions and site characteristics at the time of decommissioning.
- All cables and associated cable protection in the offshore environment will be wholly removed. It is likely that equipment similar to that which is used to install the cables may be used to reverse the burial process and expose them. Therefore, the area of seabed impacted during the removal of the cables is anticipated to be the same as the area impacted during the installation of the cables.
- Generally, decommissioning is anticipated to be a reverse of the construction and installation process for the CWP Project and the assumptions around the number of vessels on site and vessel round trips is therefore the same as described for the construction phase of the offshore components.

529. Given the above it is anticipated that for the purposes of a representative scenario, the impacts will be no greater than those identified for the construction phase.

Impact 1: Auditory injury (PTS) and disturbance from decommissioning activities

Receptor sensitivity

530. As the effects of underwater noise on marine mammals during decommissioning are considered to be no greater than those described for the construction phase, it is conservative to assume that the sensitivity of marine mammals to PTS and disturbance from decommissioning activities is synonymous with the sensitivity of marine mammals to PTS and disturbance from piling. As such, the sensitivity of all marine mammals is assessed as **Low**.

Magnitude of impact

531. The final methods chosen for decommissioning will be dependent on the technologies available at the time. The numbers of vessels and / or plant required for each activity is therefore not available at this stage. The indicative methodology, however, would be:

- Deployment of ROVs or divers to inspect each pile footing and reinstate lifting attachments if necessary.
- Mobilise a jack-up barge / heavy lifting vessel.
- Remove any scour protection or sediment obstructing the cutting process. It may be necessary to dig a small trench around the foundation.
- Deploy crane hooks from the decommissioning vessel and attach to the lift points.
- Cut piles at just below seabed level.
- Inspect seabed for debris and remove debris where necessary.
- Considering the current technology, the decommissioned components are likely to be transported back to shore by lifting onto a jack-up or heavy lift vessels, freighter, barge, or by buoyant tow.
- Transport all components to an onshore site where they will be processed for reuse / recycling / disposal.
- Inspect seabed and remove debris.

532. Auditory injury is a permanent effect from which an animal cannot recover. As the exact methods to be used for decommissioning are not able to be defined at this time, the impact from PTS and disturbance levels of decommissioning activities cannot be accurately determined. However, it is anticipated that there will be the implementation of embedded mitigation, in the form of a Decommissioning Plan / Program and a MMMP specific to decommissioning activities. Therefore, the magnitude of the impacts on individuals are not anticipated to alter population trajectory over a generational scale. Therefore, the magnitude is **Low** for all species.

Significance of the effect

533. As the sensitivity of all marine mammals to auditory injury and disturbance from decommissioning activities has been assessed as **Low,** and the magnitude of the impact has been assessed as **Low**, the significance of the effect is considered to be **Minor (Not significant)**.

Additional mitigation

534. The CWP Project has already committed to implementing a Decommissioning **MMMP** (section 11 of the **MMMP**), and the impacts of auditory injury and disturbance from decommissioning activities have been assessed as Minor (Not significant) for all marine mammals, therefore no further mitigation measures are proposed.

Residual effect

535. As no further mitigation measures have been proposed, the residual effect of auditory injury and disturbance from decommissioning activities remains **Minor (Not significant).**

Impact 2: Vessel collision

Receptor sensitivity

536. 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, Lusseau et al., 2009).

537. Marine mammal receptors are deemed to be of low vulnerability to vessel collision, 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 result in mortality. 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.

Magnitude of impact

538. It is not expected that the level of vessel activity during decommissioning would cause an increase in the risk of mortality from collisions. The adoption of an EVMP within the Decommissioning Plan will also minimise the potential for any impact by ensuing that vessel traffic moves along predictable routes and will define how vessels should behave in the presence of marine mammals. Therefore, the magnitude of the risk of vessel collisions occurring is **Negligible.**

Significance of the effect

539. The magnitude of the impact has been assessed as **Negligible** and the sensitivity of receptors as **High**. Therefore, the significance of the effect of collisions from vessels is concluded to be **Minor (Not significant).**

Additional mitigation

540. The CWP Project has already committed to the adoption of an EVMP within the Decommissioning Plan, and the impacts of vessel collisions with marine mammals during decommissioning have been assessed as Minor (Not significant), therefore no further additional mitigation is proposed.

Residual effect

541. As no further mitigation measures are proposed, the residual effect of vessel collision from decommissioning activities remains **Minor (Not significant)**.

Impact 3: Indirect impacts to prey

Receptor sensitivity

542. While there may be certain prey species that comprise the main part of their diet, all marine mammals in this assessment are considered 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.

Magnitude of impact

543. During decommissioning activities, there is the potential for impacts upon fish and shellfish species, including:

- Temporary habitat disturbance / loss;
- Noise and vibration;
- Temporary disturbance of the seabed leading to increases in SSC and associated deposition;
- Accidental pollution events; and
- The introduction of non-native invasive species.

544. As with construction activities, the assessment provided in **Chapter 9 Fish, Shellfish and Turtle Ecology** indicates no significant impacts on fish or shellfish species, and therefore the potential magnitude of impact on marine mammals is rated as **Negligible**.

Significance of the effect

545. The sensitivity of marine mammals from indirect impacts on prey species has been assessed as **Low** and the magnitude of impact has been assessed as **Negligible**. Therefore, significance of the effect is assessed as **Negligible (Not significant)**.

Additional Mitigation

546. The significance of effect from changes in prey availability and distribution is not significant in EIA terms. In addition, no additional mitigation measures were proposed as part of **Chapter 9 Fish, Shellfish and Turtle Ecology** to reduce the significance of the impacts assessed. Therefore, no additional mitigation measures relating to indirect impacts to prey species are proposed.

Residual effect

547. As no further mitigation measures have been proposed, the significance of the residual effect of indirect impacts to marine mammal prey species from decommissioning activities remains **Negligible (Not significant).**

11.11 Cumulative impacts

548. A fundamental component of the EIA is to consider and assess the potential for cumulative effects of the CWP Project with other projects, plans and activities (hereafter referred to as 'other developments'). For the cumulative impact assessment, it has been assumed that the CWP Project may conduct offshore pile driving in 2027.

549. In summary, the CEA for marine mammals does not identify any significant cumulative effects resulting from the CWP Project alongside other development.

11.11.1 Screening

550. For the potential effects for marine mammals, planned offshore wind farm projects were screened into the assessment based on the extent of the relevant marine mammal reference population area (MU). For all other planned offshore projects, those occurring in OSPAR Region III: Celtic Seas were screened into the assessment due to the smaller scale nature of the projects compared to large commercial scale offshore wind farms.

551. The long list of projects was screened to remove the following:

- All projects that are located outside of the relevant species MU;
- All projects that are already operational / active as they are considered to be existing impacts included within the baseline (this includes all shipping ports, shipping routes and oil and gas pipelines);
- All projects that are not expected to be constructing between 2023 and 2028 inclusive; and
- All projects where the timing of construction activities is unknown.

552. The following impacts were screened out of the cumulative assessment:

- 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); and
- Collision risk from vessel activity: since project specific VMPs will be put in place to reduce this already low risk of impact.

553. The following impacts were screened into the cumulative assessment:

- Disturbance from pre-construction surveys;
- Disturbance from UXO clearance;
- Disturbance from construction activities at offshore projects alongside disturbance from indicative seismic surveys; and
- Disturbance from vessel activities.

554. The full list of all offshore projects screened into the cumulative assessment are provided in **Appendix 11.1 Cumulative Effects Assessment**.

11.11.2 Assessment method

555. Details on the assessment methods are provided in **Appendix 11.1 Cumulative Effects Assessment**.

556. Where a quantitative impact assessment has been provided for marine mammals in a PEIR or ES chapter, the maximum number of animals disturbed per day presented in the assessment is used in the quantitative cumulative assessment here. For all offshore projects where there is no quantitative impact assessment available (pre-application stage projects or European projects projects), an indicative number of animals disturbed per day has been calculated. There are very high levels of uncertainty associated with all projects that do not yet have a quantitative impact assessment available.

11.11.3 Conservatism

557. There are significant levels of precaution / conservatism within this CEA, resulting in the estimated effects being highly precautionary and potentially unrealistic. Detail on the conservatism is provided in **Appendix 11.1 Cumulative Effects Assessment**.

11.11.4 All species – disturbance from pre-construction surveys

558. Please see **Appendix 11.1 Cumulative Effects Assessment** for the full CEA assessment detail. Only the conclusion is presented here.

559. It is expected that any disturbance impact range will be very small, highly localised and highly directional. Therefore, it is expected that the magnitude of disturbance across Projects is **Low**, whereby there may be short-term and / or intermittent and temporary behavioural effects in a small proportion of the population but no change to the population trajectory of any species.

560. As per the CWP Project alone assessment, the sensitivity of marine mammals to disturbance from pre-construction surveys is **Very Low** to **Low**.

561. Therefore, the overall significance of the cumulative effect is **Minor (not significant)**.

11.11.5 All species – disturbance from UXO clearance

562. Please see **Appendix 11.1 Cumulative Effects Assessment** for the full CEA assessment detail. Only the conclusion is presented here.

563. It is expected that all Projects will use low-order deflagration as the primary UXO clearance method.

564. Given the very small percentage of the MUs predicted to be impacted, and the fact the consequence of the impact is likely to be short-term, intermittent during a UXO clearance campaign, and with temporary behavioural effects that are very unlikely to alter survival and reproductive rates to the extent that the population trajectory would be altered, disturbance effects associated with low-order UXO clearance even cumulatively across Projects is assessed as **Low** magnitude.

565. As per the CWP Project alone assessment, the sensitivity of marine mammals to disturbance from UXO clearance is expected to be **Low**.

566. Therefore, the overall significance of the cumulative effect is **Minor (not significant)**.

11.11.6 Harbour porpoise – disturbance from construction activities

567. Please see **Appendix 11.1 Cumulative Effects Assessment** for the full CEA assessment detail. Only the conclusion is presented here.

Phase 1 projects

568. **Appendix 11.4 Cumulative iPCoD modelling** presents the population modelling conducted for the Phase 1 Irish OWF Projects. 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 to the harbour porpoise population. The effect of disturbance from a single piling event is expected to last less than a day, though the disturbance impact across the five projects will occur intermittently across 3–5 years depending on the piling scenario. This is expected to result in short-term and / or intermittent and temporary behavioural effects in a small proportion of the population; however, the population modelling has shown that survival and reproductive rates are very unlikely to be impacted to the extent that the population trajectory would be altered. This is therefore a **Low** magnitude.

569. As per the project alone assessment, the sensitivity of porpoise to pile driving of WTG is **Low**.

570. Therefore, the overall significance of the cumulative effect is **Minor (not significant)**.

All projects

571. The level of disturbance predicted to occur within the Celtic and Irish Sea MU between 2023 and 2028 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.

572. As per the project alone assessment, the sensitivity of porpoise to pile driving (and other construction activities) is **Low**.

573. Therefore, the overall significance of the cumulative effect is **Minor (not significant)**.

Table 11-53 Summary results for the number of harbour porpoise disturbed by construction noise across different Tiers in the CEA

Results	2023	2024	2025	2026	2027	2028
Tier 1 projects						
Total porpoise disturbed	183	277	892	2,961	5,610	309
% MU (62,517)	0.3%	0.4%	1.4%	4.7%	9.0%	0.5%
Contribution of CWP Project to total	0%	0%	0%	0%	48%	0%
Tier 1 and Tier 2a projects						
Total porpoise disturbed	183	277	892	3,517	6,166	1,460
% MU (62,517)	0.3%	0.4%	1.4%	5.6%	9.9%	2.3%
Contribution of CWP Project to total	0	0	0	0	43%	0
Tier 1 and Tier 2a and 2b projects						
Total porpoise disturbed	183	1,393	2,008	5,912	9,134	5,836
% MU (62,517)	0.3%	2.2%	3.2%	9.5%	14.6%	9.3%
Contribution of CWP Project to total	0%	0%	0%	0%	29%	0%
Tier 1 and Tier 2 and Tier 3 projects						
Total porpoise disturbed	1,169	2,414	3,029	6,950	10,172	6,839
% MU (62,517)	1.9%	3.9%	4.8%	11.1%	16.3%	10.9%
Contribution of CWP Project to total	0%	0%	0%	0%	26%	0%

11.11.7 Bottlenose dolphin – disturbance from construction activities

574. Please see **Appendix 11.1: Cumulative Effects Assessment** for the full CEA assessment detail. Only the conclusion is presented here.

Phase 1 projects

575. **Appendix 11.4 Cumulative iPCoD** presents the population modelling conducted for the Phase 1 Irish OWF Projects. The iPCoD modelling showed that 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 95–98% of the mean unimpacted population size. The effect of disturbance from a single piling event is expected to last less than a day, though the disturbance impact across the five projects will occur intermittently across 3–5 years depending on the piling scenario. This is expected to result in short-term and / or intermittent and temporary behavioural effects in a small proportion of the population; however, the population modelling has shown that survival and reproductive rates are very unlikely to be impacted to the extent that the population trajectory would be altered in the long term. This is therefore a **Low** magnitude.

576. As per the project alone assessment, the sensitivity of bottlenose dolphins to pile driving of WTG is **Low**.

577. Therefore, the overall significance of the cumulative effect is **Minor (not significant)**.

All Projects – SCANS IV density

578. The total number of animals disturbed is almost entirely driven by the predictions of disturbance at the CWP Project, which, as shown in the project-alone population modelling, is not expected to result in a change in the population trajectory over the long-term. The additional impact from other OWF projects is low in comparison and is thus not expected to result in enough additional disturbance to change the population trajectory. 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**.

579. As per the project alone assessment, the sensitivity of bottlenose dolphins to pile driving (and other construction activities) is **Low**.

580. Therefore, the overall significance of the cumulative effect is **Minor (not significant)**.

Table 11-54 Summary results for the number of bottlenose dolphins disturbed by construction noise across different Tiers in the CEA – using SCANS IV density estimates

Results	2023	2024	2025	2026	2027	2028
Tier 1 projects						
Total dolphins disturbed	108	90	72	94	575	58
% MU (8,326)	1.3%	1.1%	0.9%	1.1%	6.9%	0.7%
Contribution of CWP Project to total	0	0	0	0	87%	0
Tier 1 and Tier 2a projects						
Total dolphins disturbed	108	90	72	94	575	557
% MU (8,326)	1.3%	1.1%	0.9%	1.1%	6.9%	6.7%
Contribution of CWP Project to total	0	0	0	0	87%	0
Tier 1 and Tier 2a and 2b projects						
Total dolphins disturbed	108	112	94	138	1,118	1,144

% MU (8,326)	1.3%	1.3%	1.1%	1.7%	13.4%	13.7%
Contribution of CWP Project to total	0	0	0	0	0%	0
Tier 1 and Tier 2 and Tier 3 projects						
Total dolphins disturbed	419	441	423	485	1,465	1,473
% MU (8,326)	5.0%	5.3%	5.1%	5.8%	17.6%	17.7%
Contribution of CWP Project to total	0	0	0	0	34%	0

All Projects – SCANS III density

581. Higher levels of disturbance are predicted to occur in 2027 and 2028 (25–32% MU). While iPCOD modelling has not been conducted specifically for this scenario, the results of the Phase 1 Irish OWF iPCoD modelling showed that disturbance to 26% MU in 2027 and 53% MU in 2028 did not result in a change to the overall population trajectory in the long term. The same can be assumed here. 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**.

582. As per the project alone assessment, the sensitivity of bottlenose dolphins to pile driving (and other construction activities) is **Low**.

583. Therefore, the overall significance of the cumulative effect is **Minor (not significant)**.

Table 11-55 Summary results for the number of bottlenose dolphins disturbed by construction noise across different Tiers in the CEA – using SCANS III density estimates

Results	2023	2024	2025	2026	2027	2028
Tier 1 projects						
Total dolphins disturbed	6	5	4	27	43	25
% MU (293)	2.0%	1.7%	1.4%	9.2%	14.7%	8.5%
Contribution of CWP Project to total	0	0	0	0	40%	0
Tier 1 and Tier 2a projects						
Total dolphins disturbed	6	5	4	27	43	42
% MU (293)	2.0%	1.7%	1.4%	9.2%	14.7%	14.3%
Contribution of CWP Project to total	0	0	0	0	40%	0
Tier 1 and Tier 2a and 2b projects						
Total dolphins disturbed	6	5	4	27	60	83
% MU (293)	2.0%	1.7%	1.4%	9.2%	20.5%	28.3%
Contribution of CWP Project to total	0	0	0	0	28%	0
Tier 1 and Tier 2a and 2b and Tier 3 projects						
Total dolphins disturbed	17	17	16	40	73	95
% MU (293)	5.8%	5.8%	5.5%	13.7%	24.9%	32.4%

Contribution of CWP Project to total	0	0	0	0	23%	0

11.11.8 Common dolphin – disturbance from construction activities

584. Please see **Appendix 11.1: Cumulative Effects Assessment** for the full CEA assessment detail. Only the conclusion is presented here.

585. 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**.

586. As per the project alone assessment, the sensitivity of common dolphins to pile driving (and other construction activities) is **Low**.

587. Therefore, the overall significance of the cumulative effect is **Minor (not significant)**.

Table 11-56 Summary results for the number of common dolphins disturbed by construction noise across different Tiers in the CEA

Results	2023	2024	2025	2026	2027	2028
Tier 1 projects						
Total dolphins disturbed	493	1,105	1,082	2,743	3,166	523
% MU (102,656)	0.5%	1.1%	1.1%	2.7%	3.1%	0.5%
Contribution of CWP Project to total	0	0	0	0	16%	0
Tier 1 and Tier 2a projects						
Total dolphins disturbed	493	1,105	1,082	3,966	4,389	1,804
% MU (102,656)	0.5%	1.1%	1.1%	3.9%	4.3%	1.8%
Contribution of CWP Project to total	0	0	0	0	12%	0
Tier 1 and Tier 2a and 2b projects						
Total dolphins disturbed	493	2,293	2,280	5,164	4,469	2,427
% MU (102,656)	0.5%	2.2%	2.2%	5.0%	4.4%	2.4%
Contribution of CWP Project to total	0	0	0	0	11%	0
Tier 1 and Tier 2a and 2b and Tier 3 projects						
Total dolphins disturbed	695	2,497	2,484	5,370	4,675	2,659
% MU (102,656)	0.7%	2.4%	2.4%	5.2%	4.6%	2.6%
Contribution of CWP Project to total	0	0	0	0	11%	0

11.11.9 Risso's dolphin – disturbance from construction activities

588. Please see **Appendix 11.1: Cumulative Effects Assessment** for the full CEA assessment detail. Only the conclusion is presented here.

589. 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 **Medium**.

590. As per the project alone assessment, the sensitivity of Risso's dolphins to pile driving (and other construction activities) is **Low**.

591. Therefore, the overall significance of the cumulative effect is **Minor (not significant)**.

Table 11-57 Summary results for the number of Risso's dolphins disturbed by construction noise across different Tiers in the CEA

Results	2023	2024	2025	2026	2027	2028
Tier 1 projects						
Total dolphins disturbed	0	81	81	122	166	65
% MU (12,262)	0.0%	0.7%	0.7%	1.0%	1.4%	0.5%
Contribution of CWP Project to total	0	0	0	0	54%	0
Tier 1 and Tier 2a projects						
Total dolphins disturbed	0	81	81	122	166	70
% MU (12,262)	0.0%	0.7%	0.7%	1.0%	1.4%	0.6%
Contribution of CWP Project to total	0	0	0	0	54%	0
Tier 1 and Tier 2a and 2b projects						
Total dolphins disturbed	0	189	189	257	248	554
% MU (12,262)	0.0%	1.5%	1.5%	2.1%	2.0%	4.5%
Contribution of CWP Project to total	0	0	0	0	36%	0
Tier 1 and Tier 2a and 2b and Tier 3 projects						
Total dolphins disturbed	19	232	232	300	291	599
% MU (12,262)	0.2%	1.9%	1.9%	2.4%	2.4%	4.9%
Contribution of CWP Project to total	0	0	0	0	31%	0

11.11.10 Minke whale – disturbance from construction activities

592. Please see **Appendix 11.1: Cumulative Effects Assessment** for the full CEA assessment detail. Only the conclusion is presented here.

593. 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 **Medium**.

594. As per the project alone assessment, the sensitivity of minke whales to pile driving is **Low**.

595. Therefore, the overall significance of the cumulative impact is **Minor (not significant)**.

Table 11-58 Summary results for the number of minke whales disturbed by construction noise across different Tiers in the CEA

Results	2023	2024	2025	2026	2027	2028
Tier 1 projects						
Total whales disturbed	508	554	358	440	548	116
% MU (20,118)	2.5%	2.8%	1.8%	2.2%	2.7%	0.6%
Contribution of CWP Project to total	0	0	0	0	24%	0
Tier 1 and Tier 2a projects						
Total whales disturbed	508	554	358	657	765	362
% MU (20,118)	2.5%	2.8%	1.8%	3.3%	3.8%	1.8%
Contribution of CWP Project to total	0	0	0	0	18%	0
Tier 1 and Tier 2a and 2b projects						
Total whales disturbed	656	751	714	837	994	865
% MU (20,118)	3.3%	3.7%	3.5%	4.2%	4.9%	4.3%
Contribution of CWP Project to total	0	0	0	0	13%	0
Tier 1 and Tier 2a and 2b and Tier 3 projects						
Total whales disturbed	753	916	879	1,003	1,160	1,070
% MU (20,118)	3.7%	4.6%	4.4%	5.0%	5.8%	5.3%
Contribution of CWP Project to total	0	0	0	0	12%	0

11.11.11 Harbour seal – disturbance from construction activities

596. Please see **Appendix 11.1: Cumulative Effects Assessment** for the full CEA assessment detail. Only the conclusion is presented here.

Phase 1 projects

597. **Appendix 11.4 Cumulative iPCoD** presents the population modelling conducted for the Phase 1 Irish OWF Projects. 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 to the harbour seal population, since the impacted population is predicted to continue at a stable trajectory and at exactly the same size of the unimpacted population. The effect of disturbance from a single piling event is expected to last less than a day, though the disturbance impact across the five projects will occur intermittently across 3–5 years depending on the piling scenario. This is expected to result in short-term and / or intermittent and temporary behavioural effects in a small proportion of the population; however, the population modelling has shown that survival and reproductive rates are very unlikely to be impacted to the extent that the population trajectory would be altered. This is therefore a **Low** magnitude.

598. As per the project alone assessment, the sensitivity of harbour seals to pile driving of WTG is **Low**.

599. Therefore, the overall significance of the cumulative effect is **Minor (not significant)**.

All projects

600. The level of disturbance predicted to occur within the seal MU between 2023 and 2028 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.

601. As per the project alone assessment, the sensitivity of harbour seals to pile driving (and other construction activities) is **Low**.

602. Therefore, the overall significance of the cumulative effect to harbour seals is **Minor (not significant)**.

Table 11-59 Summary results for the number of harbour seals disturbed by construction noise across different Tiers in the CEA

Results	2023	2024	2025	2026	2027	2028
Tier 1 projects						
Total harbour seals disturbed	14	14	14	6	11	5
% MU (1,365)	1.0%	1.0%	1.0%	0.4%	0.8%	0.4%
Contribution of CWP Project to total	0	0	0	0	55%	0
Tier 1 and Tier 2a projects						
Total harbour seals disturbed	14	14	14	6	11	122
% MU (1,365)	1.0%	1.0%	1.0%	0.4%	0.8%	8.9%
Contribution of CWP Project to total	0	0	0	0	55%	0
Tier 1 and Tier 2a and 2b projects						
Total harbour seals disturbed	14	14	14	6	291	124
% MU (1,365)	1.0%	1.0%	1.0%	0.4%	21.3%	9.1%
Contribution of CWP Project to total	0	0	0	0	2%	0
Tier 1 and Tier 2a and 2b and Tier 3 projects						
Total harbour seals disturbed	14	15	15	7	292	124
% MU (1,365)	1.0%	1.1%	1.1%	0.5%	21.4%	9.1%
Contribution of CWP Project to total	0	0	0	0	2%	0

11.11.12 Grey seal – disturbance from construction activities

603. Please see **Appendix 11.1: Cumulative Effects Assessment** for the full CEA assessment detail. Only the conclusion is presented here.

Phase 1 projects

604. **Appendix 11.4 Cumulative iPCoD** presents the population modelling conducted for the Phase 1 Irish OWF Projects. 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 to the grey seal population, since the impacted population is predicted to continue at an increasing trajectory and at exactly the same size of the unimpacted population. The effect of disturbance from a single piling event is expected to last less than a day, though the disturbance impact across the five projects will occur intermittently across 3–5 years depending on the piling scenario. This is expected to result in short-term and / or intermittent and temporary behavioural effects in a small proportion of the population; however, the population modelling has shown that survival and reproductive rates are very unlikely to be impacted to the extent that the population trajectory would be altered. This is therefore a **Low** magnitude.

605. As per the project alone assessment, the sensitivity of grey seals to pile driving of WTG is **Very Low**.

606. Therefore, the overall significance of the cumulative effect is **Negligible (not significant)**.

All projects

607. The level of disturbance predicted to occur within the seal MU between 2023 and 2028 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.

608. As per the project alone assessment, the sensitivity of grey seals to pile driving and other construction activities is **Very Low**.

609. Therefore, the overall significance of the cumulative effect to grey seals is **Minor (not significant)**.

Table 11-60 Summary results for the number of grey seals disturbed by construction noise across different tiers in the CEA

Results	2023	2024	2025	2026	2027	2028
Tier 1 projects						
Total grey seals disturbed	105	68	65	28	407	11
% MU (6,056)	1.7%	1.1%	1.1%	0.5%	6.7%	0.2%
Contribution of CWP Project to total	0	0	0	0	97%	0
Tier 1 and Tier 2a projects						
Total grey seals disturbed	105	68	65	28	407	499
% MU (6,056)	1.7%	1.1%	1.1%	0.5%	6.7%	8.2%
Contribution of CWP Project to total	0	0	0	0	97%	0
Tier 1 and Tier 2a and 2b projects						
Total grey seals disturbed	105	68	65	28	824	699
% MU (6,056)	1.7%	1.1%	1.1%	0.5%	13.6%	11.5%

Contribution of CWP Project to total	0	0	0	0	48%	0
Tier 1 and Tier 2a and 2b and Tier 3 projects						
Total grey seals disturbed	105	89	86	49	845	699
% MU (6,056)	1.7%	1.5%	1.4%	0.8%	14.0%	11.5%
Contribution of CWP Project to total	0	0	0	0	47%	0

11.11.13 All species – disturbance from vessel activity

610. Please see **Appendix 11.1: Cumulative Effects Assessment** for the full CEA assessment detail. Only the conclusion is presented here.

611. 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 VMPs (or comply with exiting Marine Wildlife Watching Codes) to minimise any potential effects on marine mammals. The cumulative impact 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 windfarm), 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.

612. The sensitivity of all marine mammals to disturbance from vessel activity was assessed as **Low**.

613. Therefore, significance of the effect is assessed as **Minor (Not significant)**.

11.12 Transboundary impacts

614. Transboundary effects are defined as those effects upon the receiving environment of other European Economic Area (EEA) states, whether occurring from the CWP Project alone, or cumulatively with other projects in the wider area. Due to the highly mobile nature of marine mammal species, particularly those considered within this assessment, there is potential for transboundary impacts to occur. This assessment will consider the potential for transboundary effects of the residual impacts of the project (i.e., after mitigation measures have been applied for the project).

615. Highly localised impacts such as auditory injury (PTS) are not considered to be transboundary impacts as impact ranges do not extend into other EEA states.

616. The impact that poses the largest potential to have a transboundary impact is disturbance from underwater noise, as it has the largest spatial distribution. There may be behavioural disturbance or displacement of marine mammals from the CWP Project array 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 the CWP Project could extend into waters of other EEA states. The CWP Project 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. 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 for the CWP Project, 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 entire 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 travel large distances and may demonstrate connectivity to individuals found on the east and west coasts of RoI and the RoI and the UK populations (O'Brien et al., 2009, Robinson et al., 2012).

617. Any transboundary impacts that do occur as a result of disturbance from underwater noise at the CWP Project are predicted to be short-term and intermittent, with the recovery of marine mammal populations to affected areas following the completion of construction activities. The magnitude of impact is thus Low at a transboundary level. The sensitivity of marine mammals to disturbance from underwater noise such as pile driving has been assessed as Very Low to Low (see **Section 11.10.1**). Therefore, the significance of behavioural disturbance leading to transboundary effects is concluded to be of **Negligible** to **Minor (Not significant)**.

618. 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 CWP Project and are therefore not predicted to extend into the waters of other EEA states. Therefore, the impact of a reduction in prey ability will not lead to a significant effect.

11.13 Inter-relationships

619. The inter-related effects assessment considers the potential for all relevant effects across multiple topics to interact, spatially and temporally, to create inter-related effects on a receptor group. This includes incorporating the findings of the individual assessment chapters to describe potential additional effects that may be of greater significance when compared to individual effects acting on a receptor group.

620. This includes an assessment of:

- **Phase effects** – Assessment of the scope for all relevant effects across multiple topics to interact, spatially and temporally, to create inter-related effects on a receptor group.

621. The term 'receptor group' is used to highlight the fact that the proposed approach to the inter-relationships assessment has assessed every individual receptor considered in this chapter, but instead focuses on groups of receptors that may be sensitive to inter-related effects.

622. The potential inter-related effects that could arise in relation to marine mammals are presented in **Table 11-61**. If there are additional effects, these are considered additively and qualitatively using expert judgement.

Table 11-61 Inter-related effects (phase) assessment for marine mammals

Impact / Receptor	Related chapter	Phase Assessment
Combination of disturbance from underwater noise, the presence of vessels and indirect impacts on marine mammal prey species – impact relates to all marine mammal receptors	Chapter 9 Fish, Shellfish and Turtle Ecology	When acting in combination with one another, the greatest potential for spatial and temporal interactions arising from the CWP Project are associated with underwater noise impacts and the presence of vessels. Each of the individual impacts (i.e., disturbance from piling activities and disturbance from vessel activity) were assessed as being **Negligible (Not significant)** following the implementation of mitigation measures. Although piling activities and vessel presence within the CWP Project area could occur at the same time, it is noted that in some instances, the presence of vessels prior to piling is likely to disturb some marine mammal species (Benhemma-Le Gall et al., 2023), and thus limit the amount of disturbance and / or displacement some marine mammal species may experience as a result of piling activities. In addition, underwater noise arising from piling activities has the potential to disturb animals to an extent which reduces the potential for vessel interactions. As such, the significance of the receptor-led effects are not anticipated to increase beyond those already assessed, and are assessed as **Negligible (Not significant)**.

623. The effects to marine mammals from the above inter-relationship impacts have been assessed as **Negligible (Not significant)**. Overall, no inter-relationships 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 embedded mitigation already considered. The effect of inter-relationships between marine mammals and disturbance from underwater noise and changes to prey species has been assessed as **Negligible (Not significant)**.

11.14 Potential monitoring requirements

624. Monitoring requirements for the CWP Project will be described in the **In Principle Project Environmental Monitoring Plan** submitted alongside the EIAR and further developed and agreed with stakeholders prior to construction. The proposed development 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, with a focus on validation and evidence gathering.

625. The assessment of impacts on marine mammals as a result of the construction, operation and maintenance and decommissioning phases of the CWP Project are predicted to be not significant in EIA terms. Based on the predicted impacts it is concluded that no specific monitoring is required.

626. There are however several monitoring options that could be considered by the project to address some of the key assumptions in this impact assessment. These could include, for example:

- Monitoring of underwater noise during pile driving – to verify the underwater noise modelling predictions;
- Monitoring of dolphin responses to pile driving; and
- Monitoring of minke whale responses to pile driving.

11.15 Impact assessment summary

627. This chapter of the EIAR has assessed the potential environmental impacts on marine mammals from the construction, operation and maintenance and decommissioning phases of the CWP Project. Where significant effects have been identified, additional mitigation has been considered and incorporated into the assessment.

628. This section, including **Table 11-62**, summarises the impact assessment undertaken and confirms the significance of any residual effects, following the application of additional mitigation.

Table 11-62 Summary of potential Impacts and residual effects

Potential Impact	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance (before mitigation)	Primary mitigation	Additional Mitigation	Residual effect
Construction							
Impact 1 Auditory injury (PTS) from pre-construction surveys	All marine mammals	Very Low to Low	Negligible to Medium	Negligible to Minor (not significant)	MMMP (primary mitigation: MMO and PAM)	None required	**Negligible (Not significant)**
Impact 2 Disturbance from pre-construction surveys	All marine mammals	Very Low to Low	Negligible to Low	Negligible to Minor (not significant)	None	None required	**Negligible to Minor (Not significant)**
Impact 3 Auditory Injury (PTS) from UXO	Minke whale	Medium	Medium	**Moderate (Significant)**	MMMP (primary mitigation: MMO and PAM)	MMMP (additional mitigation: ADDs, deflagration, noise abatement)	**Negligible (Not significant)**
	All others	Low	Medium	Minor (not significant)			
Impact 4 Disturbance from UXO (26 km EDR)	All marine mammals	Low	Medium to Low	Minor (not significant)	None	None required	**Negligible to Minor (Not significant)**
			Negligible to Low	Negligible to Minor (not significant)			

Potential Impact	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance (before mitigation)	Primary mitigation	Additional Mitigation	Residual effect
Disturbance from UXO (5 km EDR) Disturbance from UXO (TTS)			Low	Minor (not significant)			
Impact 5 Auditory injury (PTS) from piling – WTGs	Harbour porpoise	Low	Medium	Minor (not significant)	MMMP (primary mitigation: MMO and PAM)	MMMP (additional mitigation: ADDs, noise abatement, alternative piling methods)	**Negligible** **(Not significant)**
	Dolphins	Low	Negligible	Negligible (not significant)			
	Minke whale	Low	Medium	Minor (not significant)			
	Seals	Low	Negligible	Negligible (not significant)			
Impact 6 Disturbance from piling – WTGs and OSSs	Harbour porpoise	Low	Negligible	Negligible (not significant)	None	None required	**Negligible to Minor** **(Not significant)**
	Dolphins	Low	Low to Medium	Minor (not significant)			
	Minke whale	Low	Negligible	Negligible (not significant)			
	Harbour seal	Low	Negligible	Negligible (not significant)			
	Grey seal	Very low	Negligible	Negligible (not significant)			

Potential Impact	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance (before mitigation)	Primary mitigation	Additional Mitigation	Residual effect
Impact 7 Auditory injury (PTS) from piling – onshore substation	All marine mammals	Low	Medium	Minor (not significant)	MMMP (primary mitigation: MMO and PAM)	None required	**Negligible (Not significant)**
Impact 8 Disturbance from piling – onshore substation	All marine mammals	Very low to Low	Negligible	Negligible (not significant)	None	None required	**Negligible (Not significant)**
Impact 9 Auditory injury (PTS) from other construction activities	Minke whale	Medium	Negligible	Minor (not significant)	None	None required	**Negligible to Minor (Not significant)**
	All others	Low	Negligible	Negligible (not significant)			
Impact 10 Disturbance from other construction activities	Cetaceans	Low	Low	Minor (not significant)	None	None required	**Negligible to Minor (Not significant)**
	Seals	Very Low	Low	Negligible (not significant)			
Impact 11 Vessel collision	All marine mammals	High	Negligible	Minor (not significant)	EVMP	None required	**Minor (Not significant)**
Impact 12 Disturbance from vessels	All marine mammals	Low	Negligible	Negligible (not significant)	EVMP	None required	**Negligible (Not significant)**
Impact 13 Indirect impacts to prey	All marine mammals	Low	Negligible	Negligible (not significant)	None	None required	**Negligible (Not significant)**

Potential Impact	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance (before mitigation)	Primary mitigation	Additional Mitigation	Residual effect
Operation and Maintenance							
Impact 1 Auditory Injury (PTS) from operational noise	Minke whale	Medium	Negligible	Minor (not significant)	None	None required	**Negligible to Minor (Not significant)**
	All others	Low	Negligible	Negligible (not significant)			
Impact 2 Disturbance from operational noise	Minke whale	Medium	Negligible	Minor (not significant)	None	None required	**Negligible to Minor (Not significant)**
	All others	Low	Negligible	Negligible (not significant)			
Impact 3 Vessel collision	All marine mammals	High	Negligible	Minor (not significant)	EVMP	None required	**Minor (Not significant)**
Impact 4 Disturbance from vessels	All marine mammals	Low	Low	Minor (not significant)	EVMP	None required	**Minor (Not significant)**
Impact 5 Indirect impacts to prey	All marine mammals	Low	Negligible	Negligible (not significant)	None	None required	**Negligible (Not significant)**
Decommissioning							
Impact 1 Auditory injury (PTS) and disturbance from decommissioning	All marine mammals	Low	Negligible	Minor (not significant)	MMMP (primary mitigation: MMO and PAM)	None required	**Minor (Not significant)**
Impact 2 Vessel collision	All marine mammals	High	Negligible	Minor (not significant)	EVMP	None required	**Minor (Not significant)**

Potential Impact	Receptor	Receptor Sensitivity	Magnitude of Impact	Significance (before mitigation)	Primary mitigation	Additional Mitigation	Residual effect
Impact 3 Indirect impacts to prey	All marine mammals	Low	Negligible	Negligible (not significant)	None	None required	**Negligible (Not significant)**

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11.17 Annex 1 – Assumptions and limitations

880. There are uncertainties relating to the underwater noise modelling and impact assessment for the CWP Project, which apply across all comparable applications of the approaches described here. 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.

881. The following limitations and assumptions have been identified for the marine mammal chapter:

- Permanent threshold shift (PTS) onset assumptions: whereby the proportion of the marine mammal management units impacted by construction, operational and decommissioning activities; the ability to predict the exposure of animals to underwater noise, as well as in predicting the response to that exposure; and, the prediction of the cumulative PTS impact ranges all have uncertainties.
- 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.
- Uncertainty associated with the prediction of response for marine mammal receptors to underwater noise arising from piling and other construction activities.
- Uncertainty associated with the duration of the impact(s).
- Limitations associated with temporary threshold shifts (TTS).
- Limitations in population modelling to assess population level consequences of disturbance.

Further detail of such uncertainty is set out below.

11.17.1 PTS-onset limitations and assumptions

882. There are no empirical data on the threshold for auditory injury in the form of PTS onset for marine mammals. 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.

Proportion impacted

883. 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. The number of animals predicted to be within PTS-onset ranges are precautionary, as this assessment assumes that all animals within the PTS-onset range are impacted.

Exposure to noise

884. 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.

885. 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 range 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 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 unvalidated in terms of actual received levels. The extent to which ambient noise and other anthropogenic sources of noise 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 SELss which may be indistinguishable from ambient noise at the ranges these levels are predicted.

Cumulative PTS

886. The cumulative sound exposure level (SELcum) 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 SELcum exceeds the energy based threshold. The calculation of SELcum is undertaken with frequency-weighted sound levels, using species group-specific weighing 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.

887. 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.

888. Another reason is that the prediction of the onset of PTS (which is assumed to be at the SELcum 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.

889. 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 (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 SELcum 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.

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

891. Modelling the SELcum impact ranges of PTS with a ‘fleeing animal’ model, as is typical in noise impact assessments, are subject to both above-mentioned uncertainties and the result is a highly precautionary prediction of impact ranges. As a result of these and the uncertainties on animal movement, model parameters, such as swim speed, are generally highly conservative and, when considered across multiple parameters, this precaution is compounded therefore the resulting predictions are very precautionary and very unlikely to be realised.

Equal energy hypothesis

892. 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). Ward (1997) highlights that the same is true for impulsive noise, giving the example of simulated gunfires of the same SELcum exposed to human, where 30 impulses with an SPLpeak of 150 dB re 1m Pa result in a TTS of 20 dB, while 300 impulses of a respectively lower SPLpeak did not result in any TTS.

893. 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., 2013a). 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. Kastelein et al. (2013a) showed that, for seals, the threshold shifts observed did not follow the assumptions made in the guidance regarding the equal-energy hypothesis. The threshold shifts observed were more similar to the hypothesis presented in Henderson et al. (1991) whereby hearing loss induced due to noise does not solely depend upon the total amount of energy, but on the interaction of several factors such as the level and duration of the exposure, the rate of repetition and the susceptibility of the animal. Therefore, the equal-energy hypothesis assumption behind the SELcum threshold is not valid, and as such, models will overestimate the level of threshold shift experienced from intermittent noise exposures.

894. Another detailed example is the study of (Kastelein et al., 2014), where a harbour porpoise was exposed to a series of 1–2 kHz sonar down-sweep pulses of 1-second duration of various combinations, with regard to received sound pressure level, exposure duration and duty cycle (% of time with sound during a broadcast) to quantify the related threshold shift. The porpoise experienced a 6–8 dB lower TTS when exposed to sound with a duty cycle of 25% compared to a continuous sound. A one second silent period in between pulses resulted in a 3 to 5 dB lower TTS compared to a continuous sound (**Plate 11-23**).

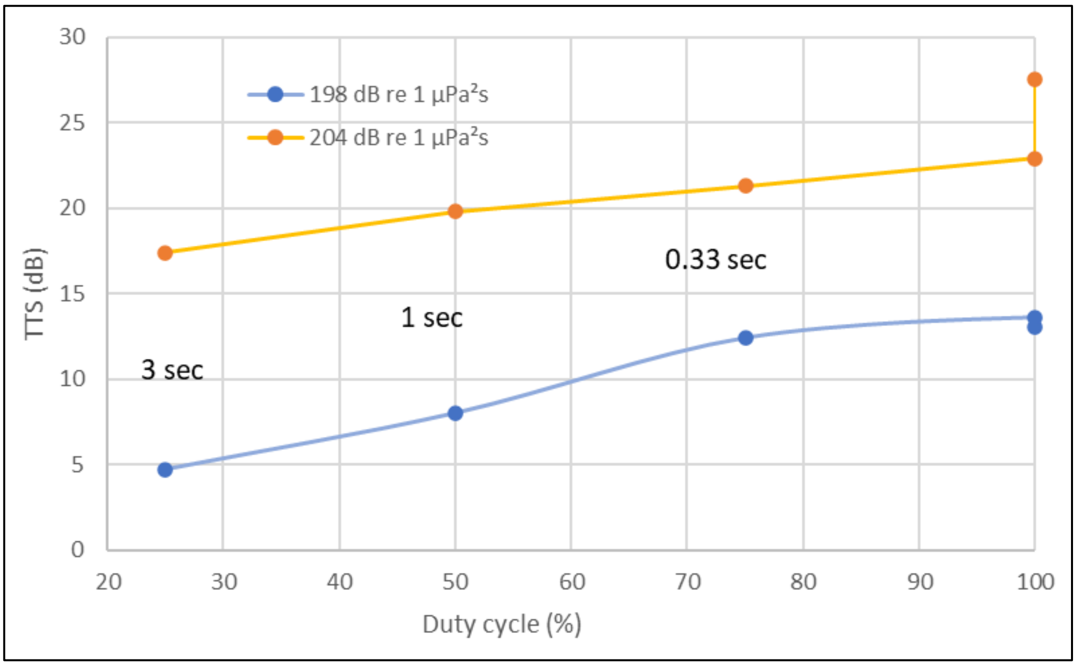

Plate 11-23 Temporary threshold shift (TTS) elicited in a harbour porpoise by a series of 1–2 kHz sonar down-sweeps of 1 second duration with varying duty cycle and a constant SEL_{cum} of 198 and 204 dB re1 µPa²s, respectively. Also labelled is the corresponding 'silent period' in-between pulses. Data from Kastelein et al. (2014).

895. Kastelein et al. (2015b) showed that the 40 dB hearing threshold shift (the PTS-onset threshold) for harbour porpoise is expected to be reached at different SEL_{cum} levels depending on the duty cycle: for a 100% duty cycle, the 40 dB hearing threshold shift is predicted to be reached at a SEL_{cum} of 196 dB re 1 µPa²s, 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 µPa²s (thus resulting in a 10 dB re 1 µPa²s difference in the threshold).

896. Pile strikes are relatively short signals; the signal duration of pile strikes may range between 0.1 seconds (De Jong and Ainslie, 2008) and approximately 0.3 seconds (Dähne et al., 2017) measured at a distance of 3.3 km to 3.6 km. Duration will however increase with increasing distance from the pile site.

897. Assuming similar effects to the hearing system of marine mammals in the CWP Project array site, the PTS-onset threshold would be expected to be around 2.4 dB higher than that proposed by Southall et al. (2019) and used in the current assessment. Southall et al. (2009) calculates the PTS-onset thresholds based on the assumption that a TTS of 40 dB will lead to PTS, and that an animal's hearing threshold will shift by 2.3 dB per dB SEL received from an impulsive sound. 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 higher SEL is needed with a 25% duty cycle than with a 100% duty cycle. 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).

898. If a 2 or 3 dB increase in the PTS-threshold is assumed, then this can make a significant difference to the maximum predicted impact range for cumulative PTS. If the threshold accounts for recovery in hearing between pulses, the PTS impact ranges for the SE location decreases from 7.9 km for harbour porpoise to 4.8 km (+2 dB) or 3.5 km (+3 dB). For minke whale the PTS impact ranges for the SE location decreases from 15 km to 9.3 km (+2 dB) or 6.9 km (+3 dB). Therefore, accounting for recovery in hearing between pulses by increasing the PTS onset threshold by 2 or 3 dB significantly decreases

the predicted PTS-onset impact ranges. This approach to modelling cumulative PTS is in development and has not yet been fully assessed or peer reviewed. Therefore, the CWP Project impact assessment will present the cumulative PTS impact ranges using the current Southall et al. (2019) PTS-onset impact threshold. While more research needs to be conducted to understand the exact magnitude of this effect in relation to pile driving sound, this study proves a significant reduction in the risk of PTS even through short silent periods for TTS recovery as found in pile driving.

Impulsive characteristics

899. Southall et al. (2019) calculated the PTS-onset thresholds based on the assumption 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 with non-impulsive sound compared to impulsive sound. Consequently, an animal subject to both types of sound has been at risk of PTS at an SELcum that lies somewhere between the PTS onset thresholds of impulsive and non-impulsive sound.

900. 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 with increasing distance as sharp transient peaks become less prominent (Southall et al., 2007). The Southall et al. (2019) updated criteria proposed that, while keeping the same source categories, the exposure criteria for impulsive and non-impulsive sound should be applied based on the signal features likely to be perceived by the animal rather than those emitted by the source. Methods to estimate the distance at which the transition from impulsive to non-impulsive noise are currently being developed (Southall et al., 2019).

901. Using the criteria of signal duration[19], rise time[20], crest factor[21] and peak pressure[22] divided by signal duration[23], 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. Hastie et al. (2019) showed that the noise signal experienced a high degree of change in its impulsive characteristics with increasing distance. Southall et al. (2019) state that mammalian hearing is most readily damaged by transient sounds with rapid rise-time, high peak pressures, and sustained duration relative to rise-time. Therefore, of the four criteria used by Hastie et al. (2019), the rise-time and peak pressure may be the most appropriate indicators to determine the impulsive / non-impulsive transition.

902. 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 milliseconds) reduces to only 20% between ~2 and 5 km from the source. Predicted PTS impact ranges based on the impulsive noise thresholds may therefore be overestimates in cases where the impact ranges lie beyond this. Any animal present beyond that distance when piling starts will only be exposed to non-impulsive noise, and therefore impact ranges should be based on the non-impulsive thresholds.

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[19] Time interval between the arrival of 5% and 95% of total energy in the signal.
[20] Measured time between the onset (defined as the 5th percentile of the cumulative pulse energy) and the peak pressure in the signal.
[21] The decibel difference between the peak sound pressure level (i.e., the peak pressure expressed in units of dB re 1 μPa) of the pulse and the root-mean-square sound pressure level calculated over the signal duration.
[22] The greatest absolute instantaneous sound pressure within a specified time interval.
[23] Time interval between the arrival of 5% and 95% of total energy in the signal.

903. It is acknowledged that the Hastie et al*.* (2019) study is an initial investigation into this topic, and that further data are required in order to set limits to the range at which impulsive criteria for PTS are applied.

904. Since the Hastie et al*.* (2019) study, Martin et al. (2020) investigated the sound emission of different sound sources to test techniques for distinguishing between the sound being impulsive or non-impulsive. For impulsive sound sources, they included impact pile driving of four 4-legged jacket foundation installed at around 20 m water depth (at the Block Island Wind Farm in the USA). For the impact piling sound, they recorded sound at four distances between ~500 m and 9 km, recording the sound of 24 piling events. To investigate the impulsiveness of the sound, they used three different parameters and suggested the use of kurtosis24 to further investigate the impulsiveness of sound. Hamernik et al*.* (2007) showed a positive correlation between the magnitude of PTS and the kurtosis value in chinchillas, with an increase in PTS for a kurtosis value from 3 up to 40 (which in reverse also means that PTS decreases for the same SEL with decreasing kurtosis below 40). Therefore, Martin et al*.* (2020) argued that:

- 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.

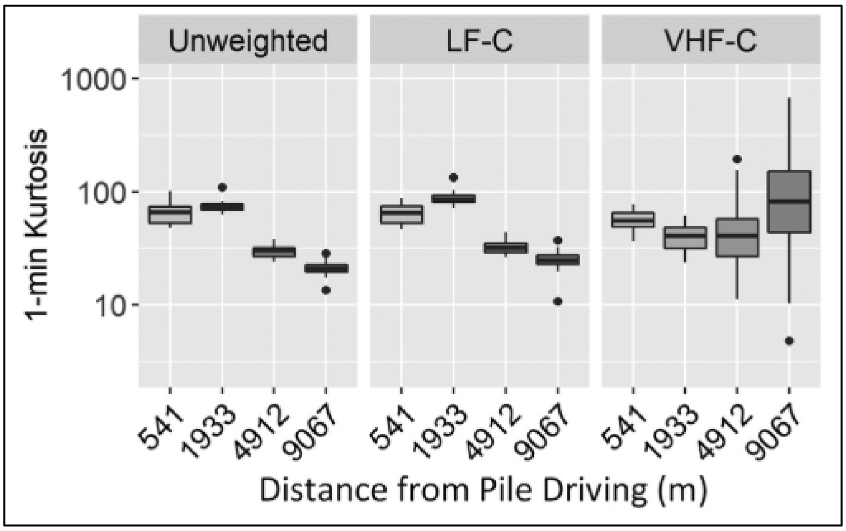

Plate 11-24 The range of kurtosis weighted by LF-C and VHF-C (Southall et al., 2019a) auditory frequency weighting functions for 30 min of impact pile driving data measured in 25 m of water at the Block Island Wind Farm. Boxplots show the median value (horizontal lines), interquartile range (boxes) and outlier values (dots). Figure from Martin et al. (2020). From these data, Martin et al. (2020) conclude that the change to non-impulsiveness 'is not relevant for assessing hearing injury because sounds retain impulsive character when SPLs are above EQT [effective quiet threshold[25]]' (i.e., the sounds they recorded retain their impulsive character while being at sound levels that can contribute to auditory injury).

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

[25] From Martin et al*.* (2020): The proposed effective quiet threshold (EQT) is the 1-min auditory frequency weighted SPL that accumulates to this 1-min SEL, which numerically is 18dB below the 1-min SEL [because 10·log$_{10}$(1 min/1 s)dB¼17.7dB]. Thus, the proposed level for effective quiet is equivalently a 1-min SPL that is 50dB below the numeric value of the auditory frequency-weighted Southall et al. (2019) daily SEL TTS threshold for non-impulsive sources.

905. However, we interpret their results differently. **Plate 11-24** 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. Based on this study and the study by Hastie *et al.* (2019), we argue that the predicted PTS impact ranges based on the impulsive noise thresholds will overestimate the risk of PTS-onset in cases and at ranges where the likelihood increases that an animal is exposed to sound with much reduced impulsive characteristics.

906. There are points that need consideration before adopting kurtosis as an impulsiveness measure, with the recommended threshold value of 40. Firstly, this value was experimentally obtained for chinchillas that were exposed to noise for a five-day period under controlled conditions. Caution may need to be taken to directly adopt this threshold-value (and the related dose-response of increasing PTS with increasing kurtosis between 3 and 40) to marine mammals in the wild, especially given that the PTS guidance considers time periods of up to 24 hours. Secondly, kurtosis is recommended to be computed over at least 30 seconds, which means that it is not a specific measure that can be used for single blows of a piling sequence. Instead, kurtosis has been recommended to evaluate steady-state noise in order to include the risk from embedded impulsive noise (Goley et al*.*, 2011). Metrics used by Hastie et al. (2019) computed for each pile strike (e.g., risetime) may be more suitable to be included in piling impact assessments, as, for each single pile strike, the sound exposure levels received by an animal are considered. It is currently unknown which metric is the most useful and how they correlate with the magnitude of auditory injury in (marine) mammals.

907. 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) proposes that the presence of high-frequency noise energy could be used as a proxy for impulsiveness, as all currently used metrics have in common that a high frequency spectral content result in high values for those metrics. This suggestion is an interim approach: 'the range at which noise from an impulsive source lacks discernible energy (relative to ambient noise at the same location) at frequencies ≥10 kHz could be used to distinguish when the relevant hearing effect criteria transitions from impulsive to non-impulsive'.

908. Southall (2021), however, 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'.

909. 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, the cumulative PTS-onset threshold for animals starting to flee at 5 km should be higher than the Southall (2021) threshold adopted for this assessment (i.e., the risk of experiencing PTS becomes lower), and any impact range estimated beyond this distance should be considered as an unrealistic overestimate, especially when they result in very large distances.

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

Cumulative PTS conclusion

911. Given the evidence presented above it is considered that the calculated SELcum 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 limitations and assumptions

912. 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 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. This is described in further detail in the marine mammal baseline characterisation.

Predicting response limitations and assumptions

913. 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 and therefore uses the most recent and site specific information on disturbance to harbour porpoise because of pile driving noise.

914. 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 above section 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 limitations and assumptions

915. 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).

916. Analysis of data from monitoring of marine mammal activity during piling of jacket pile foundations at Beatrice Offshore Wind Farm (Graham et al., 2017, 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.

11.17.2 TTS limitations and assumptions

917. It is recognised that TTS is a temporary impairment of an animal's hearing ability with potential consequences for the animal's ability to escape predation, forage and / or communicate, supporting the statement of Kastelein et al. (2012c) that 'the magnitude of the consequence is likely to be related to the duration and magnitude of the TTS'. An assessment of the impact based on the TTS thresholds as currently given in Southall et al. (2019) or the former NMFS (2016) guidelines and Southall et al. (2007) guidance would lead to a substantial overestimation of the potential impact of TTS. Furthermore, the prediction of TTS impact ranges, based on the SEL thresholds, are subject to the same inherent uncertainties as those for PTS, and in fact the uncertainties may be considered to have a proportionately larger effect on the prediction of TTS. These concepts are explained in detail below based on the thresholds detailed by Southall et al. (2019), as these are based upon the most up-to-date scientific knowledge.

918. It is SMRU Consulting's expert opinion that basing any impact assessment on the impact ranges for TTS using current TTS thresholds would overestimate the potential for an ecologically significant effect. This is because the species specific TTS thresholds in Southall et al. (2019) describe those thresholds at which the onset of TTS is observed, which is, per their definition, a 6 dB shift in the hearing threshold, usually measured four minutes after sound exposure, which is considered as 'the minimum threshold shift clearly larger than any day-to-day or session-to-session variation in a subject's normal hearing ability', and which 'is typically the minimum amount of threshold shift that can be differentiated in most experimental conditions'. The time hearing recovers back to normal (the recovery time) for such small threshold shifts is expected to be less than an hour, and therefore, unlikely to cause any major consequences for an animal.

919. A large shift in the hearing threshold near to values that may cause PTS may however require multiple days to recover (Finneran, 2015). For TTS induced by steady-state tones or narrowband noise, Finneran (2015) describes a logarithmic relationship between recovery rate and recovery time, expressed in dB/decade (with a decade corresponding to a ratio of 10 between two time intervals, resulting in steps of 10, 100, 1000 minutes and so forth). For an initial shift of 5 to 15 dB above hearing threshold, TTS reduced by 4 to 6 dB per decade for dolphins, and 4 to 13 dB per decade for harbour porpoise and harbour seals. Larger initial TTS tend to result in faster recovery rates, although the total time it takes to recover is usually longer for larger initial shifts (summarised in Finneran, 2015). While the rather simple logarithmic function fits well for exposure to steady-state tones, the relationship between recovery rate and recovery time might be more complex for more complex broadband sound, such as that produced by pile driving noise.

920. For small threshold shifts of 4 to 5 dB caused by pulsed noise, Kastelein et al. (2016) demonstrated that porpoises recovered within one hour from TTS. While the onset of TTS has been experimentally validated, the determination of a threshold shift that would cause a longer-term recovery time and is therefore potentially ecologically significant, is complex and associated with much uncertainty.

921. The degree of TTS and the duration of recovery time that may be considered severe enough to lead to any kind of energetic or fitness consequences for an individual, is currently undetermined, as is how many individuals of a population can suffer this level of TTS before it may lead to population consequences. There is currently no set threshold for the onset of a biologically meaningful TTS, and this threshold is likely to be well above the TTS-onset threshold, leading to smaller impact ranges (and consequently much smaller impact areas, considering a squared relationship between area and range) than those obtained for the TTS-onset threshold. One has to bear in mind that the TTS-onset thresholds as recommended first by Southall et al. (2007) and further revised by Southall et al. (2019) were determined as a means to be able to determine the PTS-onset thresholds and represents the smallest measurable degree of TTS above normal day to day variation. A direct determination of PTS-onset thresholds would lead to an injury of the experimental animal and is therefore considered as unethical. Guidelines such as National Academies of Sciences Engineering and Medicine (2017) and

Southall et al. (2007) therefore rely on available data from humans and other terrestrial mammals that indicate that a shift in the hearing threshold of 40 dB may lead to the onset of PTS.

922. For pile driving for offshore wind farm foundations, the TTS and PTS-onset thresholds for impulsive sound are the appropriate thresholds to consider. These consist of a dual metric, a threshold for the peak sound pressure associated with each individual hammer strike, and one for the SELcum, for which the sound energy over successive strokes is summated. The SELcum is based on the assumption that each unit of sound energy an animal is exposed to leads to a certain amount of threshold shift once the cumulated energy raises above the TTS-onset threshold. For impulsive sound, the threshold shift that is predicted to occur is 2.3 dB per dB noise received; for non-impulsive sound this rate is smaller (1.6 dB per dB noise) (Southall et al., 2007). Please see the section above for further details on the limitations of SELcum thresholds (the same limitations apply to TTS as PTS).

923. Modelling the SELcum impact ranges of PTS with a 'fleeing animal' model (as is typical during in noise impact assessments) are subject to both of these precautions. Modelling the SELcum TTS impact ranges will inherit the same uncertainties; however, over a longer period of time, and over greater ranges as the TTS impact ranges are expected to be larger than those of PTS. Therefore, these uncertainties and conservativisms will have a relatively larger effect on predictions of TTS ranges.

924. It is also important to bear in mind that the quantification of any impact ranges in the environmental assessment process, is done to inform an assessment of the potential magnitude and significance of an impact. Because the TTS thresholds are not universally used to indicate a level of biologically meaningful impact of concern per se but are used to enable the prediction of where PTS might occur, it would be very challenging to use them as the basis of any assessment of impact significance.

925. All the data that exists on auditory injury in marine mammals is from studies of TTS and not PTS. SMRU Consulting agrees with the studies' conclusion that we may be more confident in our prediction of the range at which any TTS may occur. However, this is not necessarily very useful for the impact assessment process. We accept that scientific understanding of the degree of exposure required to elicit TTS may be more empirically based than our ability to predict the degree of sound required to elicit PTS, it does not automatically follow that our ability to determine the consequences of a stated level of TTS for individuals is any more certain than our ability to determine the consequences of a stated level of PTS for individuals. It could even be argued that we are more confident in our ability to predict the consequences of a permanent effect than we are to predict the consequences of a temporary effect of variable severity and uncertain duration.

926. It is important to consider that predictions of PTS and TTS are linked to potential changes in hearing sensitivity at particular hearing frequencies, which for piling noise are generally thought to occur in the 2–10 kHz range and are not considered to occur across the whole frequency spectrum. 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. Our understanding of the consequences of PTS within this frequency range to an individual's survival and fecundity is limited, and therefore our ability to predict and assess the consequences of TTS of variable severity and duration is even more difficult to do.

TTS conclusion

927. TTS is not presented in this impact assessment (except for when used as a proxy for disturbance in the UXO clearance assessment).

11.17.3 Population modelling limitations and assumptions

928. 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.

929. There are several precautions built into the iPCoD model and this specific scenario that mean that the results are considered to be highly precautionary and likely overestimate the true population level effects. These include:

- The fact that the model assumes a minke whales and bottlenose dolphins will not forage for 24 hours after being disturbed[26];
- The lack of density dependence in the model (meaning the population will not respond to any reduction in population size);
- The level of environmental and demographic stochasticity in the model; and
- Duration of disturbance: minke whales and bottlenose dolphins.

930. 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 was amended to assume that disturbance resulted in 6 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 1 hour of feeding cessation was classified as a mild response, 2 hours of feeding cessation was classified as a strong response and 8 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 overestimate the true disturbance levels expected from the Offshore Development.

Lack of density dependence

931. 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

[26] In the updated expert elicitation in 2018, the duration of disturbance for harbour porpoise, harbour seals and grey seals was assumed to be 6 hours (Booth et al., 2019). Unfortunately, minke whales were not included in the updated expert elicitation so the duration of disturbance remains 12 hours, as used in the original expert elicitation in 2013.

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. 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 unimpacted population – i.e., it is assumed the unimpacted population is at carrying capacity) rather than continuing at a stable trajectory that is smaller than that of the unimpacted population.

Environmental and demographic stochasticity

932. 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).

933. 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 3,000 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).

934. This is clearly evidenced in the outputs of iPCoD where the unimpacted (baseline) population size varies greatly between iterations, not as a result of disturbance but simply as a result on environmental and demographic stochasticity. In the example provided in **Plate 11-25**, 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.

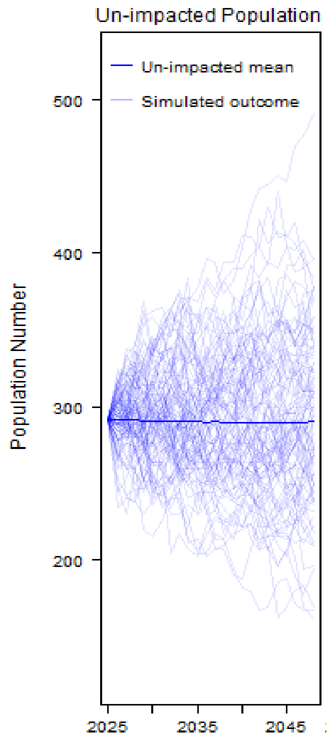

Plate 11-25 Simulated unimpacted (baseline) population size over the 25 years modelled

Summary

935. 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. The information provided is therefore considered to be sufficient to carry out an adequate assessment, though a level of precaution around the results should be taken into account when drawing conclusions.

936. In addition to this, it is noted that iPCoD is not available for common or Risso's dolphins.